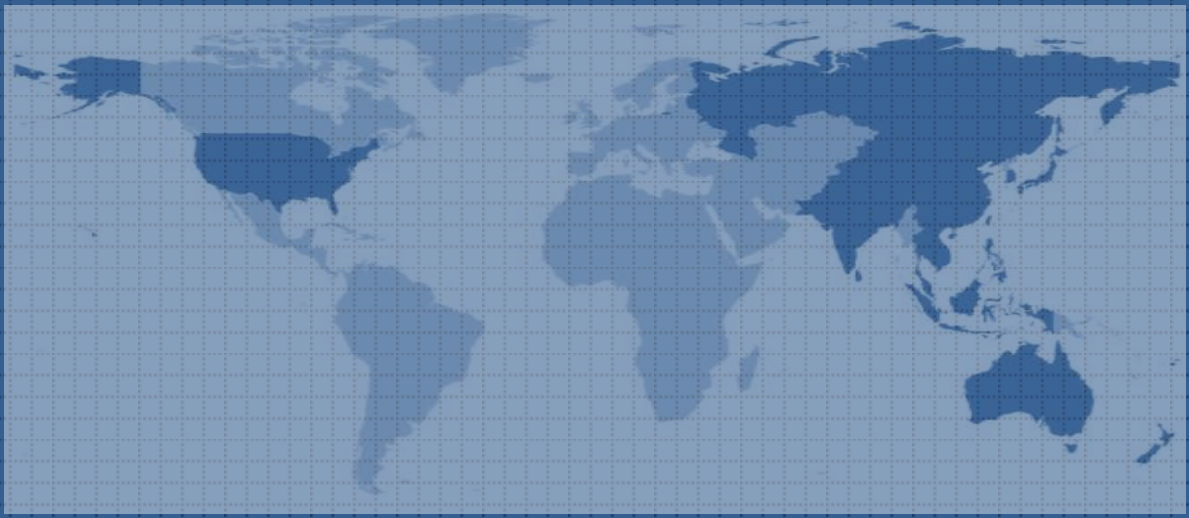
ASIA-PACIFIC NETWORK FOR GLOBAL CHANGE RESEARCH

Project Reference Number: ARCP2013-07CMY-ROY

Coastal Ecosystem and Changing Economic Activities: Challenges for Sustainability Transition along the South Asian Coasts



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Coastal Ecosystem and Changing Economic Activities: Challenges for Sustainability Transition along the South Asian Coasts

Final Report Submitted to APN

Part One: Overview of Project Work and Outcomes

Non Technical Summary [200 words]

The coastal zones of South Asia's five coastal countries (Bangladesh, India, the Maldives, Pakistan, and SriLanka) contain 22.5 percent of the global population and about 40 percent of the economic activities in the region. This region is extraordinarily rich in ecological diversity (Loiczsouthasia.org/southasiacoast.php).

This ecological richness, however, has been subjected to great interaction from humans through extraction of resources, discharge of pollution, physical alterations in coastal ecosystems resulting in changes in natural coastal aquifers, lagoons, estuaries, deltas and wetlands. Human interaction with coastal ecosystems is expected to exacerbate further with rising population and economic activities. Climate change, climate variability, and extreme events interact with numerous aspects of people's livelihoods. Weather events and climate affect *natural ecosystems and resources* on which certain livelihoods depend directly, such as rivers, lakes, and fish stocks and fish movement.

In the last four to five decades, Bangladesh, India and Sri Lanka have experienced extensive alterations in their coastal ecosystems through human intervention. Human dependence on coastal ecosystem services and resource exploitation are quite high in these countries. It is, therefore, important to understand threats and opportunities of sustaining the wellbeing of coastal communities in these countries, due to rising risks with changing diversity of the ecosystems, functions, services and the additional risk associated with climate change.

Keywords [5 maximum keywords]

Human interaction, Coastal ecosystem; Ecosystem services; Vulnerability; Risk.

Objectives

This project, through it's full two year period, tried to inventorize economic activities with corresponding ecosystem service flows along with changing risks and vulnerabilities. The most vulnerable coastal system based economic activity in each country is identified through interactions with scientists, policymakers and direct stakeholders. The specific study objectives of two phase study as was proposed are:

1. Identification and characterization of the coastal ecosystems
2. Identification and understanding of the traditional and new economic activities and also the actors along the coast line and changing pattern through first hand recall method, and mapping to ecosystem services.
3. Preparation of Inventory of ecological functions based economic activities as well as otherwise and resilience level.
4. Generation of historical data on climate parameters in order to predict future scenarios for each specific study site.
5. Application of stakeholder behaviour analysis in ecology–economy interaction framework.

The second phase focuses on the (this report is for the second phase only):

1. Given the inventory of ecological functions and economic activities understanding resilience through risk and vulnerability assessment .
2. Generation of historical data on climate parameters in order to predict future scenarios for each specific study site.
3. Stakeholder behavior analysis in ecology –economy interaction framework.

Amount Received and Number of Years Supported

The Grant awarded to this project was:

US$ 44, 000 for Year 1 **(Report Submitted in the past)**

US$ 32,600 for Year 2 **(Current Report)**

Activity Undertaken

Detailed timeline of year 2 (no cost extension upto April 2015)

Project Activities	Year 2 (2014/2015)														
	Month (from 02 February 2014 – 30 April 2015)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Case Studies : Data Collection Part 2 (Research assistants and Mentor, travel to study sites); Gap filling Study and Refinements															
Purchase of Report and Historical Data															
Data Analysis : Data collection, compilation and analysis															
International Workshop in Sri Lanka including policy makers															
Policy consultations; Interactions with policy makers															
Modelling/preparation of the final report															

Results

The proposed collaborative project has been successful in achieving its goals; same questionnaire was used by all the three collaborating countries after back and forth discussion and changes, concept note was circulated among the collaborators for comments and suggestions and country specific information from pilot in the field has been applied to India, SriLanka and Bangladesh. The main highlight of this project is extensive consultation with policy makers and stakeholders in all the three countries.

Our various field studies have helped in advancing in understanding of the current economic actor specific approach to risk assessment for coastal community given that every economic actor is trying to maximize benefit from the livelihood option chosen while the conceptual

framework suggests taking an ecosystem based approach may yield a different outcome. Using these two approaches, we have tried to understand and compare the results.

Through our field studies, we have also attempted to find examples of local resilience building efforts that can help sustainability transition. We have aimed to identify such efforts-local experiments even small in all the three countries. Other important questions addressed from our field studies relate to understanding risk and vulnerability of the local communities in terms of exposure, sensitivity and adaptive capacity to threats viewed from direct stakeholder perspective. With the diversification of income at the local level, a pertinent question relating to this diversification is: whether risk and vulnerability have reduced or enhanced because of economic goal oriented income diversification? In Year 1 we have already mapped how different economic activities relate to different ecosystem services and finally to coastal ecosystems. In Year 2 we move further to understand if livelihood diversification and changes in economic activities from old to new help in risk and vulnerability reduction and hence in resilience building? Responses are sought from direct stakeholders.

Finally, we conclude with identifying from each country the different local coastal ecosystem types, ecosystem services that communities have used the most and likely impacts of both natural and anthropogenic threats. The results are area specific so no attempt has been made to generalize.

Relevance to the APN Goals, Science Agenda and to Policy Processes

The project fits into the science agenda as it aims to study changing activities in selected coastal system, associated communities and their livelihood pattern, natural and manmade hazards led risks to ecosystem and human system and map the data base to identify vulnerable economic activities. Development of indicators and some guidelines to provide information for policy process on how best to manage these global changes in a coastal ecosystem system to make longer term transition to sustainability.

Self-evaluation

The project team is satisfied with the progress of activities in Year 02. Year 02 report from each country is provided in the Appendix to Technical part of the report.

Potential for further work

We have inventorized economic activities, interdependence on the coastal ecosystem services, and experience of threats of and vulnerability to coastal hazards and through impacts on ecosystem services and economic activities. A preliminary risk assessment for different stakeholder groups has been undertaken in this study. However, we realized this initial assessment provides a huge opportunity to take-up further research on (it is not an exhaustive list but, just next stage of possible study scope) for the coastal ecosystem based economic activities :

1. Strengthening the risk assessment study,
2. Alternative adaptation strategy designed for managing the risk,
3. Cost assessment of alternative adaptation strategies with quantification of risk reduction potential, and
4. Capacity building of various stakeholders including policy makers for better informed policy decisions and implementation.

Publications [please write the complete citation]

Publishable papers are under development and we expect to work on this more after the submission of the report.

Roy,Joyashree; Kapuria, Preeti; Datta, Satabdi; Guha, Indrila; Banerji, Rajarshi; Rao, Sandhya; Miah, Giasuddin; Chen, Shang; Li, Jingmei ; Xia, Tao; Ratnasiri, Janaka ; P.B. Terney Pradeep Kumara; Lokuhetti, Chinthaka S. "Coastal Ecosystems and Changing Economic Activities: Challanges for Sustainability Transition along Chinese and South Asian Coasts." *APN Science Bulletin* (Asia Pacific Network for Global Change Research) March 2013, no. 3 (2013).

References

Technical Report

Acknowledgments

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We are grateful to the various state and central government officials in the different departments in the Indian study site at Digha- Sankarpur- Mandarmoni for providing valuable information to and cooperating with the research team. Inputs from various departments/organizations were very useful for the study: Marine Aquarium and Research Centre, Zoological Survey of India, Govt. of India; Digha Science Centre and National Science Camp, National Council of Science Museums, Ministry of Culture, Govt. of India; Digha Sankarpur Development Authority (DSDA), Urban Development Dept, Govt. of West Bengal; Irrigation and Waterways Dept (Contai Section), Govt. of West Bengal; State Fisheries Development Corporation Ltd (Alampur), Undertaking of the Govt. of West Bengal; Fisheries Department (Contai Section), Govt. of West Bengal; Agriculture Department (Contai Section), Govt. of West Bengal; Forest Ranger Office (Contai Section), Govt. of West Bengal. Several local community organizations namely Fishermen's and Fish Trader's Association, Digha Mohona, Hotellier's Association in Old Digha and Mandarmoni have contributed to the study by sharing some secondary data and information relevant for the study. Our sincere thanks to the field surveyors: Mr. Suman Dutta, Mr. Taimur Bin Kashim Khan, Mr. Debabrata Mandal, Mr. Rajesh Bhattacharya, Mr. Surojit Bhandari associated with Jadavpur University and local surveyors and key informants of the study site Mr. Debojit Das Mohapatra, Mr. Uttam Bhuian, Mr. Nandan Karan, Mr. Shiv Shankar Maity for participating actively in field survey and primary data collection during different rounds of visit. We thank Ms. Rupsa Bhowmick, Global Change Programme, Jadavpur University for assisting in data entry.

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Part Two: Technical Report

Preface

This study examines the vulnerability of major economic activities, defined in terms of exposure and sensitivity to threats to coastal ecosystem in three study sites. These sites are located one each in Bangladesh, India and Sri Lanka. Drivers of threats can be categorized into natural (mainly weather related) and anthropogenic. The main focus of this assessment is to identify, from the field level first hand information, the most vulnerable from among current economic activities in each study site and also in determining the risks of each economic activity to understand resilience to threats identified. In addition future projections for changes in rainfall and temperature patterns for the study location are made using PRECIS data on precipitation, maximum and minimum temperature and the CORDEX model outputs. Finally, possible indications of impacts of the projected changes in the temperature and rainfall on the changing pattern of major economic activities are explored.

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1. Introduction

“Ecosystem services” is used to describe the internal functioning of the ecosystem (e.g. maintenance of energy fluxes, nutrient (re)cycling, food-web interactions), and sometimes it relates to the benefits derived by humans from the properties and processes of ecosystems (e.g. food production and waste treatment) (De Groot et al, 2002). While from an economic perspective, ecosystem services are those contributions of the natural world which generate goods which people value. ‘Goods’ refers to any item or construct that increases human welfare. This includes physical products (e.g. the role of ecosystem services in the

production of food) and less tangible goods (e.g. detoxification services). It also includes items which generate use values and non-use goods which are valued purely for their continued existence (Bateman et al ,2010). Similarly, 'value' relates to the contributions ecosystem services make to welfare, where human welfare is measured in terms of each individual's own assessment of his or her economic well-being.

The Millennium Ecosystem Assessment has clearly demonstrated that ecosystems have been significantly altered by anthropogenic activity. In fact human actions are already impairing the flow of ecosystem services. Global climate change represents an additional threat to the ecological and socioeconomic systems that are already facing tremendous pressures because of rapid urbanization and development. Coastal ecosystems are one of the most threatened but mostly populated landscapes in the world. With its huge and growing population, coastal areas are considerably vulnerable to the impacts of climate variability. Increase in frequency and intensity of climate related disasters (e.g. floods, cyclonic storms, droughts, and sea level rise), exacerbate vulnerabilities of the people living and depending on coastal ecosystem based resources.

The continued degradation of the coastal ecosystem through a variety of human-led and climate related pressures necessitates a better understanding of the extent of human dependence on ecosystem services, and hence the vulnerability of human well-being to ecosystem changes caused both by natural and anthropogenic factors.

In the first phase of the study, different ecosystem services that coastal ecosystems in Bangladesh, India and Sri Lanka provide were identified along with the corresponding economic activities that are directly or indirectly dependent on these services in the three study sites, respectively. From the overall study objectives listed below, objectives 1 and 2 were completely addressed in year I, while objective 3 was partially addressed; the preparation of inventory of ecological functions based economic activities was done in year I.

1. Identification and characterization of the coastal ecosystems
2. Identification and understanding of the traditional and new economic activities and also the actors along the coast line and changing pattern through first hand recall method, and mapping to ecosystem services.
3. Preparation of Inventory of ecological functions based economic activities as well as otherwise and resilience level.
4. Generation of historical data on climate parameters in order to predict future scenarios for each specific study site.

5. Application of stakeholder behaviour analysis in ecology–economy interaction framework.

The remaining two objectives for assessment of the resilience of coastal communities are covered in this report. The three main components of this current report are:

1. Assessment of resilience of various economic activities given their ecosystem dependence structure identified in year 1.
2. Presentation of historical data on climate parameters in order to predict future scenarios for each specific study site.
3. Stakeholder behavior analysis in ecology –economy interaction framework.

The report begins by discussing the conceptual framework that has been uniformly applied to all study sites, later with the help of empirical findings.

1.2 Conceptual Framework of the Study

Coastal systems are subject to a wide range of anthropogenic drivers (e.g. Crain *et al.*, 2009) which interact with climate-related drivers and confound efforts to attribute impacts to climate change.

These systems are considered to be affected mainly by:

a. higher sea levels,
b. increasing temperatures,
c. changes in precipitation,
d. increased ocean acidity and
e. human activities that continue to increase their pressure on the coasts with rapid urbanization in coastal areas and growth of megacities with consequences on coastal resources.

Some of the major human drivers that are directly or indirectly causing changes in the coastal systems can be listed as:

a. socioeconomic development,
b. nutrients,
c. hypoxia,
d. sediment delivery, and
e. land use change

During the last century the proportion of the world population living near coasts has increased manifolds resulting in the degradation of coastal environments because of multiple

stresses arising from local to global scale drivers (e.g. water use, influx of sediments and pollutants, ecosystem degradation, river flooding, shoreline erosion, storms, tsunamis, relative sea level rise, aggregate extraction etc.) (LOICZ, 2011). This large population is vulnerable, to a greater or lesser extent, to weather-related hazards some of which can affect the entire terrestrial landscape. Large-scale impacts of climate change are likely to include a rise in sea levels, changing temperature and precipitation patterns and extreme weather events, causing economic loss and disruption in life.

	Consequences of sea-level rise for coastal systems:
1	Increased levels of inundation and storm flooding
2	Accelerated coastal erosion
3	Seawater intrusion into fresh groundwater
4	Encroachment of tidal waters into river systems
5	Increased rainfall during monsoons is likely to increase the frequency of floods, with areas already prone to floods likely to suffer more

Hazards in coastal areas often become disasters driven by environmental change and human activities (Adger et al 2005). Enhancing long-term livelihood resilience among poor and marginalized people require (IPCC, 2013):

a. Insurance schemes,
b. social protection programs, and
c. disaster risk reduction

Hence, in this report **resilience** of the so called coupled "social and natural system" **is assessed** in terms of the **vulnerabilitie**s of the coupled system to various disturbances caused by both human and natural factors **and the enhancing opportunities for reducing risks** to the system **by building adaptive capacity**.

The term "Vulnerability" has its roots mostly in geography and natural hazards research but this term is now a central concept in a variety of research contexts such as natural hazards and disaster management, ecology, public health, poverty and development, secure livelihoods and famine, sustainability science, land use change, and climate impacts and adaptation. Vulnerability can be defined in many ways which we summarise in Table 1.

According to Brien et al (2003) vulnerability has three important characteristics:

1. Vulnerability is inherently a differential concept, because risks or changes and the ability to cope with them vary across physical space, as well as among and within social groups,

2. Vulnerability is scale dependent. That is, it varies depending on the unit of analysis, from 'country' to 'region', 'community' or 'social group', and

3. Vulnerability is dynamic, and may change over time as underlying structures and conditions change.

Table 1: Various definitions of vulnerability

Vulnerability defined in terms of	Definition	Source
Exposure		
	Vulnerability is the threat to which people are exposed	Gabor and Griffith (1980
	Vulnerability is defined in terms of exposure, capacity and potentiality	Watts and Bohle (1993)
	The extent to which climate change may damage or harm a system	IPCC (1997)
	" Vulnerability is the exposure of groups or individuals to stress as a result of social and environmental change, where stress refers to unexpected changes and disruption to livelihoods"	Adger (1999)
	Function of the risk of adverse future climate change	UNEP (2000)
Sensitivity	Degree to which a system acts adversely to the occurrence of a hazardous event	Timmerman (1981)
	Vulnerability is a function of sensitivity to climate change	IPCC (1997)
	It is a function of sensitivity to present climatic variability	UNEP (2000)
	Vulnerability is the potential for loss of property or life from environmental hazards	Cutter et al. (2000)
Adaptive capacity	Vulnerability is the inability to take effective measures to insure against losses due to the impossibility or improbability of effective mitigation, and is a function of our ability to detect the hazards.	Bogard (1989)
	It is a function of the ability to adapt to new conditions that occur because of climate change	IPCC (1997)
	Function of the capacity to adapt to climate variability	UNEP (2000)
	Presence or lack of ability to withstand shocks and stresses to livelihood	Adger (2000)
	Capacity of individuals and social groups to	Kelly and Adger

Vulnerability defined in terms of	Definition	Source
	respond to, that is, to cope with, recover from or adapt to, any external stress placed on their livelihoods and well-being	(2000)
Social vulnerability	Individual and collective vulnerability and public policy determine the social vulnerability to hazards and environmental risks	Adger (2000)

The Intergovernmental Panel on Climate Change (IPCC) defines vulnerability as "the degree to which a system is susceptible to or unable to cope with, adverse effects of climate change, including climate variability and extremes". The three components of vulnerability, according to the IPCC definition are:

a. exposure,
b. sensitivity,
c. adaptive capacity

Where a relation among quantification through scores can be shown as ,

$$Vulnerability\ score = f(exposure\ score - adaptive\ capcity\ score) * sensitivityscore \quad (1)$$

Vulnerability score is a function of the exposure score less the adaptive capacity score and obtained by multiplying the above difference by the sensitivity score.

Exposure is the magnitude and duration of the climate-related exposure such as a drought or change in precipitation. Sensitivity is the degree to which the system is affected by the exposure, and adaptive capacity is the system's ability to withstand or recover from the exposure. Adaptation involves reducing risk and vulnerability, seeking opportunities and building the capacity of nations, regions, cities, the private sector, communities, individuals, and natural systems to cope with climate impacts, as well as mobilizing that capacity by implementing decisions and actions. Adaptation requires adequate information on risks and vulnerabilities in order to identify needs and appropriate adaptation options to reduce risks and build capacity.Adaptation options can be implemented either to modify the drivers or exposure and vulnerability or both (IPCC, 2013).

Adaptation measures can be classified into:

a. institutional and social measures ,
b. technological and engineered measures, and
c. ecosystem- based adaptation measures .

The schematic of the complex links of interdependence among vulnerability, risk and other components as mentioned above are presented below:

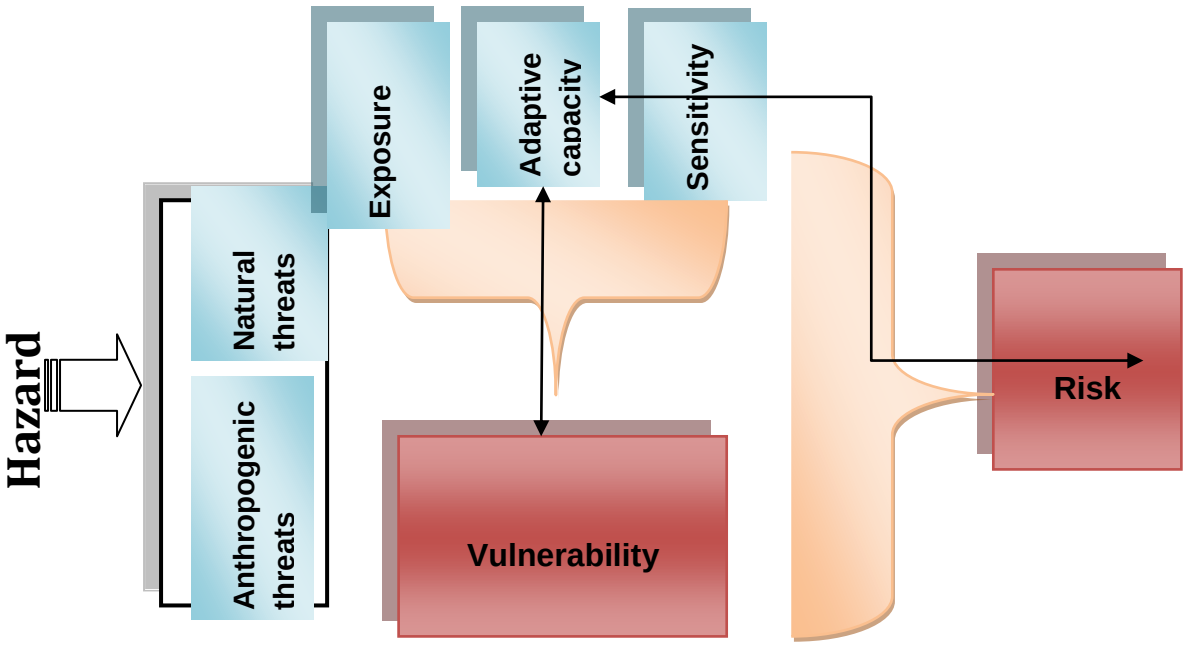


Figure 1: Components of Resilience Assessment Framework

Risk refers to the potential for adverse effects on lives, livelihoods, health status, economic, social and cultural assets, services (including environmental), and infrastructure due to uncertain states of the world. Risk can also be subjective in the sense that the likelihood and outcomes are based on the knowledge or perception that a person has about a given situation (IPCC, 2013). Risks differ, depending whether they are natural (e.g. floods) or the result of human activity (e.g. conflict) and also by frequency and welfare impact (for example catastrophic or non-catastrophic). Moreover, they can affect individuals in an unrelated manner (idiosyncratic), they can be correlated among individuals (covariate), across time (repeated) or with other risks (bunched).

In the Fifth Assessment Report of IPCC (2013) special focus is given on climate change, related stressors, resulting vulnerabilities, and associated risks. Some of the key risks listed

in the report are: Risk of death, injury, and disruption to livelihoods, food supplies, and drinking water, in addition to loss of common-pool resources, sense of place, and identity due to coastal flooding and storm surges affecting high concentrations of people, economic activity, biodiversity, and critical infrastructure in low-lying coastal zones and small island developing states.

Resilience is a concept that takes into account how systems, communities, sectors, or households deal with disturbance, uncertainty and surprise over time, and it is characterized by both adaptability and transformability. The term is used by various disciplines to carry different meanings across different contexts, applied to a range of systems across a range of scales from individuals to households, communities, regions and nations. Cutting across all disciplines the concept is used to specify a system's ability' to deliver defined set of services when the system is facing risk due to adversities and perturbations which are external and intended/unintended from system's and system based service users point of view. The most widely used notion has the core assumption that the concept of resilience of a 'system' is 'its' capacity to return to original state after experiencing a given level of disturbance. We summarise in Table 2 the most widely used concepts of Resilience.

Table 2: Commonly used concepts of Resilience

Resilience characterized as no resulting structural change in any given system in response to a perturbation		**Source**
Resilience		
	Is a measure of a system's or part of a system's capacity to absorb and recover from the occurrence of a hazardous event	Timmerman (1981)
	Is the buffer capacity or the ability of a system to absorb perturbations or the magnitude of disturbance that can be absorbed before a system changes its structure by changing variables and processes that control behaviour	Adger, 2000
	Is the amount of change a system can undergo and still retain the same controls on function and structure	Walker, et al 2002
	Is the ability of an actor to cope with or adapt to hazard stress	Dolan and Walker, 2004
	is referred to as the speed with which a system	Klein, et al 2004

Resilience characterized as no resulting structural change in any given system in response to a perturbation		Source
	returns to its original state following a perturbation	
	Resilience is defined as the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt naturally to stress and change	IPCC, Working Group II (Technical Summary)
	Is the capacity of linked social-ecological systems to absorb recurrent disturbances	Adger, et al 2005
Resilience when it refers to no loss of functionality of a given system		
	capacity of a system in a given state to accommodate perturbations without losing functionality	TEEB, 2010

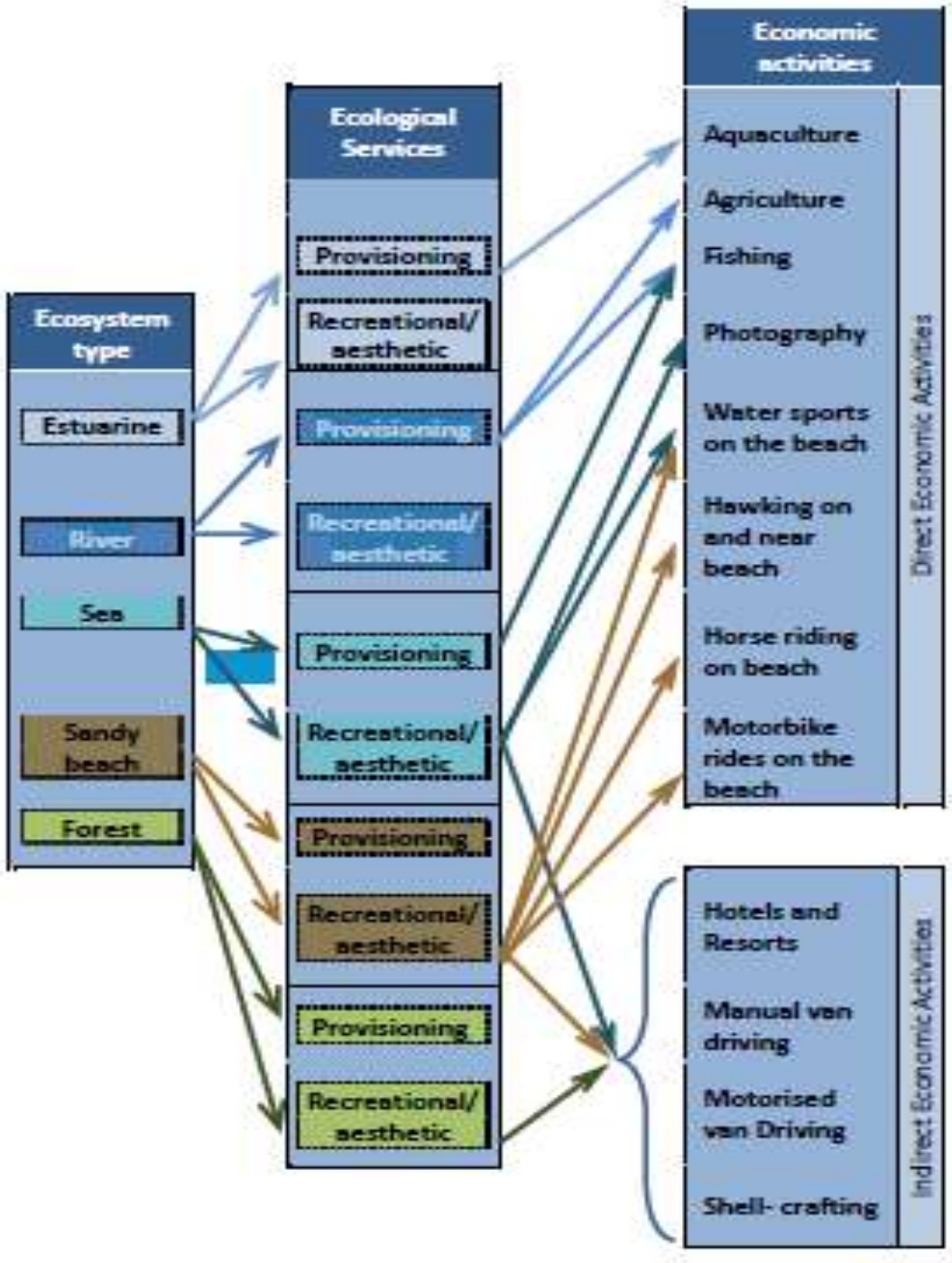
In the context of direct dependence of communities on the coastal ecosystems of the three study sites, it was observed that the resilience mainly depends on the stability particularly of the livelihoods of these communities, which is closely connected to the health and functioning of the natural coastal ecosystem. This implies the need to ensure continuous flow of ecosystem services that come from natural resource base and are of vital significance to the local economy.

2. Methodology

In year I, we mapped different economic activities to various ecological services provided by different ecosystem types found in the three study sites, respectively. Figure 2 shows this mapping in the context of Digha-Sankarpur study site in India[1] . Based on this mapping for each study site, stakeholders were identified, and grouped into two categories: those whose main economic activity is directly dependent on ecological services and the other category with indirect dependence on ecological services, hence the ecosystem. In year 2, these stakeholders were interviewed to assess the vulnerability of economic activities to changes

[1] For all three sites this has been created.

in ecological processes (mainly supporting and regulating services) as a result of environmental factors. This study is designed at an interface of ecology-economy interaction framework where different economic activities, though dependent on the ecosystem, impact the ecology of the ecosystem and in turn are impacted because of these changes, which are cumulated because of external environmental factors. In this backdrop, year 2 analysis was carried out.



2.1 Data

2.1.1 Primary Survey

The study draws data mainly from primary field surveys to selected study sites in the three countries. The second year survey was carried out within the same geographical areas as the previous year's surveys: (a) Digha-Sankarpur in West Bengal, India, (b) Cox's Bazar-Moheshkhali, Bangladesh, (c) village of Koggala extending from Habaraduwa to Ahangama in Sri Lanka[2].

Field visits in year I were mainly organized to obtain information on socio-economic and demographic characteristics of people living in these sites. The focus then was mostly on identifying the changing patterns in economic activities over the years and understanding the reasons associated with these patterns. In year I the focus was only on seeking information from individuals, while in year II in addition to individuals, a separate questionnaire was designed for officials/scientists/experts working in that area with a good understanding of issues at the ground.

The second year primary survey was carried out using two structured questionnaires[3] (one for the officials/scientists/experts from the relevant departments/institutions and the other for the local people engaged in different livelihood activities in the selected study sites in the three countries). The main focus of the second phase of the survey is to identify important threats (natural and anthropogenic) to different economic activities and ecosystem types, ongoing intervention[4] strategies available and implemented so far to reduce the impact of such threats from the perspective of different stakeholders in the three study sites.

Data were sought on different types of threats, drivers of such threats, frequency of occurrence of natural events/ hazards and human induced threats resulting in monetary loss to different stakeholders and changes in ecosystem services. Sensitivity to various threats is assessed at the level of economic activities found in the study sites in year 1. Stakeholders' responses are sought at a scale ranging from highly sensitive to no impact at all. Vulnerability is examined by using information on frequency of occurrence of various threats and sensitivity to these threats. Apart from this, stakeholders' views on the effectiveness of adaptive measures implemented by the local administrative bodies against various threats

[2] Refer to Appendix I for details on respective field surveys
[3] Same instrument was used in all three country sites
[4] We are not naming them as adaptation as these are not in response to climate change per se but can provide clue for future adaptation strategies

were also sought. Interventions are categorized into: technological strategies, financial strategies and institutional strategies. An assessment of risk is also made using information relating to different impacts a particular threat can have on a respondent's household, for instance, fixed asset loss, income loss, health risk, property loss, crop loss and so on. In this survey an important focus is given on assigning ranks to the responses received. All assessments are made using information relating to levels of intensity of impact or extent of importance of different interventions quantified with the help of ranks assigned by each respondent.

In addition to this survey a supplementary survey on the fisheries Sector in Sri Lanka was also carried out. Fisheries have been a traditional occupation of the coastal people in Sri Lanka. Fishers venturing into the sea are vulnerable to risks due to the occurrence of rough seas during stormy weather and in the recent past, there had been many casualties due to capsizing of boats. With the anticipated climate change and accompanying sea-surface temperature rise, such stormy conditions are expected to increase making fishers more vulnerable to them. One option available to reduce this risk is for fishers to venture into the sea only in large boats capable of withstanding stormy conditions.

In Sri Lanka, most of the fishers still use traditional boats and gear for harvesting fish which comprise 47 percent of the total fleet. More recently, fishers have started to use motorized boats with out-board engine or in-board engine and multiday boats. However, multi-day boats comprise only 8% of the total fleet or about 15 percent of non-traditional fleet. Though the government is offering financial assistant to fishers to acquire multi-day boats, fishers seem to opt for single-day fishing in coastal waters. Hence, the objective of the survey was to determine the reasons for fishers not willing to shift to multi-day boats which will ensure their safety in the sea and also provide them with an opportunity to earn a higher profit. Fishers' opinion on the recently imposed ban on fishery products by the European Union was also sought. The supplementary survey was conducted in February 2015 in five selected fishery harbours in Southern Coast of Sri Lanka - Mirissa, Dondra, Gandara, Nilwella and Kudawella. Among the respondents interviewed, 28 percent were those who practiced coastal fishing (up to edge of continental shelf), 72 percent who practiced off-shore fishing (up to EEZ) and deep-sea fishing (beyond EEZ). Preliminary analyses were conducted by using Semi-Structured Interviews, Focus Group Discussions and Oral Histories to generate qualitative data about the stakeholder groups. As a survey method questionnaire was used to quantify the collected information. Analyzed data, both quantitative and qualitative, were used to evaluate fishers' perceptions on shifting to off-shore and deep-sea fishing.The results based on findings from different surveys are explained in detail in the next two sections. The results vary across sites because of the

differences in economic activities being pursued in each site hence categories of stakeholders selected are not the same. Also, selection of policy makers/ scientists/ experts is site specific depending on local relevance given the study objectives.

2.1.3 Secondary data

Long term trends in annual and seasonal-precipitation, maximum and minimum temperature in the study sites of India, Bangladesh and Sri Lanka at daily time scales have been analyzed to arrive at current baseline climatology. Climate projections are made using PRECIS data on precipitation, maximum and minimum temperature and the CORDEX model outputs. This analysis is done to address objective 2 of the year II study.

2.2 Methods

2.2.1 Primary Data Analysis

As mentioned in equation one and Resilience Assessment framework schematic diagram we need to generate some scores to arrive at the quantitative assessment of risk levels. As a first step, basic survey data is normalized using the formula:

$$x_{new} = \frac{x - x_{min}}{x_{max} - x_{min}} \qquad (2)$$

As a result of this normalization, new transformed variables are obtained that range from 0 to 1. We consider all the data we got as reflecting baseline information as planned no targeted adaptation has been taken up in the study sites. So as per equation 1 adaptation score can be taken as zero so final formula for assessing 'baseline vulnerability[5]' at study sites can be rewritten as:

Vulnerability = Exposure x Sensitivity *(3)*

Exposure is estimated by using information on frequency of occurrence[6] of a threat (stress) taken from the responses to the questionnaire. Higher the frequency, greater is the stress (exposure). Whereas sensitivity is the degree to which the system is affected by the exposure. System here refers to "economic activity". Sensitivity is estimated with the help of information on intensity of impact of threats on various economic activities from our

[5] Baseline vulnerability assessment can provide a useful set of information to prioritise adaptive action in future and additional vulnerability reduction through adaptation can be assessed using baseline information.

[6] We did ask people during survey

questionnaire. Formula (3) provides an assessment of vulnerability of an economic activity in the absence of interventions.

Changes (increase or decrease) in vulnerability of the system can be examined after factoring in risk using the following formula:

Vulnerability x Risks associated with vulnerability *(4)*

2.2.2 Climate Change Analysis

India

The long term trends in observed seasonal precipitation in Digha –Sankarpur (Purba Medinipur) are analyzed using IMD gridded daily rainfall data with a resolution of 0.5° for the time period 1971-2005 (35 years).Two grids daily data falling in the study area have been considered. Similarly, daily maximum and minimum temperature are analyzed using IMD gridded data with a resolution of 1° for the time period 1969-2005 (37 years). One grid daily data falling in the study area has been used.

Analysis of the Climate Change Data (AR4)

The PRECIS data on precipitation, maximum and minimum temperature have been analyzed for Digha-Sankarpur for baseline (1961-1990) and mid century (2021-2050). One grid daily data falling in the study area has been used.

Climate change Data Extraction (AR4)

Data for many different indicators (Physical quantities, Rainfall, Temperature,) at a variety of different timescales; daily, monthly are used for the study area. All model data represent grid cell averages, i.e. an average quantity over a 2500 km^2 (50 km X 50 km) and are available in binary format.

Climate Indices for extremes (AR5)

Same suite of climate change indices used in AR5 projections derived from the CORDEX model outputs - both historic (1961-1990) and climate projections (2021-2050) at 0.5°×0.5° have been assessed for Digha-Sankarpur of Purba Mednipur district. Projections have been made at a grid-spacing of 0.2°x0.2° resolution using single model (SMHI-RCA4) for RCP 4.5 (moderate emission scenario) only due to data availability.

Bangladesh

Gridded daily rainfall data at Cox's Bazaar Sadar-Moheshkhali is used for the time period 1969-2005 (37 years).Five grids daily data falling in the study area have been considered.

Aphrodite grid 128147 is nearest to the study area with gridded rainfall resolution of 0.25° x 0.25°.

The daily maximum and minimum temperature data from GSOD observed station namely Chittagong which is around Cox's Bazaar Sadar-Moheshkhali is used for the time period 1982-2014 (37 years). Based on data availability, daily data falling around the study area from only one station has been used.

Analysis of the Climate Change Data (AR4)

The PRECIS data on precipitation, maximum and minimum temperature have been analyzed for Cox's Bazaar- Sadar Moheshkhali for baseline (1961-1990) and mid century (2021-2050). Data for many different indicators (Physical quantities, Rainfall, Temperature,) at a variety of different timescales; daily, monthly are used for the study area. All model data represent grid cell averages, i.e. an average quantity over a 2500 km^2 (50 km X 50 km) and are available in binary format.

Four grids daily data falling in the study area have been used. Annual maximum temperature is projected to increase by 1.6^0C and annual minimum temperature by about 1.8^0C towards mid-century. Average annual rainfall is projected to increase by about 23percent for four grids on average towards the mid-century scenario compared to the baseline.

Analysis of the Climate Change Data (AR5)

CORDEX-based mid-term (2030's, representing climatology over 2021-2050 climate change projections has been assessed for Cox's Bazaar Sadar-Moheshkhali in Bangladesh. Projections have been made at a grid-spacing of 0.2°x0.2° resolution using single model (SMHI-RCA4) for RCP 4.5 (moderate emission scenario). Both historic and climate projections were at 0.5°×0.5°. The data was further re-gridded to spatial scale of 0.2×0.2° resolution by using bilinear interpolation, thus, three grids falling in Cox's Bazaar Sadar-Moheshkhali have been analyzed.

Sri Lanka

Gridded daily rainfall data at Koggala area in the Habaraduwa Divisional Secretariat (DS) is used for the time period 1969-2005 (37 years). Three grids daily data falling in the study area have been considered. Aphrodite grid 81085 is nearest to the study area with gridded rainfall resolution of 0.25° x 0.25°.

Daily maximum and minimum temperature data is taken from GSOD observed stations namely Hambantota and Galle around Koggala area in the Habaraduwa Divisional Secretariat (DS) division for the time period 1969-2005(37 years) and 2003-2013 (11 years) respectively. Stations daily data falling around the study area has been used according to data availability.

Analysis of the Climate Change Data (AR4)

The PRECIS data on precipitation, maximum and minimum temperature have been analyzed for Koggala area for baseline (1961-1990) and mid century (2021-2050). Data for many different indicators (Physical quantities, Rainfall, Temperature,) at a variety of different time scales; daily, monthly are used for the study area. All model data represent grid cell averages, i.e. an average quantity over a 2500 km^2 (50 km X 50 km) and are available in binary format. Two grids daily data falling in and around the study area has been used. Annual maximum temperature is projected to increase by 1.5^0C and annual minimum temperature by 1.6^0C on average towards the mid-century. Average annual rainfall is projected to increase marginally by 8.3percent (grid: 5474) and 5.9percent (grid: 5474) towards the mid century scenario compared to the baseline.

Analysis of the Climate Change Data (AR5)

The CORDEX simulations with SMHI indicate an all-round warming over the study area. Both historic and climate projections were at 0.5°×0.5°. The data was further re-gridded to spatial scale of 0.2×0.2° resolution by using bilinear interpolation, thus, two grids falling in Koggala area have been analyzed.

The next section presents the survey findings and long term trends in annual and seasonal-precipitation, maximum and minimum temperature over the study sites of India, Bangladesh and Sri Lanka at daily time scales to arrive at current baseline climatology and climate change projections. An overview of baseline temperature and precipitation trends at different scales along with climate projections for mid-century is presented in section 3.

3. Results & Discussion

This section presents survey results from all the three study sites.

Digha-Sankarpur , India

Table 3 identifies some of the major threats as perceived by individuals pursuing different economic activities/direct stakeholders in Digha-Sankarpur. As is evident from the table, coastal erosion, sea water intrusion and coastal storms are the three most important natural threats that the coastal community of Digha-Sankarpur is facing. Around 78-79 percent of the sampled population considers coastal erosion and sea water intrusion as two major threats while close to 54 percent reported coastal storms as a major threat. As for the anthropogenic threats, wastewater discharged from hotels and restaurants polluting the coast and the seawater is a major concern for this community (around 50 percent). These findings are supported by Table 4 which gives a disaggregated picture across different economic activities. Sea water intrusion is a major threat for stakeholders engaged in economic activities like photography and horse-riding on the beach and fish drying (100 percent response). Coastal storms impacts aquaculture the most (80 percent) while hoteliers are the least impacted. Similarly, wastewater polluting the coast and sea water impacts aquaculture the most (100 percent response), agriculture the least (22.22 percent) and hoteliers (33.33 percent). Economic activities mainly dependent on the condition of the coast are mostly affected by pollution on the beach and sea water. Running of vehicles and waste water pollution are major issues of concern for these small-scale activities like, shell-crafting, photography and horse-riding on the beach.

Table 3: Identification of threats (natural and anthropogenic) to economic activities in Digha-Sankarpur

S.No.	Threats	Percentage response
	Natural:	
1	Coastal storms	54.00
2	Sea water intrusion during high tide	77.68
3	Flooding due to heavy rainfall	5.36
4	Inadequate rainfall	1.79
5	Coastal erosion	78.57
	Anthropogenic:	
6	Wastewater from hotels and restaurants polluting the coast and the seawater	50.00
7	Running of petrol or diesel vehicles on the beach resulting in the pollution of the beach	24.11
8	Sand mining	10.71

Table 4: Threats (natural and anthropogenic) to different economic activities in Digha-Sankarpur (percentage response)

Threat	Economic activity						
	1	2	3	4	5	6	7
Natural							
Coastal storms	22.22	50.00	28.57	75.00	44.44	50.00	50.00
Sea water intrusion	77.78	87.50	100	100	77.78	75.00	92.86
Flooding due to heavy rainfall	0.00	12.50	0.00	0.00	0.00	25.00	0.00
Inadequate rainfall	0.00	12.50	0.00	0.00	0.00	0.00	0.00
Coastal erosion	77.78	75.00	71.43	75.00	77.78	0.00	78.57
Anthropogenic							
Wastewater from hotels and restaurants	44.44	75.00	85.71	50.00	38.89	75.00	42.86
Running of petrol or diesel vehicles on the beach	44.44	37.50	42.86	0.00	16.67	75.00	7.14
Sand mining on the beach	0.00	12.50	28.57	0.00	5.56	0.00	7.14

Table 4: continued..

Threat	Economic activity					
	8	9	10	11	12	13
Natural						
Coastal storms	50.00	55.56	66.67	66.67	80.00	8.33
Sea water intrusion	75.00	66.67	100.00	55.56	40.00	58.33
Flooding due to heavy rainfall	0.00	33.33	0.00	11.11	0.00	0.00
Inadequate rainfall	0.00	0.00	0.00	11.11	0.00	0.00
Coastal erosion	100.00	88.89	77.78	77.78	80.00	66.67
Anthropogenic						
Wastewater from hotels and restaurants	75.00	44.44	44.44	22.22	100	33.33
Running of petrol or diesel vehicles on the beach	25.00	11.11	11.11	11.11	40.00	33.33
Sand mining on the beach	0.00	0.00	0.00	22.22	0.00	25.00

Note: Economic activity 1 refers to manual van driving, 2: motorized van driving, 3: photography on the beach, 4: horse-riding on the beach, 5: hawking on and around the beach, 6: shell-crafting, 7: fishing using mechanized boats, 8: deep sea fishing using trawlers, 9: fishing using manual boats, 10: fish drying, 11: agriculture, 12: aquaculture, 13: hotels and restaurants

Exposure to threats is assessed[7] for all the 13 economic activities identified in Digha-Sankarpur. The intensity of Exposure depends on the frequency of occurrence of different threats on a varying time scale as reported by stakeholders based on their past experience. . As identified in tables 3 and 4 and now in table 5, sea water intrusion and coastal erosion are the two important threats concerning various economic activities in Digha-Sankarpur.

[7] Based on ranking reported during survey has been coveted to scores by formula 2

The occurrence of coastal storms has a significant impact on fishing activities that use manual boats (0.83) and aquaculture (0.83). For other economic activities the exposure is either low to moderate or stakeholder does not perceive risk . For instance, motorised and manual van driving though showing absence of threat from coastal storms (when we consider median values), otherwise have indicated the exposure to vary on a scale between 0.00 to 0.83, implying from no exposure to once every year. Same is the case with economic activity like photography on the beach. On the other hand, most hawkers though, found on or around the beach), have a mixed perception of the severity of exposure to coastal storms. Their perception varies from 0.00 to 1.00 (multiple times in a year) with 1 out of 18 interviewed, reporting exposure as high (0.83), while 3 reporting exposure as very high (1.00), another 4 ranking the exposure as almost marginal, and the remaining 10 ranking coastal storms as no threat at all their economic activity. Another important coastal economic activity; fishing using mechanised boats, though not impacted by coastal storms (as reported by 57 percent of the respondents), does show exposure to be more than moderate to very high for the remaining 43 percent of the sampled population. Surprisingly, deep sea fishing with trawlers is mostly not exposed to storms. 60 percent of the total interviewed reported no exposure and the remaining 40 percent reported only marginal exposure. This trend could be because of the installation of early warning and GPS devices in the trawlers which help in deciding when to venture into the sea for fishing. Finally, hoteliers do not consider coastal storms as a serious threat to their proliferating business. This is evident from the responses collected. Only 1 out of 12 hoteliers interviewed mentioned exposure as increasing (0.50). Exposure to sea water intrusion is high for motorized van driving (0.83) and photography on beach (0.83). Exposure to sea water intrusion with varying degrees has been identified by all the activities except aquaculture. This is mainly due to the fact that around 60 percent of the sampled population reported no exposure to threat to aquaculture from sea water intrusion. However, the response range varies from 0 to 0.67 (once in every 2 months). It is also evident from the table that flooding due to heavy rainfall is not a concerning issue for almost all economic activities, though the minimum and maximum values of the score are between 0.00 to 0.83 (one to two times every month) . Only one individual of the total 113 interviewed reported high exposure (0.83) due to flooding from heavy rainfall. Inadequate rainfall is not reported as threat at all by any of the economic activity covered in this study. Among the anthropogenic threats considered relevant in the study area, exposure to pollution from hotels and restaurants in terms of wastewater discharged on the coast and finally into the sea, has been reported by all the economic activities. Exposure to this threat is the highest for aquaculture (0.83) followed by shell-crafting (0.75). The exposure to pollution due to running of vehicles on the beach, though reported by some activities, is mostly marginal, which could be due to absence of information or the threat has been identified only recently.

The important finding here is that even economic activities that are based on beach recreation like photography and horse-riding on the beach are not exposed to this source of pollution. Economic activity like providing horse-rides on the beach is either not exposed at all or is only marginally exposed and that too could be because of the absence of information on the part of the respondent. One out of the seven professional photographers interviewed on the beach reported increasing exposure (0.50; implying exposure exists from last 3-5 years) on its economic activity due to pollution from vehicles on the beach. Responses from fishermen and aquaculture farmers indicating absence of this driver of threat do not come as a surprise as their economic activity is not directly dependent on the condition of the beach. However a detailed picture of each response under these economic activities reveals some fishermen and aquaculture farmer do consider exposure to pollution as high (0.83; exposure exists for almost 9-10 years now) to very high threat (1.00; exposure exists for more than 10 years now) to their economic activities. Fish drying which is mostly done on the beach, is also not severely impacted from this pollution with 7 out of 10 respondents considering no exposure to this driver of threat another 2 are unable to provide any information, while one respondent considers exposure as very high. Finally, exposure to sand mining on the beach is a marginal concern for the sprawling hotel industry, hawking on the beach, agriculture and fish drying (with 0.17 scale; on account of absence of information on the part of the respondents) though these activities may be directly or indirectly dependent on the condition of the beach. As for the remaining activities exposure to sand mining does not exist with most responses in the range between 0.00 to 0.17. Exceptions are activities like , motorised van driving (0.00 to 0.83), photography on beach (0.00 to 0.67), fish drying (0.00 to 0.5), agriculture (0.00 to 1.00) and hotel industry (0.00 to 0.83).

Table: 5 Exposure to threats (median values of the scores)

Threat	**Economic activity**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Natural							
Coastal storms	0.00	0.00	0.00	0.50	0.00	0.08	0.00
Sea water intrusion	0.17	0.83	0.83	0.33	0.42	0.25	0.25
Flooding due to heavy rainfall	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Inadequate rainfall	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coastal erosion	0.5	0.83	0.83	0.75	0.50	0.83	0.50
Overall*	**1.00**	**1.50**	**1.67**	**1.42**	**1.00**	**1.08**	**1.17**

Anthropogenic							
Wastewater from hotels and restaurants	0.17	0.58	0.67	0.17	0.17	0.75	0.17
Running of petrol or diesel vehicles on the beach	0.17	0.08	0.00	0.00	0.17	0.42	0.17
Sand mining on the beach	0.00	0.00	0.00	0.00	0.17	0.00	0.08
Overall**	**0.33**	**0.67**	**1.00**	**0.33**	**0.50**	**1.25**	**0.50**

Note: Score **0**- no exposure due to absence of threat, **0.166**- exposure is marginal due to absence of information or the exposure is recent,**0.33**- Exposure to some extent as the threat exists from the last 3-5 years or time interval of the threat is 1-2 times every year / once in 4 years, **0.5**- Exposure increasing as the existence of threat increases to 6-8 years or the time interval of the threat decreasing further to once in 3 years/once in 3 months , **0.66**- Exposure to the threat exists even after 9-10 years or the frequency of occurrence is high over a short period (alternate years/once in every 2 years), **0.83**-Exposure is high over a short period or the exposure exists for a long period now (more than 10 years) , **1**-Exposure is very high over a short period (3-4 times in a month/ multiple times in a year).

* the overall exposure score ranges from 0 to 5 with 0 no exposure to 5 very high exposure
**the overall exposure score ranges from 0 to 3 with 0 no exposure to 3 very high exposure

Table 5: continued….

Threat	**Economic activity**					
	8	**9**	**10**	**11**	**12**	**13**
Natural						
Coastal storms	0.00	0.83	0.17	0.17	0.83	0.00
Sea water intrusion	0.33	0.17	0.33	0.17	0.00	0.17
Flooding due to heavy rainfall	0.00	0.00	0.00	0.00	0.00	0.00
Inadequate rainfall	0.00	0.00	0.00	0.83	0.00	0.00
Coastal erosion	0.83	0.50	0.50	0.83	0.33	0.17
Overall	**1.17**	**1.50**	**1.50**	**1.17**	**1.00**	**0.33**
Anthropogenic						
Wastewater from hotels and restaurants	0.50	0.17	0.17	0.17	0.83	0.17
Running of petrol or diesel vehicles on the beach	0.00	0.00	0.00	0.17	0.00	0.17
Sand mining on the beach	0.00	0.00	0.17	0.17	0.00	0.17
Overall	**0.67**	**0.50**	**0.50**	**0.50**	**0.67**	**0.50**

Table 6 highlights the sensitivity of various economic activities to both natural and anthropogenic threats. Responses are based on the perception of the individuals pursuing these activities. Four natural threats are considered in the sensitivity assessment. It is seen that in some cases sensitivity is dependent on the exposure to the drivers of threats. In other

words, sensitivity is not entirely based on the exposure but also on the perception of the respondents about the impact of drivers of threats on their economic activity. Most of the activities (and in some cases almost all the activities) are sensitive to almost all the threats except flooding due to heavy rainfall (with most responses either 0.00 or 0.25). The score range, however, lies between 0.00 to 1.00. Coastal storms impact manual fishing and agriculture the most (0.75) while hotel industry, deep sea fishing, photography on beach and motorized van driving are not impacted (0.00) by this threat. The individual assessment of each of these activities reveal that the minimum and maximum scale values for motorised van driving, photography on beach, deep sea fishing and hotel industry are 0.00 to 1.00, 0.00 to 0.5, 0.00 to 1.00, and 0.00 to 0.75, respectively. However, sea water intrusion during high tide seems to be impacting almost 9 out of 13 activities with different intensities (ranging from 0.50 to 0.75) though the sensitivity is only marginal to medium and in the remaining cases none at all (0.00 to 0.25). Here again there are cases with 0.00 score that have reported no sensitivity due to absence of threat and those with 0.25 score that are not impacted by the threat. One out of 9 agriculturalists interviewed reported very significant impact of sea water intrusion on agriculture, 2 reported medium impact, while 1 reported marginal impact. Based on median value scores, it can be said that in all 6 economic activities are marginally impacted from coastal storms. The remaining are either not impacted or the extent of impact cannot be known. Sensitivity to anthropogenic threats is mostly negligible or is absent since the threats are not considered to exist in most cases and in other where they exist, they have no impact on the economic activity. A further exploration reveals the score range for each economic activity across all the three anthropogenic threats. For instance, the score range for manual van driving is between (0.00-0.75) , motorised van driving (0.00-0.25), photography on beach (0.00-1.00), horse-riding on beach (0.00-0.50), hawking in and around beach (0.00-0.75), shell-crafting (0.00-0.25), fishing using mechanised boats (0.00-1.00), deep sea fishing (0.00-0.75), fishing using manual boats (0.00-1.00), fish drying (0.00-1.00), agriculture (0.00-0.75), aquaculture (0.00-1.00) and hotel industry (0.00-1.00).

Table: 6 Sensitivity assessment of various economic activities (based on median values of the scale)

Threat	**Economic activity**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
natural							
Coastal storms	0.25	0.00	0.00	0.62	0.50	0.25	0.50
Sea water intrusion	0.50	0.25	0.75	0.75	0.75	0.62	0.75

Flooding due to heavy rainfall	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coastal erosion	0.25	0.25	0.75	0.75	0.37	0.62	0.75
Overall*	**1.25**	**0.87**	**1.5**	**2.12**	**1.5**	**1.75**	**2.00**
Anthropogenic							
Wastewater from hotels and restaurants	0.25	0.25	0.37	0.25	0	0.25	0.00
Running of petrol or diesel vehicles on the beach	0.00	0.00	0.12	0.00	0	0.25	0.00
Sand mining on the beach	0.00	0.00	0.00	0.00	0	0.00	0.00
Overall**	**0.25**	**0.25**	**0.5**	**0.25**	**0.12**	**0.5**	**0.12**

Note: Scales: **0**- absence of sensitivity since threat does not exist, **0.25**- no impact on the economic activity, absence of sensitivity, **0.50-** sensitivity is marginal, **0.75**-medium impact on the economic activity, **1.00**- very significant impact.

* the overall sensitivity score ranges from 0 to 4 with 0 no sensitivity to 4 very high sensitivity
**the overall sensitivity score ranges from 0 to 3 with 0 no sensitivity to 3 very high sensitivity

Table 6: continued….

Threat	**Economic activity**					
	8	**9**	**10**	**11**	**12**	**13**
Natural						
Coastal storms	0.00	0.75	0.50	0.75	0.25	0.00
Sea water intrusion	0.25	0.50	0.50	0.00	0.50	0.25
Flooding due to heavy rainfall	0.00	0.00	0.00	0.00	0.00	0.00
Coastal erosion	0.25	0.25	0.50	0.50	0.25	0.25
Overall	**0.75**	**1.50**	**1.75**	**2.00**	**1.25**	**0.75**
Anthropogenic						
Wastewater from hotels and restaurants	0.25	0.00	0.00	0.00	0.75	0.00
Running of petrol or diesel vehicles on the beach	0.00	0.00	0.00	0.00	0.00	0.00
Sand mining on the beach	0.00	0.00	0.00	0.00	0.00	0.00

Threat	Economic activity					
Overall	**0.25**	**0.00**	**0.00**	**0.00**	**0.75**	**0.25**

Table 7 is based on the risk perception of individuals pursuing different economic activities. From a wide range of risks mentioned in the questionnaire, four risk types are considered relevant from an economic activity perspective. These risks are: asset loss (shop loss/Van loss/boat loss, etc.), Income loss, risk to lives and health risk. Higher the scale greater is the risk. Given these risk types, such an assessment for anthropogenic threats is not considered meaningful, hence risk is assessed vis-à-vis natural threats only. Majority of economic activities are not associated with high levels of four risk types, considered in this analysis, in the event of an occurrence of any of the identified threats. Economic activities reporting no risk from coastal storms are manual van driving (range of the scale is between 0-1.75), motorised van driving (scale range 0- 2.5), photography on beach (scale range 0-2), hawking on the beach (scale range 0-1.75), deep sea fishing (scale range 0-2.25) and hotel industry (0.1.75). Similarly, aquaculture farmers have reported absence of risks from sea water intrusion though, the scale ranges from 0 to 1. The next driver of threat; flooding due to heavy rainfall does not result to any risk for almost all the activities with the exception of motorised van driving (scale range 0-1.25), fishing using manual boats (scale range 0.2.25), and agriculture (scale range 0-1.5). Inadequate rainfall does not lead to any kind of risk for almost all the activities, exception being agriculture (scale range 0-1).

Table 7: Risk to different economic activities (median values)

Threat	Economic activity						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Natural							
Coastal storms	0.00	0.00	0.00	1.62	0.00	0.50	0.50
Sea water intrusion	1.50	1.00	1.50	1.50	1.50	1.25	1.12
Flooding due to heavy rainfall	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Inadequate rainfall	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coastal erosion	1.50	1.00	1.00	1.25	1.00	1.37	1.00

Note: Scale- 0 to 4 with 0- absence of threats hence no risk and 4- very significant risk.

Table 7: continued…..

Threat	Economic activity					
	8	**9**	**10**	**11**	**12**	**13**
Natural						
Coastal storms	0.00	1.50	1.75	1.25	1.00	0.00
Sea water intrusion	1.5	1.25	1.75	1.00	0.00	1.00
Flooding due to heavy rainfall	0.00	0.00	0.00	0.00	0.00	0.00
Inadequate rainfall	0.00	0.00	0.00	0.00	0.00	0.00
Coastal erosion	1.00	1.00	1.00	1.00	1.00	1.00

Using the information from tables 5, 6 and 7, vulnerability of various economic activities to different threats is examined in table 8. Vulnerability is assessed for both natural and anthropogenic threats though the scores are different depending on the number of threats within these two broad categories. The vulnerability levels across all economic activities been studied are quite low; in some cases close to insignificant vulnerability. The lowest score is reported by the hoteliers followed by manual van rickshaw drivers while horse riding on the beach has reported the highest relative vulnerability levels. Factoring in risk does not change the overall results, since the risk to all the natural threats combined together is mostly 0 implying absence of four risk types associated with different natural threats.

However, if risk is separately looked into through all the indicators identified apart from the four indicators used in risk analysis for vulnerability assessment e.g. asset loss, income loss, unavailability of drinking water, health risk, life loss, crop loss, migration, borrowing money, damage to embankment, roads and other public properties, then it gives a broader perspective. Since it came out from the analysis so far that three major threats to the coastal economic activities are coastal storms, sea water intrusion during high tides and coastal erosion, impact of these three threats can be taken into account to get an in depth view.

Figure 3 displays the percentage distribution of respondents based on impact of loss of several types due to coastal storms. The losses are broadly categorized by taking into account fixed household and occupational asset loss, income loss, health and life loss, migration, lack of availability and access to basic facilities like drinking water, infrastructure. On the other hand the degree of losses are measured on a scale of zero to three where value zero implies no loss and three implies very significant loss. According to Figure 2, due to coastal storms a substantial proportion of the respondents have reported to have experienced very significant loss of fixed asset (more than 20percent of the respondents)

and income (more than 17percent of the respondents). Whereas the highest category of loss is faced by less than 5percent of respondents in case of other assets, health, death, migration. Also none have reported to have very significant occupational change loss due to coastal storms. Losses of life, other assets, health, migration, occupational change have been reported as “no loss” by more than 90percent of the respondents. Around 20percent of the respondents have experienced marginal to very significant loss of fixed assets and income.

Table: 8 Assessment of vulnerability of different economic activities with and without risk (based on median values)

	Economic activity						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Vulnerability (Natural threats)[1]							
Exposure x Sensitivity (median value)	**1.04**	**1.42**	**2.50**	**3.00**	**1.42**	**1.31**	**2.48**
Vulnerability [2] (Anthropogenic threats)							
Exposure x Sensitivity	**0.08**	**0.17**	**0.67**	**0.17**	**0.06**	**0.63**	**0.10**
Risk (natural threats)[3]	0	0	0	0.5	0	0	0
Vulnerability x Risk (Natural threats)[4]	**0.001***	**0.001***	**0.001***	**1.5**	**0.001***	**0.001***	**0.001***

Notes: 1- Vulnerability ranges from 0 to 20 depending upon the number of threats considered in estimating exposure and sensitivity with 0- absence of threats hence no vulnerability and 20- very significant vulnerability.
2- Vulnerability ranges from 0 to 9 with 0- absence of threats hence no vulnerability and 9- very significant vulnerability
3- Risk ranges from 0 to 4 with 0- absence of threats hence no risk and 4- very significant risk.
4-Vulnerability is very small since risk is zero

Table 8: continued..

	Economic activity					
	8	**9**	**10**	**11**	**12**	**13**
Vulnerability (Natural threats)[1]						
Exposure x Sensitivity (median value)	**0.75**	**2.00**	**1.75**	**2.00**	**1.67**	**0.38**
Vulnerability [2] (Anthropogenic threats)						

Exposure x Sensitivity	**0.17**	**0.00**	**0.00**	**0.00**	**0.25**	**0.00**
Risk (natural threats)[3]	0.00	1.00	0.00	0.00	0.00	0.00
Vulnerability x Risk (Natural threats)[4]	**0.001***	**2.00**	**0.001***	**0.001***	**0.001***	**0.001***

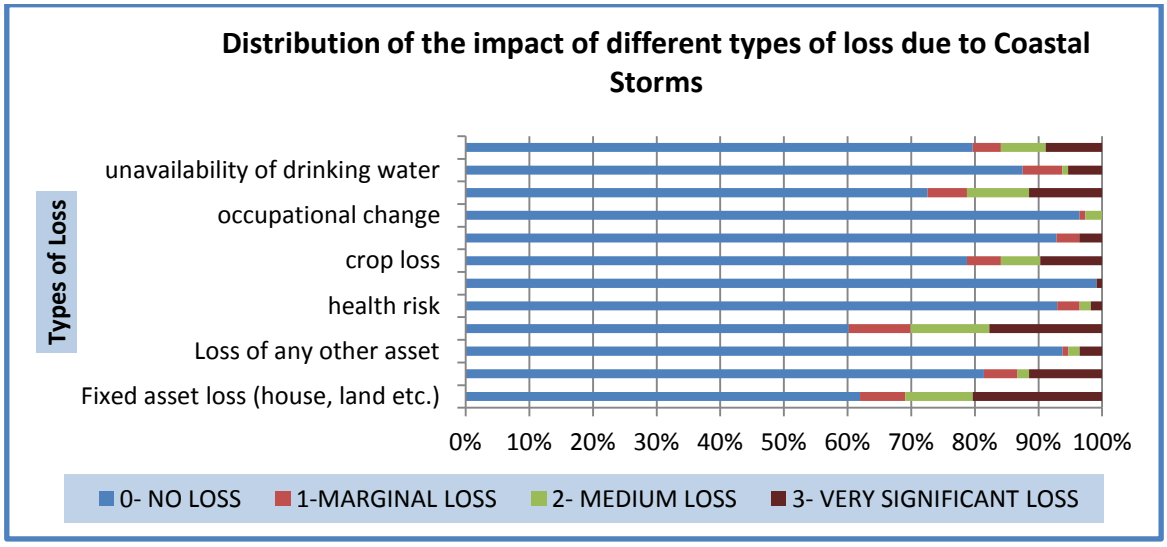


Figure 3: Distribution of the impact of different types of losses due to coastal storms

As per figure 4, sea water intrusion during high tides has led to very significant loss of roads, embankments and other public resources according to more than 20 percent of the respondents and it is followed by lesser number of very significant losses to income, occupational assets and fixed assets. From the responses it is found that sea water intrusion during high tides has not claimed any life, and more than 90 percent of the respondents have reported that it has not led to any loss of health, loss of assets other than fixed and occupational assets, occupational change. Loss at any degree ranging from marginal to very significant has been experienced by close to 50 percent of the respondents in case of income, roads, and embankment loss. Loss at any degree ranging from marginal to very significant has been experienced by close to 30 percent of the respondents in case of fixed assets, occupational assets, borrowing money.

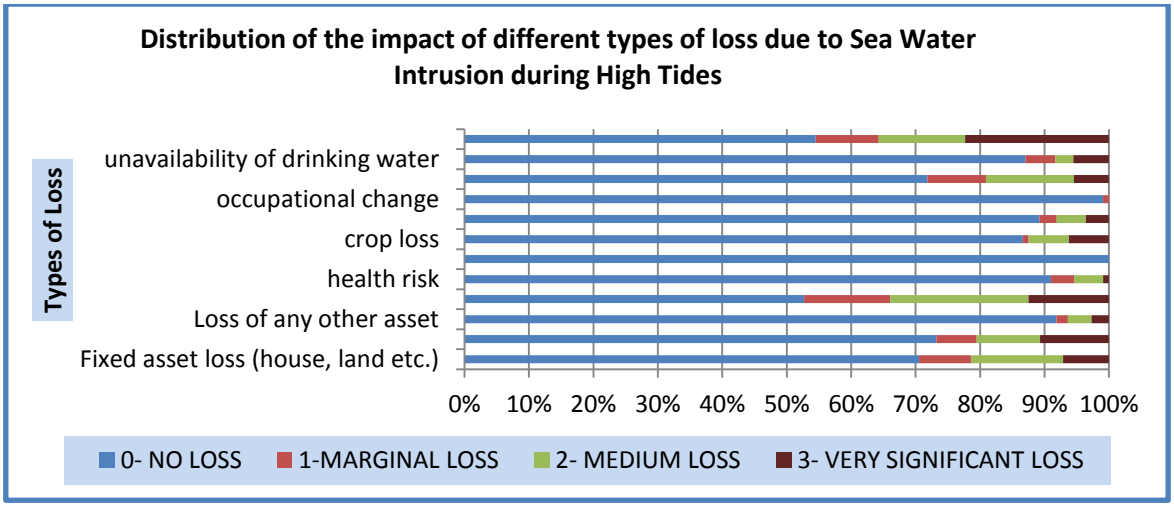


Figure 4: Distribution of the impact of different types of losses due to sea water intrusion during high tides

Figure 5 displays distribution of the impact of different types of loss due to coastal erosion. From the responses it is found that coastal erosion does not have any impact on life risk and occupational change and it has impacted less than 10 percent of the respondents in terms of unavailability of drinking water, migration, crop loss, health risk and asset loss other than fixed and occupational asset. More than 10 percent of the respondents have incurred very significant losses in terms of loss of roads, embankments and other public resources due to coastal erosion while another 10 percent have suffered from fixed and occupational assets loss.

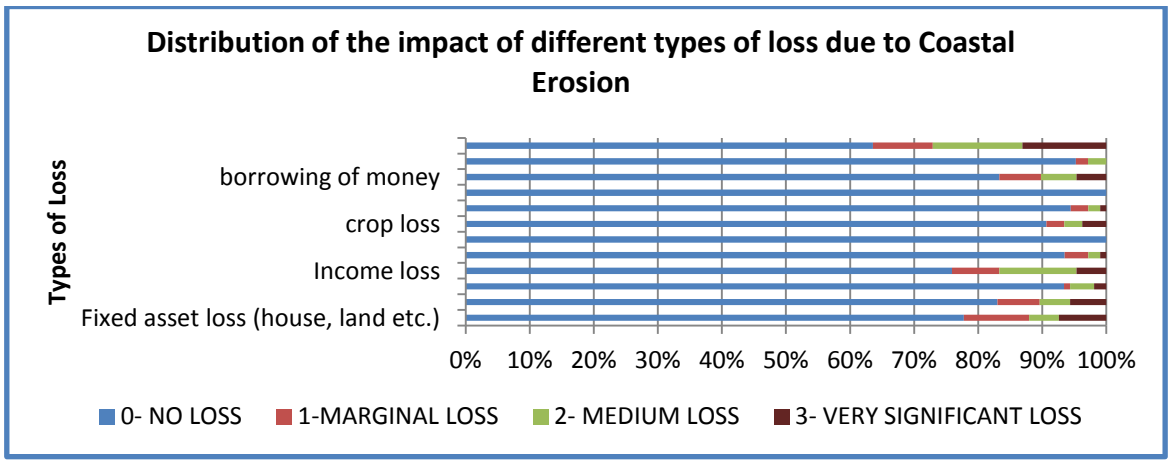


Figure 5: Distribution of the impact of different types of losses due to coastal erosion

For an overall risk scenario, categorization of loss due to different threats was done where all the indicators of risk or loss incurred were considered. The levels of risk that coastal economic activities are exposed to can also be found out through a quantitative assessment.

The focus here is to find out the annual average monetary loss as a percentage of current annual income of the respondents and categorize those to get percentage distribution of individuals across all the coastal economic activities (as identified previously).

The methodology followed to calculate percentage of annual loss to annual income for tables 9, 10 and 11 is as follows. From the data on recall period of loss (RP) measured in number of years, number of times the loss occurred for each of the risk indicators (say N1, N2, N3 for indicators 1, 2, 3 respectively) and monetary loss (in Rs.) incurred each time (say M1, M2, M3 for indicators 1, 2, 3 respectively) we use the following formulae to calculate average annual monetary loss (AML):

AML= {(M1*N1) + (M2*N2) + (M3*N3)}/RP

For the average annual monetary loss calculation, from among the 12 indicators of risk, we take into account only: fixed household asset loss, occupational asset loss, other asset loss, income loss, health loss and crop loss since monetary values are available only these types of losses. Next the average annual income of the respondents (which is an aggregate of primary and secondary occupations) is calculated and finally average annual monetary loss as a percentage of annual income of respondents is calculated. This exercise was done for three major threats in Digha- Sankarpur study area only. These threats are: coastal Storms, sea water intrusion during high tides and coastal erosion.

Table 9: Percentage distribution of respondents across economic activities based on percentage of income loss due to coastal storms

	Categories Percentage of annual average monetary loss to annual individual income							
Economic Activity	**0 % LOSS**	**1 to 8 % LOSS**	**9 to 20 % LOSS**	**21 to 40 % LOSS**	**41 to 60 % LOSS**	**61to 80 % LOSS**	**More than 80 % LOSS**	**Total**
Manual van driving	66.67	-	22.22	11.11	-	-	-	100
Motorized van driving	62.50	12.50	-	12.50	-	12.50	-	100
Photography on the beach	71.43	14.29	-	14.29	-	-	-	100
Horse-riding on the beach	25.00	25.00	25.00	25.00	-	-	-	100
Hawking on and around the beach	72.22	-	5.56	-	11.11	-	11.11	100
Shell-Crafting	50.00	25.00	-	-	-	-	25.00	100
Fishing using mechanized boats	69.23	7.69	7.69	-	7.69	-	7.69	100

	Categories Percentage of annual average monetary loss to annual individual income							
Economic Activity	**0 % LOSS**	**1 to 8 % LOSS**	**9 to 20 % LOSS**	**21 to 40 % LOSS**	**41 to 60 % LOSS**	**61to 80 % LOSS**	**More than 80 % LOSS**	**Total**
Deep sea fishing using trawlers	60.00	-	20.00	-	-	-	20.00	100
Fishing using manual boats	33.33	11.11	22.22	-	33.33	-	-	100
Fish drying	40.00	20.00	20.00	-	-	-	20.00	100
Agriculture	33.33	11.11	22.22	22.22	-	-	11.11	100
Aquaculture	50.00	25.00	-	25.00	-	-	-	100

It is seen in table 9, that more than 60 percent of the respondents from economic activities: agriculture, fish drying, fishing using manual boats, and horse riding on beach have experienced monetary losses due to coastal storms while it is around 50 percent of the respondents engaged in shell-crafting and aquaculture that have incurred monetary losses. As for the rest of the economic activities the figure ranges from a little less than 30percent to 40percent of the respondents. Based on the responses it is found that although around 70percent of the hawkers on and near beach are not affected by coastal storms in terms of monetary loss but around 12percent have experienced monetary losses that is more than 80percent of their annual income. Among other economic activities, 8 to 25percent of the respondents from each of the activities shell crafting, fishing using mechanized boats, deep sea fishing using trawlers, fish drying and agriculture have reported to have experienced monetary losses that is more than 80percent of their annual income. More than 20percent of the respondents from manual van driving, horse riding on beach, deep sea fishing using trawlers, fishing using manual boats, fish drying and agriculture have incurred 9 to 20percent annual monetary loss out of annual income due to coastal storms. More or less all the economic activities as specified in table 9, apart from aquaculture, horse riding and photography on beach have experienced high degrees of variability in income loss due to coastal storms.

Table 10: Percentage distribution of respondents across economic activities based on percentage of income loss due to sea water intrusion during high tides

	Categories Percentage of annual average monetary loss to annual individual income							
Economic Activity	**0 % LOSS**	**1 to 8 % LOSS**	**9 to 20 % LOSS**	**21 to 40 % LOSS**	**41 to 60 % LOSS**	**61to 80 % LOSS**	**More than 80 % LOSS**	**Total**
Manual van driving	33.33	44.44	-	-	22.22	-	-	100
Motorized van driving	62.50	12.50	12.50	12.50	-	-	-	100
Photography on the beach	14.29	57.14	14.29	-	14.29	-	-	100
Horse-riding on the beach	-	75.00	-	25.00	-	-	-	100
Hawking on and around the beach	38.89	16.67	16.67	22.22	-	5.56	-	100
Shell-Crafting	50.00	-	25.00	-	-	25.00	-	100
Fishing using mechanized boats	46.15	46.15	-	-	-	7.69	-	100
Deep sea fishing using trawlers	40.00	20.00	20.00	-	-	20.00	-	100
Fishing using manual boats	66.67	22.22	-	11.11	-	-	-	100
Fish drying	40.00	20.00	20.00	10.00	10.00	-	-	100
Agriculture	66.67	11.11	22.22	-	-	-	-	100
Aquaculture	100.00	-	-	-	-	-	-	100

Table 10 shows the distribution of individuals involved in a particular economic activity based on percentage of annual monetary loss due to sea water intrusion during high tides as a share of annual individual income. Due to sea water intrusion during high tides none of the respondents from aquaculture have reported to have experienced monetary loss. On the other hand, respondents from horse riding on beach have faced some amount of loss. Some respondents from activities like hawking on and near beach, shell-crafting, fishing using mechanized boats, deep sea fishing using trawlers have faced monetary loss that ranges from 61 to 80percent of annual income due to sea water intrusion during high tides. More than 50percent of the respondents from motorized van driving, shell-crafting, fishing using manual boats and agriculture have experienced no monetary loss due to sea water intrusion during high tides.

Table 11: Percentage distribution of respondents across economic activities based on percentage of income loss due to coastal erosion

	Categories Percentage of annual average monetary loss to annual individual income							
Economic Activity	**0 % LOSS**	**1 to 8 % LOSS**	**9 to 20 % LOSS**	**21 to 40 % LOSS**	**41 to 60 % LOSS**	**61to 80 % LOSS**	**More than 80 % LOSS**	**Total**
Manual van driving	25.00	62.50	12.50	-	-	-	-	100
Motorized van driving	71.43	-	14.29	14.29	-	-	-	100
Photography on the beach	42.86	57.14	-	-	-	-	-	100
Horse-riding on the beach	50.00	25.00	-	-	-	-	25.00	100
Hawking on and around the beach	62.50	6.25	12.50	6.25	6.25	-	6.25	100
Shell-Crafting	50.00	-	-	-	-	-	50.00	100
Fishing using mechanized boats	63.64	9.09	18.18	-	-	9.09	-	100
Deep sea fishing using trawlers	80.00	-	-	-	-	-	20.00	100
Fishing using manual boats	62.50	12.50	-	25.00	-	-	-	100
Fish drying	80.00	10.00	-	-	10.00	-	-	100
Agriculture	55.56	22.22	22.22	-	-	-	-	100
Aquaculture	50.00	50.00	-	-	-	-	-	100

It is seen from table 11, that due to coastal erosion more than 70 percent of the respondents engaged in motorized van driving, deep sea fishing in trawlers, fish drying respectively are not affected in terms of monetary loss. On the other hand, coastal erosion has caused monetary loss to some degree of 50 and above to the respondents from activities like manual van driving, photography on beach, horse riding on beach, shell crafting and aquaculture. Some of the respondents from activities horse riding on beach, hawking on and near beach, shell crafting, deep sea fishing using trawlers are in the highest loss category (annual monetary loss of 80percent and above to annual income). None of the respondents from manual van driving, photography on beach, agriculture and aquaculture have experienced more than 20percent monetary loss. More than 20percent of the respondents from fishing using manual boats, deep sea fishing using trawler, shell-crafting, hawking on and near beach and horse riding on beach have reported to have incurred annual monetary loss that is more than 20percent of annual income.

Bangladesh: Cox's Bazar-Moheshkhali

The major threats from the perspective of individuals following different economic activities in Cox's Bazar-Moheshkhali are illustrated in table 12. From the Table, coastal storms followed by sea water intrusion and flooding due to heavy rain are the major natural threats that the coastal community of Cox's Bazar-Moheshkhali is facing. Around 49 percent of the sampled population opined that coastal storms are a major threat for the coastal community. Seawater pollution as a result of wastewater discharged from hotels and restaurants and running of petrol or diesel vehicles on the sea beach are two important anthropogenic threats that are regarded as major concerns for the coastal community. Coastal storm is a major threat to all the economic activities. However, salt-shrimp farming is most affected (table12). Seawater intrusion affects agriculture, salt-shrimp farming and fish drying equally (50 percent), while such impact was least on hoteliers and none on other activities. Flooding due to heavy rainfall impacts the most salt-shrimp farming, while inadequate rainfall affects agriculture similarly (75 percent). Coastal erosion has little impact on hoteliers as erosion of sea beach area is quite common. Wastewater pollution and running of vehicles impacts tourism and fishing sectors the most. These two threats are also fair issues of concern for agriculture and fish drying. Besides, sand mining have little impact on hotel industry and agriculture.

Table 12: Identification of threats (natural and anthropogenic) to economic activities in Cox's Bazar-Moheshkhali

S.No.	Threats	Percentage response
	Natural:	
1	Coastal storms	48.72
2	Sea water intrusion during high tide	21.79
3	Flooding due to heavy rainfall	15.38
4	Inadequate rainfall	10.26
5	Coastal erosion	5.13
	Anthropogenic:	
6	Wastewater from hotels and restaurants polluting the coast and the seawater	20.51
7	Running of petrol or diesel vehicles on the beach resulting in the pollution of the beach	19.23
8	Sand mining	7.69

Table 13: Threats (natural and anthropogenic) to different economic activities in Cox's Bazar-Moheshkhali (percentage response)

Threat	Economic activity							
	1	2	3	4	5	6	7	8
Natural								
Coastal storms	62.50	57.14	75.00	25.00	41.67	50.00	33.33	50.00

Sea water intrusion	50.00	0.00	50.00	25.00	50.00	0.00	0.00	0.00
Flooding due to heavy rainfall	25.00	0.00	75.00	0.00	33.33	0.00	0.00	0.00
Inadequate rainfall	75.00	14.29	0.00	0.00	0.00	0.00	0.00	0.00
Coastal erosion	0.00	0.00	0.00	33.33	0.00	0.00	0.00	0.00
Anthropogenic								
Wastewater from hotels and restaurants	0.00	71.43	0.00	33.33	16.67	0.00	0.00	0.00
Running of petrol or diesel vehicles on the beach	25.00	57.14	0.00	25.00	16.67	0.00	0.00	0.00
Sand mining on the beach	25.00	0.00	0.00	33.33	0.00	0.00	0.00	0.00

Note: Economic activity 1 refers to agriculture, 2- fishing, 3-salt shrimp,4-hotel and restaurants, 5-fish drying, 6-hawking,7-photography, 8- shop business

Exposure to both natural and anthropogenic threats is assessed for all the eight economic activities identified in Cox's Bazar-Moheshkhali site. The intensity of exposure depends on the frequency of occurrence of different threats on a varying time scale. In general, exposure to various natural threats is higher in salt-shrimp farming (0.67). This is fact that the whole coastline is exposed to cyclone and storm surges and the earthen dykes are poorly constructed to protect the area. On the other hand, exposure to anthropogenic threats is higher for hotel industry (0.58), presumably the sector is a rapidly growing for the development of tourism (Table 14). The occurrence of coastal storms has a significant impact on salt-shrimp farming (0.92), and fishing and fish drying activities (0.75). Exposure to sea water intrusion is high for salt-shrimp farming (0.75) and fish drying (0.50), while it is not a threat for fishing (0.00). Exposure to sea water intrusion with varying degrees has been also identified by agriculture and hotel and restaurants activities. Flooding due to heavy rain has high impact on salt-shrimp farming, agriculture and least impact on fishing, fish drying and hotel industry. Inadequate rainfall considerably increases soil salinity and consequently has much adverse impact on agriculture, and marginally impact on salt-shrimp farming. Exposure to coastal erosion has considerable adverse effects on agriculture and hotel industry and marginal impacts on salt-shrimp farming and fish drying. Among the anthropogenic threats, exposure to pollution from hotels and restaurants in terms of wastewater discharged on the coast and finally into the sea, has been reported by four economic activities. Due to exposure to this threat, the most affected one is hotel industry followed by agriculture, salt-shrimp farming and fishing. The exposure to pollution due to running of vehicles on the beach is a great concern for hotel industry and fishery sector,

marginal concern for agriculture, salt-shrimp, fish drying and shop business. Finally, exposure to sand mining on the beach is a minor concern for hotel industry and agriculture.

Table: 14 Exposure to threats (median values of the scale)

Threat	Economic activity							
	1	2	3	4	5	6	7	8
Natural								
Coastal storms	0.42	0.75	0.92	0.42	0.75	0.50	0.33	0.50
Sea water intrusion	0.33	0.00	0.75	0.33	0.50	0.00	0.00	0.00
Flooding due to heavy rainfall	0.58	0.33	0.67	0.33	0.33	0.00	0.00	0.33
Inadequate rainfall	0.92	0.00	0.50	0.00	0.00	0.00	0.00	0.00
Coastal erosion	0.58	0.00	0.33	0.58	0.33	0.00	0.00	0.33
Overall	**0.50**	**0.50**	**0.67**	**0.33**	**0.50**	**0.50**	**0.33**	**0.33**
Anthropogenic								
Wastewater from hotels and restaurants	0.58	0.42	0.50	0.83	0.00	0.00	0.00	0.00
Running of petrol or diesel vehicles on the beach	0.33	0.50	0.33	0.75	0.33	0.00	0.00	0.33
Sand mining on the beach	0.17	0.00	0.00	0.33	0.00	0.00	0.00	0.00
Overall	**0.33**	**0.50**	**0.33**	**0.58**	**0.33**	**0.00**	**0.00**	**0.33**

Note: Score 0- no exposure due to absence of threat, 0.166- exposure is marginal due to absence of information or the exposure is recent,0.33- Exposure to some extent as the threat exists from the last 3-5 years or time interval of the threat is 1-2 times every year / once in 4 years, 0.5- Exposure increasing as the existence of threat increases to 6-8 years or the time interval of the threat decreasing further to once in 3 years/once in 3 months , 0.66- Exposure to the threat exists even after 9-10 years or the frequency of occurrence is high over a short period (alternate years/once in every 2 years), 0.83-Exposure is high over a short period or the exposure exists for a long period now (more than 10 years) , 1-Exposure is very high over a short period (3-4 times in a month/ multiple times in a year).

Table 15 highlights the sensitivity of various economic activities to both natural and anthropogenic threats. Responses are based on the perception of the individuals pursuing these activities. All the five natural threats are considered in the sensitivity assessment. It reveals that all the activities are sensitive to natural threats, while some of the activities are found absence of sensitivity to specific anthropogenic threats. Overall, natural threats are more sensitive to agriculture and salt-shrimp farming (0.75) than other activities, while anthropogenic threats are sensitive to hotel industry (0.63). Coastal storm has very significant impact on the sensitivity of salt-shrimp farming and fish drying (1.00). Similar impact is also reported for salt-shrimp farming due to sea water intrusion. Sensitivity to flooding due to heavy rain or inadequate rainfall ranges from marginal to medium on agriculture and salt-shrimp farming and fish drying. Coastal erosion has no impact on any

economic activity indicating absence of sensitivity. Sensitivity to anthropogenic threats is mostly negligible or is absent since the threats are not considered to exist in most cases and in other where they exist, they have no impact on the economic activity. However, wastewater from hotels and restaurants is reported significant impact on hotel industry, and marginal impact on fishing, fish drying and shop business. Pollutions from running vehicles on the beach is also reported significant impact on hotel industry and fishing.

Table: 15 Sensitivity assessment of various economic activities (based on median values of the scale)

Threat	Economic activity							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Natural								
Coastal storms	0.75	0.88	1.00	0.50	1.00	0.50	0.50	0.75
Sea water intrusion	0.88	0.50	1.00	0.50	0.63	0.50	0.50	0.75
Flooding due to heavy rainfall	0.75	0.25	0.75	0.25	0.50	0.25	0.25	0.25
Inadequate rainfall	0.88	0.25	0.50	0.25	0.50	0.25	0.25	0.25
Coastal erosion	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Overall	**0.75**	**0.50**	**0.75**	**0.50**	**0.50**	**0.50**	**0.25**	**0.50**
Anthropogenic								
Wastewater from hotels and restaurants	0.00	0.50	0.00	1.00	0.50	0.25	0.25	0.50
Running of petrol or diesel vehicles on the beach	0.00	0.50	0.00	0.75	0.25	0.25	0.25	0.25
Sand mining on the beach	0.25	0.00	0.00	0.25	0.25	0.25	0.25	0.25
Overall	**0.25**	**0.50**	**0.00**	**0.63**	**0.25**	**0.25**	**0.25**	**0.50**

Scales: 0- absence of sensitivity since threat does not exist, 0.25- no impact on the economic activity, absence of sensitivity, 0.50- sensitivity is marginal, 0.75-medium impact on the economic activity, 1.00- very significant impact.

Table 16 is based on the risk perception of individuals pursuing different economic activities. From a wide range of risks mentioned in the questionnaire, four risk types are considered relevant from the perspective of an economic activity. These risks are: asset loss (shop loss/ fishing boat loss, etc.), income loss, risk to lives and health risk. Higher the scale greater is the risk. Given these risk types, such an assessment for anthropogenic threats is not considered meaningful, hence risk is assessed vis-à-vis natural threats only. Majority of economic activities are not associated with high levels of four risk types, except in the field of agriculture and fishery , where coastal storm is considered as very significant risk. Coastal

storm is also exhibited as medium risks for salt-shrimp farming, hotel industry, fish drying and shop business. Among other threats inadequate rainfall is also a considerable risk for agriculture and flooding due to heavy rainfall is medium risk for salt-shrimp farming.

Using the information from Tables 14-16, vulnerability of various economic activities to different threats is examined in Table 17. Vulnerability is assessed for both natural and anthropogenic threats though the scales are different depending on the number of threats within these two broad categories. The vulnerability levels across all economic activities been studied are quite low; in some cases close to insignificant vulnerability. The lowest score is reported by the photography followed by hoteliers and hawking, while the highest relative vulnerability levels have reported by the agriculture followed by salt-shrimp farming. Factoring in risk does not change the overall results, since the risk to all the natural threats combined together is mostly closed to 1 implying existing of very marginal risk types associated with different natural threats.

Table 16: Risk to different economic activities (median values)

Threat	**Economic activity**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Natural								
Coastal storms	4.0	4.0	3.0	3.0	3.0	2.0	2.0	3.0
Sea water intrusion	2.5	0.0	2.5	2.0	2.0	1.0	1.0	1.0
Flooding due to heavy rainfall	2.0	1.0	3.0	1.0	1.0	0.0	1.0	0.0
Inadequate rainfall	3.5	0.0	1.0	1.0	0.0	1.0	0.0	1.0
Coastal erosion	1.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
Overall	**3.0**	**2.0**	**2.0**	**1.5**	**1.5**	**1.0**	**1.0**	**2.0**

Table:17 Assessment of vulnerability of different economic activities with and without risk (based on median values)

Threat	**Economic activity**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Vulnerability (Natural threats)[1]								
Exposure x Sensitivity (median value)	0.38	0.25	0.50	0.17	0.25	0.25	0.08	0.17
Vulnerability [2] (Anthropogenic threats)								
Exposure x Sensitivity	0.08	0.25	0.00	0.37	0.08	0.00	0.00	0.17
Risk (natural threats)[3]	3.0	2.0	2.0	1.5	1.5	1.0	1.0	2.0
Vulnerability x Risk (Natural threats)[4]	1.13	0.50	1.01	0.25	0.38	0.25	0.08	0.33

Notes: 1- Vulnerability ranges from 0 to 20 depending upon the number of threats considered in estimating exposure and sensitivity.

2- Vulnerability ranges from 0 to 9
3- Risk ranges from 0 to 4.
4-Vulnerability is very small since risk is zero

Koggala, Sri Lanka

Table 18 gives the number of persons interviewed in each category of occupation. The highest is in fisheries and the second highest is agriculture, both of which are traditional occupations in the area. Though coir industry is also a traditional industry, the number engaged in this industry has declined. The most popular new economic activity is 3-wheel vehicle driving which has a demand among tourists.

Table 18: Distribution of respondents among occupations

Category	Number of respondents	Response percent
Agriculture	32	26.67
Coir Industry	05	4.17
Fisheries	48	40.0
Handicraft	04	3.34
Restaurant	03	2.5
Three-Wheel Driving	21	17.5
Hotel	7	5.83
Total	120	100

The respondents were requested to indicate what concern or driver they thought was a major threat in pursuing their occupation. This information was collected for different occupations separately. The aggregated results are shown in Table 19, according to which flooding and sea water intrusion during high tide (80 percent) and storms during rains (75 percent) were the two main threats affecting their occupations particularly agriculture. Coastal erosion was considered the next grave threat (43 percent) while inadequate rainfall was also considered a serious threat (37percent). Other concerns such as storms without rain and flooding during rain were not considered as serious threats. The discharge of waste water from hotels and restaurants to the coasts was the only anthropogenic driver considered as a threat.

Table 19: Percentage respondents who identified a particular concern as a threat

Threat	Percentage response

Natural:	
Storms during rains	75
Storms during other seasons	10
Flooding and sea water intrusion during high tide	80
Flooding due to heavy rainfall	20
Inadequate rainfall	37
Coastal erosion and sea approaching closer	43
Anthropogenic:	
Wastewater from hotels and restaurants polluting the coast and the seawater	60

The disaggregated situation among different occupations is shown in Table 20. Coastal storms were identified as a major threat in the fisheries sector (75 percent), while sea water intrusion was identified as a major threat in the fisheries (95 percent), hospitality (55percent) and agriculture (25 percent) sectors. Flooding due to heavy rainfall was considered a major threat in the agriculture sector (83 percent) and to a small extent in the coir industry (15 percent). Both these sectors also considered inadequate rainfall as serious threats, 92 percent and 53 percent, respectively. Coastal erosion was considered as a major threat by fishers (87percent), hotels (82 percent) and restaurants (86 percent). The waste water discharge from hotels was considered as a threat only by fishers (35 percent). The new economic activities including both 3-wheel vehicle driving and handicraft sales were not affected by any of the natural hazards.

Table 20: Respondents who identified a particular concern as a threat in each occupation category (Percentage of total number responded)

Threat	**Economic activity**						
Natural	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Coastal storm	0.00	15.00	0.00	75.00	5.00	5.00	10.00
Sea water intrusion	25.00	0.00	2.00	95.00	0.00	55.00	23.00
Flooding due to heavy rainfall	83.00	0.00	15.00	8.00	0.00	0.00	0.00
Inadequate rainfall	92.00	0.00	53.00	0.00	0.00	0.00	16.00

Coastal erosion	0.00	0.00	0.00	87.00	0.00	82.00	86.00
Anthropogenic	0.00	0.00	0.00		0.00		
Wastewater from hotels & restaurants	0.00	0.00	0.00	35.00	0.00	0.00	0.00

Note: Economic activity 1 refers to agriculture, 2- 3 wheeler driving, 3-coir industry,4-fisheries, 5-handicraft, 6-hotel industry,7-restuarant

Vulnerability Assessment:

Exposure to each threat across different economic activities is assessed by taking the median exposure values for each economic activity. These are tabulated in Table 21. The highest exposure to coastal storms is in the fisheries sector (1.0), followed by the hotels (0.66) and restaurants (0.66). Sea water intrusion also caused the highest exposure of 1.0 in the fisheries (inland) sector, while causing equal exposure of 0.66 in agriculture, coir industry, hotels and restaurants. Flooding due to heavy rainfall caused high exposure of 0.66 in the agriculture sector, followed by the coir industry with an exposure of 0.5 and the fisheries sector with an exposure of 0.33. Coastal erosion cause high exposure of 0.83 in the fisheries sector only. Discharge of waste water from hotels and restaurants also caused high exposure of 1.0 in the fisheries sector.

Table 21: Exposure to different threats Koggala coastal area

Threat	**Economic activity**						
Natural	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Coastal storm	0.00	0.33	0.00	1.0	0.33	0.66	0.66
Sea water intrusion	0.33	0.00	0.33	1.0	0.00	0.33	0.33
Flooding due to heavy rainfall	0.83	0.00	0.33	0.33	0.00	0.00	0.00
Inadequate rainfall	0.66	0.00	0.5	0.33	0.00	0.00	0.00
Coastal erosion	0.00	0.00	0.00	0.83	0.00	0.00	0.00
Anthropogenic							

Wastewater from hotels & restaurants	0.00	0.00	0.00	1.0	0.00	0.00	0.00

Note: Score 0- no exposure due to absence of threat, 0.166- exposure is marginal due to absence of information or the exposure is recent, 0.33- Exposure to some extent as the threat exists from the last 3-5 years or time interval of the threat is 1-2 times every year / once in 4 years, 0.5- Exposure increasing as the existence of threat increases to 6-8 years or the time interval of the threat decreasing further to once in 3 years/once in 3 months , 0.66- Exposure to the threat exists even after 9-10 years or the frequency of occurrence is high over a short period (alternate years/once in every 2 years), 0.83-Exposure is high over a short period or the exposure exists for a long period now (more than 10 years) , 1-Exposure is very high over a short period (3-4 times in a month/ multiple times in a year).

Table 22 gives the sensitivity of various economic activities to both natural and anthropogenic threats. These are highly subjective as the responses are based on the perception of respondents engaged in these economic activities. All the economic activities are sensitive to all the natural events to varying degree ranging from 0.25 to 1.0. The fisheries sector shows the highest sensitivity of 1.0 for coastal storms, sea water intrusion and coastal erosion. The hotel industry also shows high sensitivity of 1.0 for sea water intrusion and coastal erosion. The agriculture sector shows sensitivity to a lesser degree with a maximum of 0.75 against flooding due to heavy rainfall as well as due to inadequate rainfall. Restaurants also show similar sensitivity (0.75) against coastal storms and inadequate rainfall.

Table 22: Sensitivity assessment of various economic activities in Koggala coastal area

Threat	**Economic Activity**						
Natural	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Coastal storm	0.5	0.25	0.25	1.0	0.5	0.75	0.75
Sea water intrusion	0.5	0.25	0.5	1.0	0.25	1.0	0.25
Flooding due to heavy rainfall	0.75	0.25	0.5	0.5	0.25	0.25	0.25
Inadequate rainfall	0.75	0.25	0.25	0.25	0.25	0.25	0.75
Coastal erosion	0.25	0.5	0.25	1.0	0.25	1.0	0.25
Anthropogenic							
Wastewater from hotels & restaurants	0	0	0	0	1.0	0	0

Note: Scales: 0- absence of sensitivity since threat does not exist, 0.25- no impact on the economic activity, absence of sensitivity, 0.50- sensitivity is marginal, 0.75-medium impact on the economic activity, 1.00- very significant impact.

Risk Assessment

Table 23 gives the risks as perceived by respondents engaged in different economic activities. From a wide range of risks mentioned in the questionnaire, only the following four risks are considered from the point of view of different economic activities. These are:

a. Asset loss
b. Income loss
c. Risk to lives
d. Health risk

These are considered against each of the four natural events and the values given by each of the respondents in each economic activity is summed up and a risk index is determined. Higher the scale, greater is the risk. Of the three traditional occupations, the fisheries sector offer some level of risks against all events, whereas the agriculture and coir industry have no risks against coastal storms and coastal erosion as expected. Both the hotels and restaurants have some risk factors against coastal storms and sea water intrusion.

Table 23: Estimated risks to different economic activities (median values)

Threat	**Economic Activity**						
Natural	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Coastal storm	0	1.75	0	1.8	0	1.6	1.6
Sea water intrusion	1.75	0	1.75	1.8	0	1.75	1.75
Flooding due to heavy rainfall	1.5	0	1.75	1.75	0	0	0
Inadequate rainfall	1.7	0	1.0	1.75	0	0	0
Coastal erosion	0	0	0	1.5	0	0	0

Note : Risk ranges from 0-4. 0- no risk due to absence of threats, 1- no impact of threats on income, lives, health and assets, 2- marginal impact of threats on four types of risks identified, 3- medium impact, 4 very significant impact.

Using the information from previous tables, vulnerability of various economic activities to different threats was determined and shown in Table 24.

Table 24: Vulnerability and risks

Threat	**Economic Activity**						
Natural	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Vulnerability (Natural Threats)							
Exposure*Sensitivity	1.73	1.62	0	2.5	0	0	0
Vulnerability (Anthropogenic Threats)							
Exposure*Sensitivity	0	0	0	0	0	0	0
Risk (Natural Threats)	1.5	0	1.0	0	0	0	0
Vulnerability*Risk (Natural Threats)	2.3	0.001	2.0	0.001	0.001	0.001	0.001

Findings of the Supplementary Survey on the Fisheries Sector

Out of the fishers who were interviewed, 84 percent were traditional fishermen and at least 50 percent of them have zero opportunity cost. Apart from traditional fishers, 16 percent of newly involved fishers, engage in fishing due to lack of alternative occupation (68 percent). Fishers involved in offshore fishing are about 72 percent and the rest did fishing only in coastal waters. The latter did not want to spend several days out in deep sea because of the uncertainty in getting a better harvest. Those who were engaged in off-shore fishing used solely multiday boats. The majority of them (40 percent) use gill-net and long-line fishing gear while the next highest category (36 percent) used purse-seine (course) fishing gear.

The impact of banning fishery exports by European Union is highly significant in Dondra, Gandara and Nilwella as they entirely depend on tuna catch. Of all the respondents, 60 percent were affected by the EU ban on Sri Lanka's imports. Almost the entire population (96 percent) of fishers do not have an alternative source of income and they have to solely rely on the income generated from fishing.

The majority of fishers (62 percent) are aware about the standards and criteria that must be maintained in fish harvesting while the others do not have any knowledge on them. Respondents have stated that they ensure the quality of products that they collect but the deterioration of the quality may be due to the selling of their harvest mixed with imported

illegal catches as a whole. To maintain the required standards they do not have any freezer systems which are must in maintaining the quality of the product. The major issues that they have faced are stock depletion probably due to the usage of course-net and unregulated fishing practices by foreign fishing fleets. In addition, the inconsistency of market price for their harvest is another concern.

Objective 2: Historical data on climate parameters in order to predict future scenarios for each specific study sites

As mentioned earlier, long term trends in annual and seasonal-precipitation, maximum and minimum temperatures in all the three study sites at daily time scales have been analyzed to arrive at current baseline climatology and climate change projections. The summary of the country characteristics is shown in Table 24. Area, population density, study period, mean, trend of climate variables and projected change in the climate variables from baseline to midterm have been summarized for the study sites in the table.

Table 24: Overall summary of the study sites of India, Bangladesh and Sri Lanka

Parameter	India (Digha-Sankarpur)	Bangladesh (Cox's Bazaar Sadar-Moheshkhali)	Sri Lanka (Koggala)
Area (sq km)	69	512.8	39
Population Density (persons per sq.km)	636		1250
Cox's Bazar Sadar		2011	
Moheshkhali		887	
Study period			
Temperature	1969-2005 (37 years)	1982-2014 (33 years)	2003-2013 (11 years)
Rainfall	1971-2005 (35 years)	1969-2005 (37 years)	1969-2005 (37 years)
Observed Climate trends			
Maximum Temperature : Mean (°C)			

Parameter	India (Digha-Sankarpur)	Bangladesh (Cox's Bazaar Sadar-Moheshkhali)	Sri Lanka (Koggala)
Annual	31.5	30.2	29.9
Winter (JF)	27.4	27.0	30.1
Pre Monsoon (MAM)	34.9	31.6	30.9
Monsoon (JJAS)	32.6	31.3	29.2
Post Monsoon (OND)	29.4	29.4	29.7
Maximum Temperature : Trend			
Annual	Negative trend (0.6°C /37 years); Statistically significant	Negative trend; Statistically not significant	Negative trend (No appreciable change); Statistically not significant
Winter (JF)	Negative trend (1.1°C /37 years); Statistically significant	Positive trend; Statistically not significant	Negative trend; Statistically not significant
Pre Monsoon (MAM)	Negative trend (0.7°C /37 years); Statistically significant	Positive trend; Statistically not significant	Positive trend; Statistically not significant
Monsoon (JJAS)	Positive trend; Statistically not significant	Negative trend; Statistically not significant	Negative trend; Statistically not significant
Post Monsoon (OND)	Negative trend (0.7°C /37 years); Statistically significant	Negative trend; Statistically not significant	Positive trend; Statistically not significant
Minimum Temperature : Mean (°C)			
Annual	21.8	22.5	25.2
Winter (JF)	15.0	16.2	24.0
Pre Monsoon (MAM)	24.0	23.8	25.8
Monsoon (JJAS)	25.9	25.8	26.0

Parameter	India (Digha-Sankarpur)	Bangladesh (Cox's Bazaar Sadar-Moheshkhali)	Sri Lanka (Koggala)
Post Monsoon (OND)	18.7	21.0	24.5
Minimum Temperature : Trend			
Annual	Positive trend (0.8°C /37 years); Statistically significant	Positive trend (1.2°C /37 years); Statistically significant	Negative trend (1.2°C /11 years); Statistically significant
Winter (JF)	Positive trend (0.8°C /37 years); Statistically significant	Positive trend (1.2°C /37 years); Statistically significant	Negative trend (1.6°C /11 years); Statistically significant
Pre Monsoon (MAM)	Positive trend (0.8°C /37 years); Statistically significant	Positive trend (1.2°C /37 years); Statistically significant	Negative trend ; Statistically not significant
Monsoon (JJAS)	Positive trend (0.8°C /37 years); Statistically significant	Positive trend (0.9°C /37 years); Statistically significant	Negative trend (1.9°C /11 years); Statistically significant
Post Monsoon (OND)	Positive trend; Statistically not significant	Positive trend (1.7°C /37 years); Statistically significant	Negative trend (1.1°C /11 years); Statistically significant
Rainfall : Mean (mm)			
Annual	1746	2814	2200
Winter (JF)	37	19	152
Pre Monsoon (MAM)	218	368	582
Monsoon (JJAS)	1288	2178	694
Post Monsoon (OND)	204	250	764
Seasonal Contribution to annual rainfall			
Winter (JF)	Insignificant	Insignificant	7percent
Pre Monsoon	13percent	13percent	26percent

Parameter	India (Digha-Sankarpur)	Bangladesh (Cox's Bazaar Sadar-Moheshkhali)	Sri Lanka (Koggala)
(MAM)			
Monsoon (JJAS)	74percent	77percent	32percent
Post Monsoon (OND)	12percent	9percent	35percent
Rainfall : trend			
Annual	Positive trend; Statistically significant	Positive trend; Statistically not significant	Negative trend; Statistically not significant
Winter (JF)	Negative trend; Statistically not significant	Negative trend; Statistically not significant	Positive trend; Statistically not significant
Pre Monsoon (MAM)	Positive trend; Statistically not significant	Positive trend; Statistically not significant	Negative trend; Statistically not significant
Monsoon (JJAS)	Positive trend; Statistically not significant	Positive trend; Statistically not significant	Negative trend; Statistically not significant
Post Monsoon (OND)	Positive trend; Statistically significant	Positive trend; Statistically not significant	Negative trend; Statistically not significant
1 day maximum rainfall trend	Negative trend; statistically not significant	Positive trend; Statistically significant	Negative trend; statistically not significant
Number of rainy days trend	Positive trend; statistically not significant	Positive trend; statistically not significant	Negative trend; statistically not significant
Climate Change : IPCC AR4 Projections PRECIS A1B Scenario			
Maximum Temperature (°C) : Change from BL to midterm			
Annual	1.9	1.6	1.4
Winter (JF)	2.0	1.7	1.4
Pre Monsoon (MAM)	1.8	1.4	1.6
Monsoon (JJAS)	1.4	1.4	1.3

Parameter	India (Digha-Sankarpur)	Bangladesh (Cox's Bazaar Sadar-Moheshkhali)	Sri Lanka (Koggala)
Post Monsoon (OND)	2.4	2.0	1.4
Minimum Temperature (°C): Change from BL to midterm			
Annual	1.9	1.8	1.6
Winter (JF)	2.1	2.0	1.7
Pre Monsoon (MAM)	2.1	1.8	1.6
Monsoon (JJAS)	1.4	1.5	1.3
Post Monsoon (OND)	2.3	2.1	1.6
Annual Rainfall, mm (percent change): Change from BL to midterm			
Annual	-39 (-1.8)	426 (20.1)	131 (5.9)
Winter (JF)	-8.1 (-10.7)	-0.3 (-0.5)	-9.5 (-17.8)
Pre Monsoon (MAM)	41.2 (10.9)	151.2 (20.4)	2.2 (0.6)
Monsoon (JJAS)	-18 (-1.2)	272 (23.3)	95 (6.8)
Post Monsoon (OND)	-55.1 (-23.3)	2.4 (1.6)	43.3 (11.2)
Climate Change : IPCC AR5 Projections SMHI RCP4.5			
Maximum Temperature (°C): Change from BL to midterm			
Annual	1.1	1.1	1.1
Winter (JF)	1.5	1.6	0.9
Pre Monsoon (MAM)	1.1	0.9	1.3
Monsoon (JJAS)	1.2	0.8	1.0
Post Monsoon (OND)	1.1	1.1	1.0
Minimum Temperature (°C): Change from BL to midterm			

Parameter	India (Digha-Sankarpur)	Bangladesh (Cox's Bazaar Sadar-Moheshkhali)	Sri Lanka (Koggala)
Annual	1.5	1.3	1.3
Winter (JF)	2.0	1.7	1.3
Pre Monsoon (MAM)	1.7	1.6	1.5
Monsoon (JJAS)	1.3	1.2	1.1
Post Monsoon (OND)	1.4	1.3	1.3
Annual Rainfall (mm): Change from BL to midterm			
Annual	20 (0.7)	167 (5.2)	331 (12.9)
Winter (JF)	5.7 (29.5)	-8.2 (-38.1)	0 (0)
Pre Monsoon (MAM)	3.3 (1.1)	-2 (-0.6)	47.3 (6.1)
Monsoon (JJAS)	10 (0.4)	214 (7.8)	193 (18.3)
Post Monsoon (OND)	1.2 (0.3)	-36.5 (-26.6)	90.1 (18)

The following paragraphs carry description of observed climate data analysis and IPCC AR4 followed by IPCC AR5 climate change projections. All the figures have been drawn on the basis of facts given in Table 24.Area and population density for the study sites are shown in Figure 6. Cox's Bazar Sadar of Bangladesh has the largest area and density amongst the three site locations.

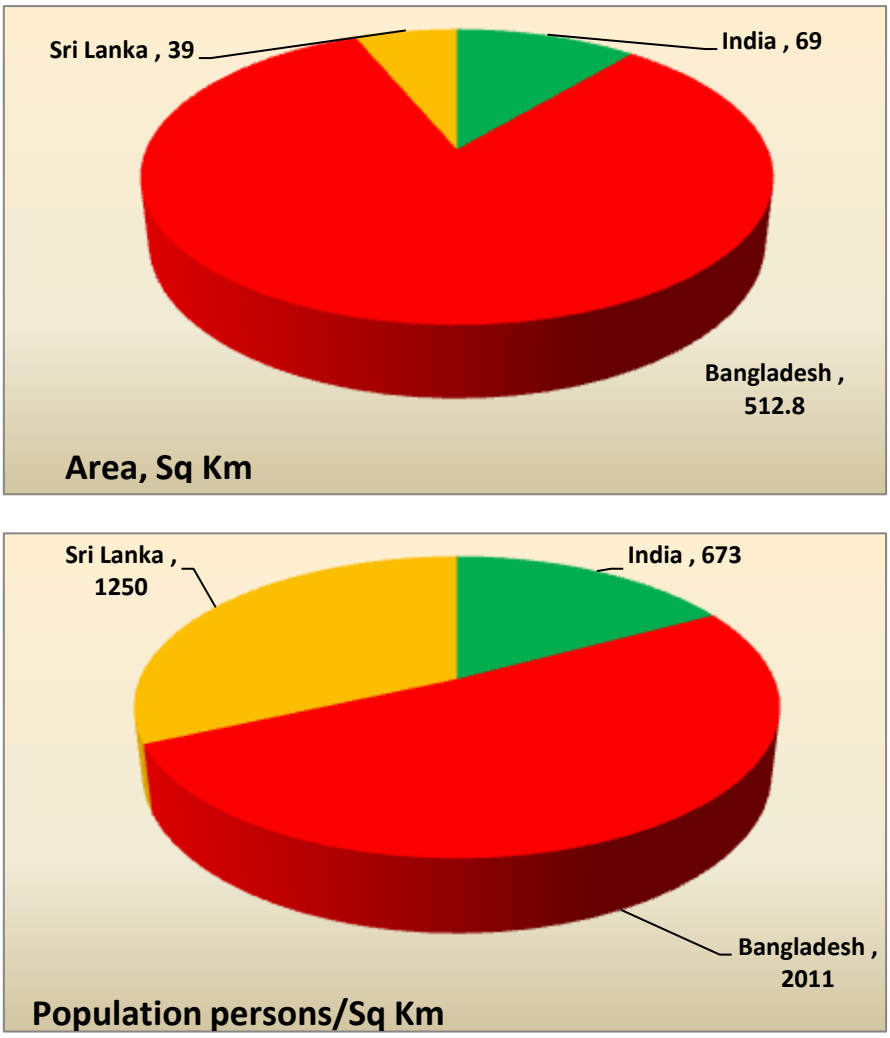
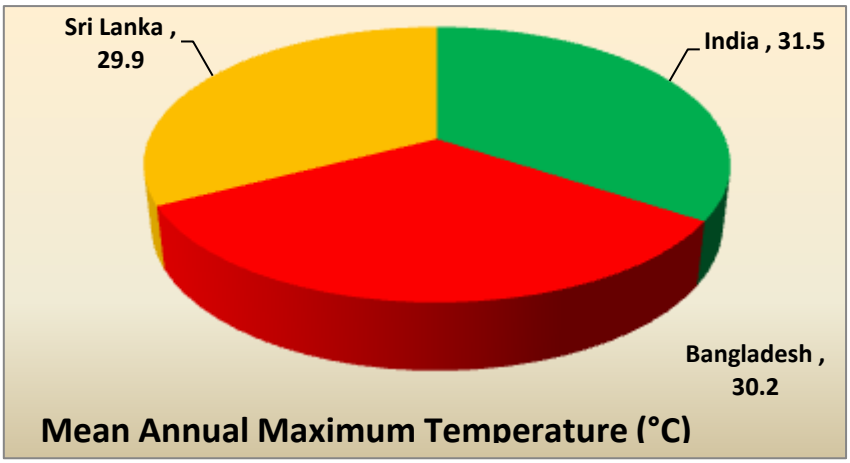
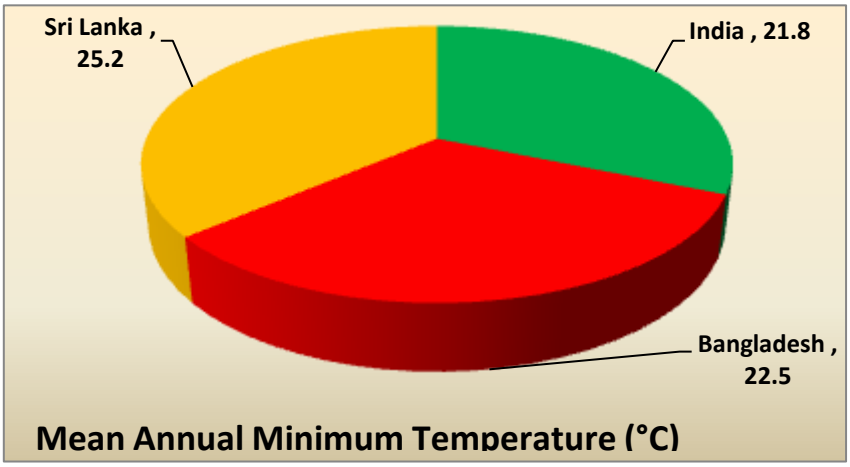


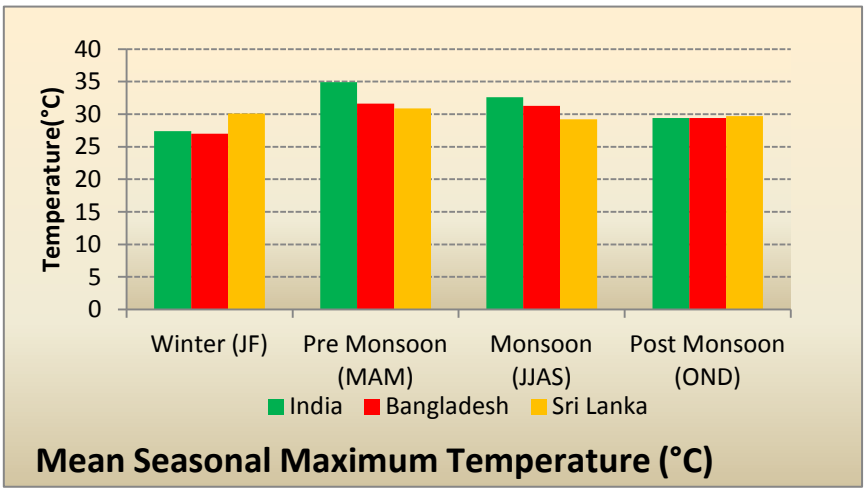
Figure 6: Area and population density of study sites of India, Bangladesh and Sri Lanka

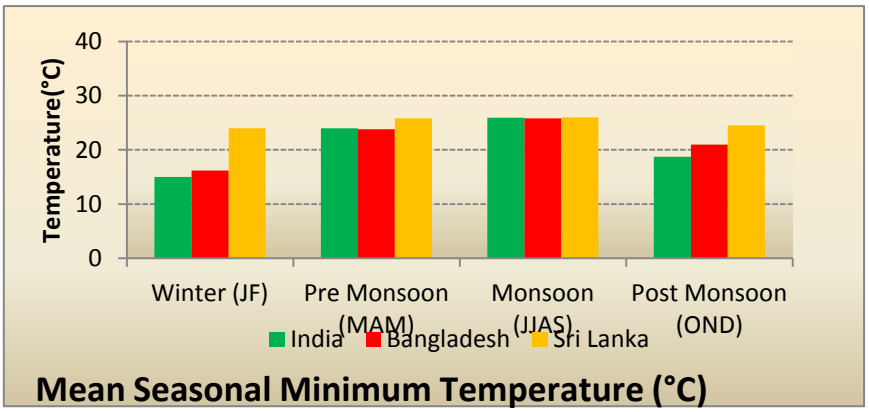
Characteristics of observed climate variables for the study sites are shown in Figure .

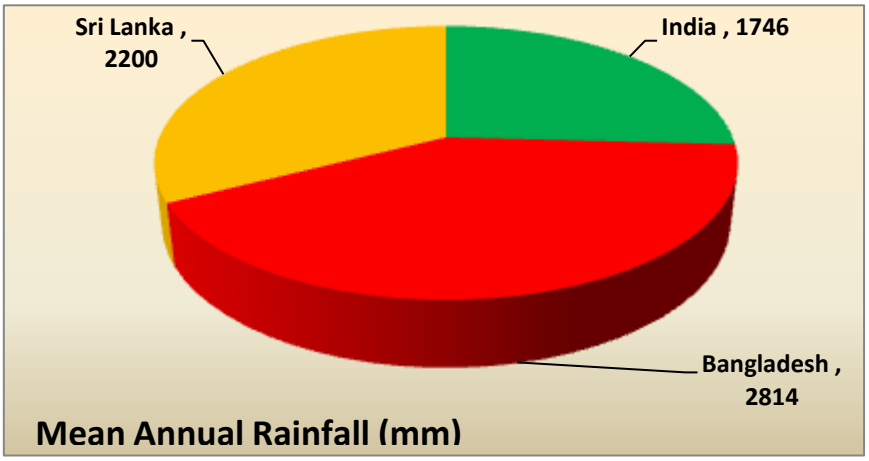
1. Mean annual maximum temperature is highest for India (31.5°C) while mean annual minimum temperature is the highest for Sri Lanka (25.2°C).
2. Maximum temperature attains its mean highest value during pre monsoon season (MAM) while it attains its mean lowest value in winter season.
3. Minimum temperature attains its mean highest value during monsoon season (JJAS), while it attains its mean lowest value in winter season.
4. Mean annual rainfall amongst the three sites is the highest for Bangladesh site (2814 mm).
5. The mean south-west monsoon (June, July, August and September) rainfall contributes the maximum to annual rainfall for Bangladesh (77percent) while lowest for Sri Lanka site (32percent).


Sri Lanka , 29.9
India , 31.5
Bangladesh , 30.2
Mean Annual Maximum Temperature (°C)


Sri Lanka , 25.2
India , 21.8
Bangladesh , 22.5
Mean Annual Minimum Temperature (°C)


Temperature(°C)
40
35
30
25
20
15
10
5
0
Winter (JF)
Pre Monsoon (MAM)
Monsoon (JJAS)
Post Monsoon (OND)
India
Bangladesh
Sri Lanka
Mean Seasonal Maximum Temperature (°C)





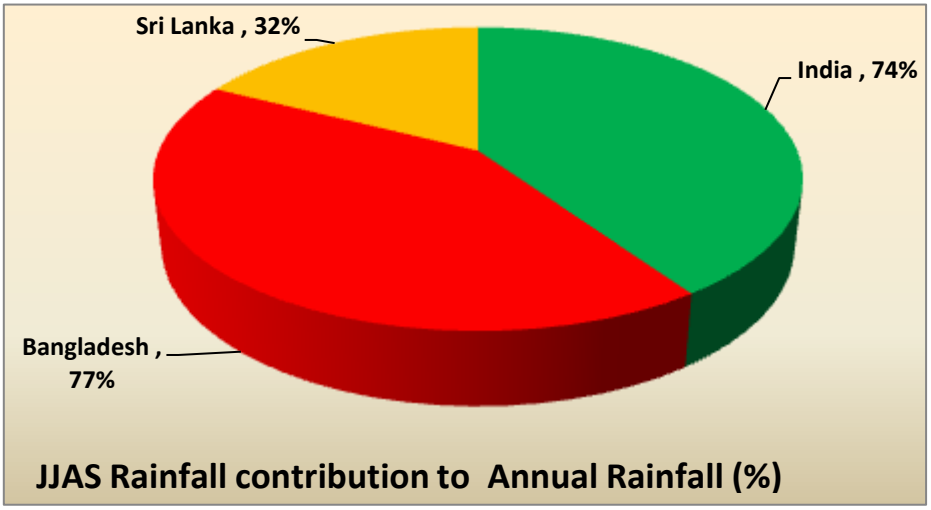


Figure 7: Characteristics of observed climate variables of study sites of India, Bangladesh and Sri Lanka

Characteristics of overall trend scenario of observed climate variables for the study sites are shown in Figure 8.

1. Trend analysis results for maximum temperature show that the three study sites have a negative trend however trend is statistically significant only for India.

2. Trend analysis results for minimum temperature show that Bangladesh and India have a positive trend while Sri Lanka has a negative trend; trend is statistically significant for all three sites.
3. Annual rainfall show positive trend which is statistically significant for India, positive trend which is statistically not significant for Bangladesh and negative trend which is statistically not significant for Sri Lanka.
4. 1 day maximum rainfall shows positive trend which is statistically significant only for Bangladesh while negative trend which is statistically not significant for India and Sri Lanka.

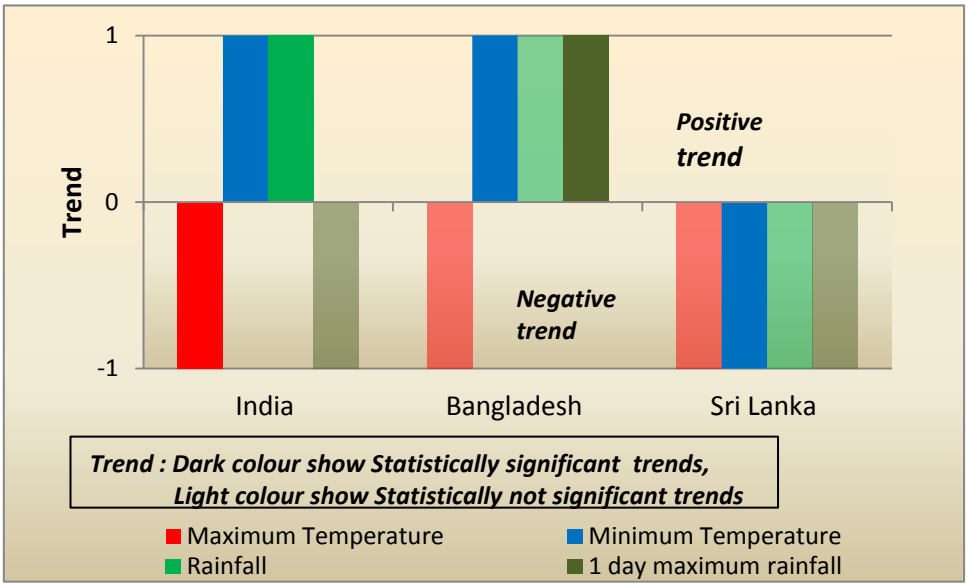
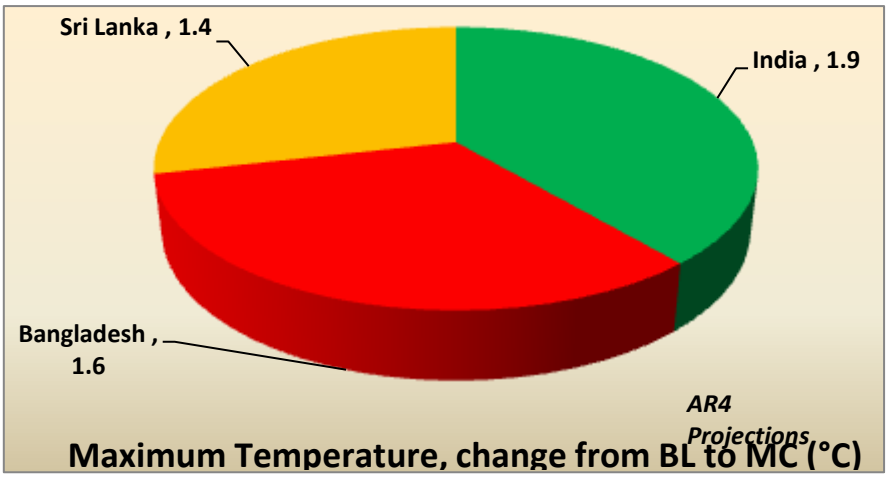
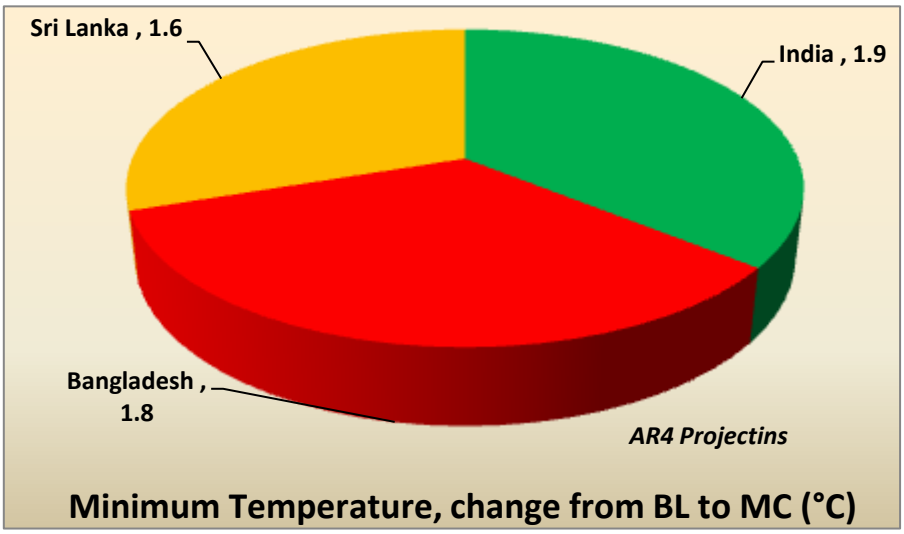


Figure 8: Characteristics of overall trend scenario of observed climate variables of study sites of India, Bangladesh and Sri Lanka

Characteristics of climate change projections (IPCC AR4 Projections, PRECIS A1B Scenario) for the study sites are shown in Figure 9.

1. Mean annual maximum and minimum temperature rise by mid-century is projected to be the highest for India amongst the three sites (1.9°C).
2. Mean annual rainfall is projected to decrease marginally towards the mid-century for India while increase for Bangladesh and Sri Lanka. Increase is projected to be the maximum for Bangladesh (426 mm).





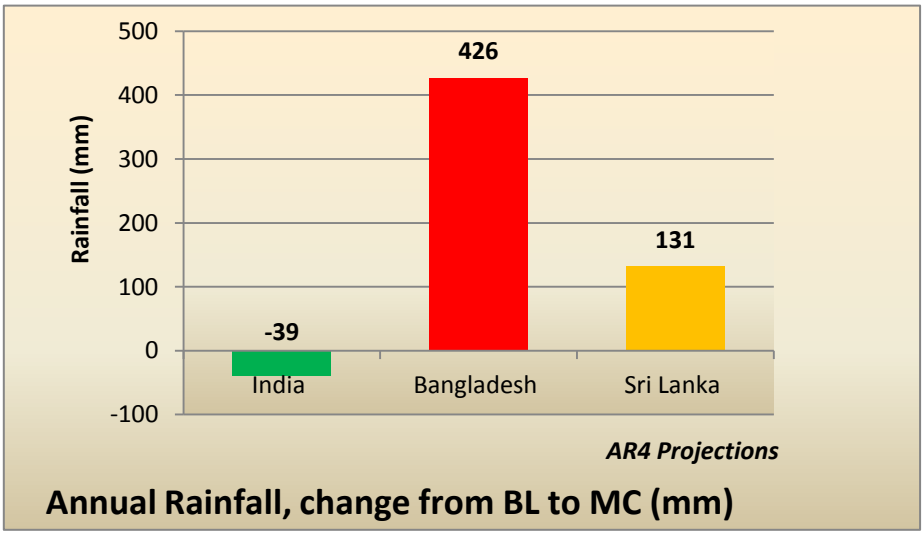
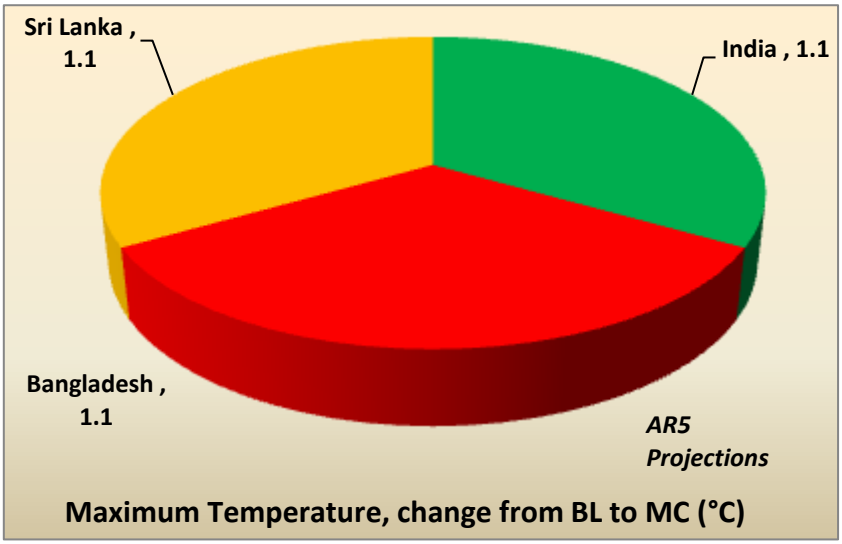
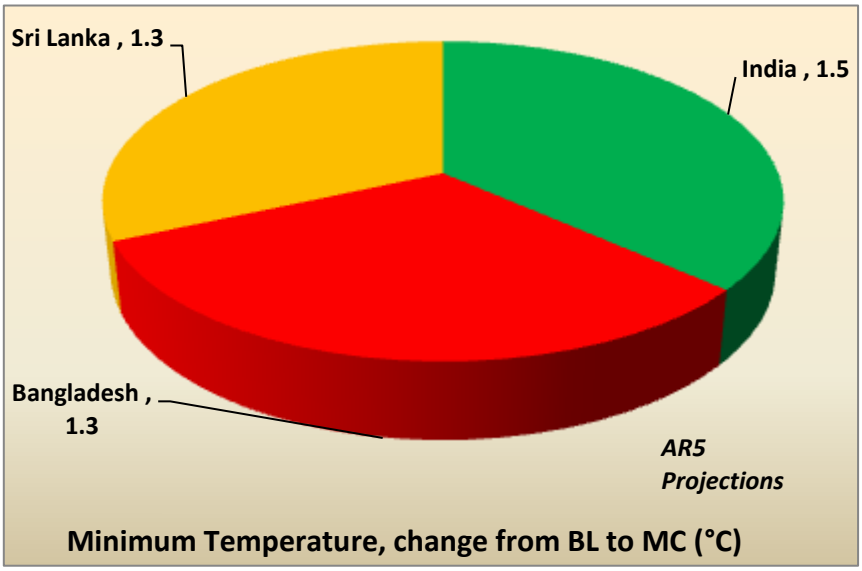


Figure 9: Characteristics of climate change projections of study sites of India, Bangladesh and Sri Lanka (IPCC AR4 Projections, PRECIS A1B Scenario)

Characteristics of climate change projections (IPCC AR5 Projections, SMHI RCP4.5Scenario) for the study sites are shown in Figure 10.

1. Mean annual maximum temperature rise by mid-century is projected to be the same for all three sites (1.1°C) while minimum temperature rise by mid-century is projected to be the highest for India (1.5°C). amongst the three sites.
2. Mean annual rainfall is projected to increase towards the mid-century for all three site locations. Increase is projected to be the maximum for Sri Lanka (331 mm).





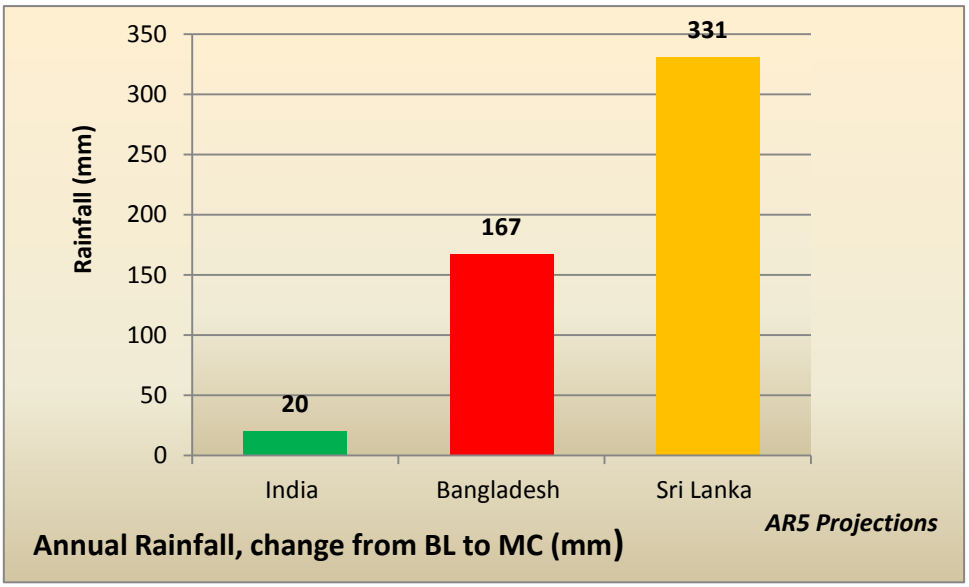


Figure 10 : Characteristics of climate change projectionsof study sites of India, Bangladesh and Sri Lanka (IPCC AR5 Projections, SMHI RCP4.5Scenario)

Projections of future climate over Sri Lanka carried out by the Asia Disaster Preparedness Centre in Bangkok in 2011 are shown in Appendix II. These projections are based on HadCM3 General Circulation Model and they were downscaled using PrecisV3.2 Regional Model, corresponding to A1B emission scenario. The observed data over the period 1970-2000 were used as the baseline data, and the projections were made for the period 2030-2060. From the temperature and rainfall projection maps given in the Appendix II, the following climate data corresponding to Koggala were extracted.

Change in Climate Parameter relative to 1970-2000 values	Projected values for 2030-2060
Annual average max. temperature	1.76 - 1.91 ^{o}C
Annual average min. temperature	1.86 - 1.95 ^{o}C
Annual precipitation	495 – 790 mm

Source: Basnayake (2014)

4. Summary and Conclusions

The results show that most of the economic activities in Digha-Sankarpur, India are mainly impacted by natural threats like, coastal erosion, sea water intrusion, coastal storm and anthropocentric pollution caused due to wastewater discharged from hotels and restaurants on the beach. The intensity of exposure to different threats is estimated on the basis of the frequency of occurrence of these threats on a varying time scale. Among the list of economic activities covered, it appears that economic occupation category photography on beach is exposed to all the natural threats though the average current exposure level is marginal. As for the exposure to anthropogenic threats it is the shell-crafting activity which is marginally impacted even though the exposure is high among all the activities. Similarly, sensitivity results show that the natural threats have the highest impact on individuals engaged in horse-riding on the beach though average level of exposure is marginal. The other economic activities that are close to be marginally sensitive to various threats are: shell-crafting and fish drying. On the other hand, sensitivity to anthropogenic threats is almost negligible. An important component of the vulnerability assessment is the risk categorization of each economic activity vis-à-vis different natural threats. Under the risk assessment, four risk types are considered, these are: asset loss (shop loss/Van loss/boat loss, etc.), Income loss, risk to lives and health risk. Our findings show that the selected economic activities do not lead to any of the four specific risks mentioned earlier(the median response is close to 1 (not impacted) for almost all economic activities, except for fish drying and horse-riding activities). In other words, in an event of occurrence of any threat, none of the economic activities is likely to experience four risks with medium to significant intensity. People engaged in beach recreation especially those providing horse-rides on the beach to the tourists are vulnerable followed by photographers taking pictures of tourists on the beach. After factoring in risk, it is the horse-riding and fishing using manual boats that are relatively more vulnerable.

However, when risk was separately looked into through all the indicators identified (apart from the four indicators used in risk analysis for vulnerability assessment) namely asset loss, income loss, unavailability of drinking water, health risk, life loss, crop loss, migration, borrowing money, damage to embankment, roads and other public properties, then it gave a broader perspective. Since it came out from the analysis so far that three major threats to the coastal economic activities in Digha- Sankarpur- Mandarmoni are coastal storms, sea water intrusion during high tides and coastal erosion, impact of these three threats was taken into account to get an in depth view.

Due to coastal storms a substantial proportion of the respondents have reported to have experienced very significant loss of fixed asset and income among different types of risks

mentioned above. Losses of life, other assets, health, migration, occupational change due to coastal storms have not impacted majority of the respondents. Sea water intrusion during high tides has led to very significant loss of roads, embankments and other public resources according to a considerable proportion of the respondents. From the responses it is found that sea water intrusion during high tides has not claimed any life, and majority of them have reported that there was no loss of health, loss of assets other than fixed and occupational assets, occupational change. Coastal erosion does not have any impact on life risk and occupational change of the respondents and it has impacted very few respondents in terms of unavailability of drinking water, migration, crop loss, health risk and other asset loss (which excludes fixed and occupational asset). Some of the respondents have reported that there were very significant losses of roads, embankments and other public resources due to coastal erosion.

For an overall risk scenario, apart from categorization of degrees of various types of loss due to different threats, as mentioned in the last paragraph, calculation of annual average monetary loss as a percentage of current annual income of the respondents was worked out. Further, the monetary loss percentage was categorized to get percentage of individuals from difference economic activities across these categories. It got reflected from the analysis that a major share of the respondents from economic activities: agriculture, fish drying, fishing using manual boats, and horse riding on beach have experienced significant monetary losses due to coastal storms and that for the respondents engaged in shell-crafting and aquaculture was a little lesser. More or less all the economic activities apart from aquaculture, horse riding and photography on beach have experienced high degrees of variability in income loss due to coastal storms. Due to sea water intrusion during high tides none of the respondents from aquaculture was affected from monetary loss. A good number of respondents from activities like hawking on and near beach, shell-crafting, fishing using mechanized boats, deep sea fishing using trawlers faced very high degree of monetary loss that ranges from 61 to 80 percent of annual income due to sea water intrusion during high tides. Coastal erosion did not affect majority of the respondents engaged in motorized van driving, deep sea fishing in trawlers, fish drying in terms of monetary loss. A substantial part of the respondents from activities horse riding on beach, hawking on and near beach, shell crafting, deep sea fishing using trawlers faced very high degree of monetary loss from Coastal erosion.

In Cox's Bazar-Moheshkhali of the eight economic activities considered, most of the economic activities are mainly impacted by threats like, coastal storm, sea water intrusion, coastal flooding, inadequate rainfall during dry period and pollution caused due to wastewater discharged from hotels and restaurants on the beach and running of petrol or

diesel vehicles on the beach. The intensity of exposure to different threats is estimated on the basis of the frequency of occurrence of these threats on a varying time scale. Among the list of economic activities covered, it appears that salt-shrimp farming followed by agriculture have exposure from marginal to high for all the natural threats. As for the exposure to anthropogenic threats it is the hotel industry which is highly impacted. Similarly, sensitivity results show that the natural threats have the highest impact on salt-shrimp farming followed by agriculture. These impacts can be categorized as medium. The other economic activities those are marginally sensitive to various threats except photography. On the other hand, sensitivity to anthropogenic threats is closed to medium for hotel industry and marginal for fishing and shop business. An important component of the vulnerability assessment is the risk categorization of each economic activity vis-à-vis different natural threats. Under the risk assessment, four risk types are considered, these are: asset loss, income loss, risk to lives and health risk. Our findings show that majority of economic activities are not associated with high levels of four risk types, except in the field of agriculture and fishery , where coastal storm is considered as very significant risk. Coastal storm is also exhibited as medium risks for salt-shrimp farming, hotel industry, fish drying and shop business. In other words, in an event of occurrence of any threat, none of the economic activities is likely to experience four risks with medium to significant intensity. Hence vulnerability with and without risk remains the same, which is any case is not significant. The highest relative vulnerability levels are reported by the agriculture followed by salt-shrimp farming. After factoring in risk, it does not change the overall results.

The opinions expressed by the respondents in the Southern coast of Sri Lanka show that the traditional economic activities such as agriculture and fisheries are more vulnerable to natural hazards than the new economic activities such as 3-wheel vehicle driving or handicraft selling. The survey findings showed that the majority of fishers amounting to 86percent have not heard of climate change and were not aware that this could cause an increasing threat in the future with higher vulnerability to stormy weather conditions, especially to those who venture into the sea in small boats. As an adaptation measure, it is proposed that fishers be encouraged to phase out the use of small boats in preference to large boats which can withstand stormy weather conditions in mid-sea. Intervention of the government is essential by providing the necessary financial assistance possibly through cooperative bodies to acquire large multi-day boats which will serve two purpose – firstly to increase the harvest from off-shore/deep-sea sources and secondly to reduce the risks faced by fishers in mid-sea during stormy weather conditions.

The fishers also urged that immediate government intervention is required regarding the prohibition imposed by EU, because the majority of fishers who depend on tuna catches

suffer severely due to loss of their income. Moreover, attention must be paid in order to control unauthorized fishing by foreign vessels as they exploit the fish stock unsustainably. Restriction of course-net is also a must because it leads to the population depletion being an untargeted fishing method. Enforcing a guaranteed market price for the products, awareness on sustainable exploitation of yield and maintain the required quality standards, subsidies on fuel and other fishing gears, proper loan systems, efficient mechanism to sell their catch are some of suggestions that can be adopted to encourage a greater number of fishers seeking offshore and deep-sea fishing.

China (This was part of year I study)

The field site, Tianjin in China is located in latitude 38 ° 34 'N to 40 ° 15', longitude 116 ° 43 '-118 ° 04'E and is around 189 km long from north to south and 117 km wide from east to west. The land area of Tianjin is about 11,919 sq.km, sea area is about 3,000 sq. km. The intertidal zone covers an area of about 336 sq. km, with a mainland coastline length of about 153.67 km and island coastline around 0.47 km. The tidal bank is 3 to 8 km long. The tide, is typical semidiurnal, and the tidal range of 2.4 meters. More than 90 percent of the coastal waves arise due to wind. Tianjin sea waters belong to Bohai Sea, which is a enclosed sea. So the hydrodynamic force is weak, so is the exchange of seawater. The power of self-purification is not strong, and the ecological environment is fragile. Coastal waters are polluted and the major pollutant is inorganic nitrogen and active phosphate. According the Marine Environment Quality Bulletin of Tianjin in 2006.About 2,870 sq km do not reach the standard of sea water quality, among them: less clean area is about 380 sq km, light pollution is about 630 sq. km, moderate pollution area is about 760 sq km, serious pollution of the sea area is about 1100 sq km.

Tianjin coastline can be classified as: fishery coastline, transportation coastline, tourism coastline, sewage dumping coastline, reclamation coastline, special use coastline and other coastline. The main marine economic activities in the study area include marine fishery, offshore oil and gas, salt-making, marine shipbuilding industry, marine biomedicine, marine transportation, coastal tourism etc. Of these economic activities, coastal ecosystem relevant economic activities are marine fishery (i.e. for fishing and mariculture). Mariculture has received a lot of attention now than before, with strict marine fishing regulations and declining natural fishery resources, shallow sea and beach culture were developed to increase the mariculture production.

Coastal zone of Tianjin is the most vulnerable area in China. Sea-level rise and storm surges remain a major problem. As sea-levels rise, the defense capabilities of breakwater gradually declines, hence, all kinds of tidal impacts on coastal area in Tianjin are observed. After sea-levels rise, only less than 1/2 of the breakwater can resist the historical highest or a once-in-a-century highest tide. Based on observations, the sea level of Tianjin has risen to about 65mm in the last 30 years. Of all influencing factor, the largest contributor is the land subsidence.

Overall climate change analysis

The overall trend scenario of observed climate variables for the study sites show:

1. That the three study sites have a negative trend results for maximum temperature however trend is statistically significant only for India.
2. Bangladesh and India have a positive trend for minimum temperature while Sri Lanka has a negative trend; trend is statistically significant for all three sites.
3. Annual rainfall has a positive trend which is statistically significant for India, positive trend which is statistically not significant for Bangladesh and negative trend which is statistically not significant for Sri Lanka.
4. 1 day maximum rainfall having a positive trend which is statistically significant only for Bangladesh while negative trend which is statistically not significant for India and Sri Lanka.

Climate change projections (IPCC AR4 Projections, PRECIS A1B Scenario) for the study sites show that mean annual maximum and minimum temperature rise by mid-century is projected to be the highest for India amongst the three sites (1.9°C) while climate change projections based on IPCC AR5 Projections, SMHI RCP4.5 Scenario for the study sites indicate mean annual maximum temperature rise by mid-century projected to be the same for all three sites (1.1°C). Minimum temperature rise by mid-century is projected to be the highest for India (1.5°C) amongst the three sites. The increase in minimum temperature is likely to impact the recreational and provisioning services in both SriLanka and India, while mainly provisioning services in Bangladesh. The main economic activities impacted in each study site because of the increase in minimum temperature are: fishing, agriculture and tourism in SriLanka, fishing, aquaculture and tourism in India while fishing and agriculture in Bangladesh.

As per the IPCC AR4 Projections, PRECIS A1B Scenario for the study sites, the mean annual rainfall is projected to decrease marginally towards the mid-century for India while increase for Bangladesh and Sri Lanka. Increase is projected to be the maximum for Bangladesh (426 mm). The IPCC AR5 Projections, SMHI RCP4.5 Scenario for the study sites project an increase in mean annual rainfall towards the mid-century for all three site locations. Increase is projected to be the maximum for Sri Lanka (331 mm). These projections will have an impact on the ecosystem services in the three study sites. For instance, provisioning and regulating services in all the study sites will be adversely impacted. In addition, regulatory services will be severely impacted in India. The most vulnerable activities identified in the study sites as a result of mean annual rainfall changes are: Fishing, tourism and aquaculture in India, fishing, agriculture and tourism in SriLanka and finally, fishing, agriculture and aquaculture in Bangladesh.

The implications of the change in temperatures and rainfall projected for the mid-century will be mainly felt in the fisheries and tourism sector across the three study sites. The possible impacts on the coastal tourism can be listed as:

1. Narrow Diurnal temperature range
2. Increase in cooling demand,
3. reduction in beach recreational time window,
4. degradation of beaches and coastal vegetations,
5. increase in flooding frequency, risk to health and safety concerns

Coastal fisheries will be impacted because of:

1. elevated water surface temperature
2. Increased salinity
3. Need for quick transport or cold storage facilities
4. Increasing storm surges and frequency resulting in loss of fishing man hours

In addition to natural factors, ecosystem services are also severely impacted due to anthropogenic factors. The policy response to contain the adverse impacts of natural and anthropogenic factors on different coastal ecosystem services has been listed in the tables 25, 26 and 27 below. The main focus of these tables is to highlight specific policy response to coastal ecosystem threats along with barriers in implementation of such a policy.

Table: 25 Policies targeting specific threats to coastal ecosystem services in Bangladesh

Major Coastal Policy	Targeted Ecosystem services	Targeted Economic Activities	Barriers in implementation
Pollution level monitoring- Reducing agro-chemicals use in agriculture	Regulating	Agriculture	Lack of awareness of the local people, over-population, lack of improved technologies and research, Lack of facilities and infrastructure attitude of the people, Pressure of influential people
Implementing set back line- Coastal Regulation Zone Notifications	Provisioning, Regulating, Supporting and Cultural/Recreational/Aesthetic	Tourism and Fisheries	No regulatory action in construction of hotels/ restaurants, avoiding rules of catching fish into the sea, influence by the rich people, lacking inter-disciplinary coordination; corruption in different levels, Population pressure Lack of manpower
Mangrove plantation	Provisioning, Regulating, Supporting and Cultural/Recreational/Aesthetic	Aquaculture, Tourism, Agriculture	No regulatory action in construction of hotels/ restaurants, avoiding rules of catching fish into the sea, influence by the rich people, lacking inter-disciplinary coordination; corruption in different levels, Population pressure Lack of manpower
Ban of hawking, boat/horse riding on beach	Cultural/Recreational/Aesthetic	Tourism	
Ban of fishing during breeding period	Provisioning and Supporting	Fisheries	
Regulating pirating in deep sea fishing	Regulating	Fisheries	
Climate change management to adaptation strategy	Regulating and Supporting	Fisheries and Tourism	
Fishery management policy	Provisioning	Fisheries	

Forest management policy	Provisioning, Regulating, Supporting and Cultural/Recreational/Aesthetic	Tourism	

Table: 26 Policies targeting specific threats to coastal ecosystem services in India

Major Coastal Policy	Targeted ecosystem services	Targeted Economic Activities	Barriers in implementation
Pollution level monitoring: Sewerage treatment plant Pollution related regulations	Provisioning, Supporting and Cultural/Recreational/ Aesthetic	Tourism and Fisheries	Capacity and resource constraints, Not having a dedicated programme and guidelines, ad hoc monitoring depending on projects, lack of coordination among departments
Implementing set back line- Coastal Regulation Zone Notifications	Provisioning, Regulating, Supporting and Cultural/Recreational/ Aesthetic	Tourism , Fisheries and Aquaculture	Political interference, favoritism, non-demarcation , non-compliance Corruption at local administrative level and hoteliers, lack of coordination among departments
Ban of deep sea fishing during fish breeding period	Provisioning	Fisheries	Political interference, favoritism, non-demarcation , non-compliance Corruption at local administrative level and hoteliers, lack of coordination among departments
Ban of gill nets in fishing	Provisioning	Fisheries	
Fishermen training for sustainable fishing	Provisioning	Fisheries	
Setting up of MPEDA	Provisioning and Regulation	Fisheries	
Promotion of DSDA	Provisioning, Regulating, Supporting and Cultural/Recreational/ Aesthetic	Tourism, Fisheries, Aquaculture, Agriculture	
Tourism policy	Supporting and and Cultural/Recreational/ Aesthetic	Tourism	

Table: 27 Policies targeting specific threats to coastal ecosystem services in Sri Lanka

Major Coastal Policy	Targeted ecosystem services	Targeted Economic Activities	Barriers in implementation
Pollution level monitoring: Declaring effluent standards Policy to control garbage dumping	Provisioning, Regulating, Supporting and Cultural/Recreational/Aesthetic	Fisheries and Tourism	Lack of trained people, lack of well-established infrastructures, lack of proper guidelines, political influences, lack of cooperation from hoteliers and lack of funding
Implementing set back line: Establishment of setback along the coast Coastal Zone Management Plan (CZMP): IEE and EIA approvals for construction	Provisioning, Regulating, Supporting and Cultural/Recreational/Aesthetic	Tourism and Fisheries	Political influence, lack of cooperation from relevant stakeholders towards spatial planning, absence of systematic monitoring system, lack of inter-agencies coordination, state interference, High tourism demand, non demarcation , non compliance
Ban of illegal fishing gears		Fisheries	Political influence, lack of cooperation from relevant stakeholders towards spatial planning, absence of systematic monitoring system, lack of inter-agencies coordination, state interference, High tourism demand, non demarcation , non compliance
Ban of coral mining	Provisioning, Regulating, Supporting and Cultural/Recreational/Aesthetic	Fisheries and Tourism	
Policy of banning Mining / removal of sand		Tourism	
Ecosystem restoration (re-plantation)	Provisioning, Regulating, Supporting and Cultural/Recreational/Aesthetic	Tourism	
Policy dealing with land reclamation	Supporting and Cultural/Recreational/Aesthetic	Tourism	

Environmental Protection License under National Environmental Act for operation	Provisioning, and Cultural/Recreational/Aesthetic	Fisheries and Tourism	
Coast Conservation Act: IEE and EIA approvals for developmental projects	Provisioning, Regulating, Supporting and Cultural/Recreational/Aesthetic	Fisheries and Tourism	
Fisheries and aquatic resources development act	Provisioning, Regulating and Supporting	Fisheries	
Environmental Clearance/ building approvals for small scale operators	Provisioning, Regulating and Supporting	Tourism	

5. Future Directions

The study shows inventorization of economic activities, the relation to the ecosystem services, and experience of climate parameters related variability and impacts on ecosystem services and economic indicators.

A preliminary risk assessment for different stakeholder groups has been undertaken in this study. However, we realized this initial assessment provides a huge opportunity to take-up further research on (it is not an exhaustive list but, just next stage of possible study scope):

1. Strengthening the risk assessment study,
2. Alternative adaptation strategy designed for managing the risk,
3. Cost assessment of alternative adaptation strategies with risk reduction potential, and
4. Capacity building of different policy makers for better informed policy decisions relating to ecosystem vulnerability to various threats and possible adaptive strategies to reduce this vulnerability.

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Appendix I: Field study methodology and observations

Digha-Sankarpur-Mandarmoni, India

At the initial stage of Phase II, an overall understanding of the study site was done through observation and consultation with various stakeholders e.g. individuals from different economic activities, fisherman association, hotelier's association, government officials in the study site of the concerned departments and key informants in the study site. Tourism based economic activities and fisheries activities are the major occupations in the Indian study site Digha-Sankarpur-Mandarmoni, although among traditional activities agriculture still exists in some pockets of the study site along with several other secondary occupations. Tourism Development started first in Old and New Digha and substantially it expanded towards Mandarmoni, Tajpur and Sankarpur. The recent government policies are also directed towards tourism promotion. Hotels and resorts of various types are rapidly being built along the coastline and expanding inwards too. Number of Hotels is the highest in Old and New Digha, followed by Mandarmoni, Tajpur and Sankarpur. In respect of other tourism related activities, the diversity as well as number of activities is the highest in Old and New Digha. In the scenario of tourism expansion in the region, violation of Coastal Regulation Zone (CRZ) is a matter of concern. Apart from the tourism sector, fisheries sector contributes significantly to the local economy. There is large diversity in fisheries activities. Fish landed and processed in Digha-Sankarpur fishing harbor meets India's export demand as well. In the present scenario, the tourism sector is exposed to major natural and anthropogenic threats e.g. coastal storms, sea water intrusion during high tides, coastal erosion, improper waste disposal, running heavy vehicles on the beach, loss of vegetation cover. On the other hand some of the threats that the fisheries sector is exposed to include coastal storms, contamination of water, loss of fish stock and diversity etc.

Phase II data collection commenced with a pilot testing of questionnaire by interviewing 19 individuals from different economic activities across the entire Indian study site Digha-Sankarpur-Mandarmoni. It was followed by analysis of pilot survey data and other information, revisions and final drafting of individual and official's questionnaire.

The main rounds of primary data collection were done in three phases from September till November 2014. In main rounds of survey 113 samples were collected from 13 economic activities as primary occupations across six locations (namely Duttapur, New Digha, Old

Digha, Sankarpur, Tajpur, Mandarmoni) of the study site. The methodology of sampling used for primary data collection was random. In each location it was targeted to collect at least two samples for each economic activity as identified previously. However, in some cases it was less than two due to unavailability of samples. Apart from that, all the 13 economic activities were not there in all the six locations specified. Several govt. offices in the study site and some local community level organizations were visited for collection of information at various levels.

Table A1: Economic Activities studied in Phase II

Sl. No.	Primary Occupation	Sample Size
1	Agriculture	9
2	Aquaculture	5
3	Deep Sea Fishing In Trawler	5
4	Fish Drying	9
5	Fishing In Manual Boat	9
6	Fishing In Mechanised Boat	14
7	Hawking On And Near Beach	18
8	Horse Riding On Beach	4
9	Hotels And Resorts	12
10	Manual Van Driving	9
11	Motorised Van Driving	8
12	Photography On Beach	7
13	Shell Crafting	4
	Total	**113**

Table A2: Government Departments and community level organizations consulted

Central Government bodies	State Government bodies	Community Organisations
Marine Aquarium and Research Centre, Zoological Survey of India, Govt. of India	Digha Sankarpur Development Authority (DSDA), Urban Development Dept, Govt. of West Bengal	Fishermen's and Fish Trader's Association, Digha Mohona
Digha Science Centre and National Science Camp, National Council of Science Museums, Ministry of Culture, Govt. of India	Irrigation and Waterways Dept (Contai Section), Govt. of West Bengal	Hotellier's Association (Digha and Mandarmoni)
	State Fisheries Development Corporation Ltd (Alampur), Undertaking of the Govt. of West Bengal	
	Fisheries Department (Contai Section), Govt. of West Bengal	
	Agriculture Department (Contai Section), Govt. of West Bengal	
	Forest Ranger Office (Contai Section), Govt. of West Bengal	

Cox's Bazar Sadar-Moheshkhali, Bangladesh

At the initial stage of Phase II, an overall understanding of the study site was done through field visit, observation and consultation meeting with various stakeholders i.e. individuals involved in different economic activities including agriculture, fishing, salt-shrimp farming, tourism, fish drying, and various associations/organizations related to these activities, government, non-government and autonomous officials of the concerned departments and key informants in the study site.

Tourism-based economic activities are now rapidly flourishing, although the traditional fisheries activities are still the major occupation in the study site Cox's Bazar Sadar-Moheshkhali. Other important economic activities are shrimp farming and salt production using coastal sea water. Among other traditional activities, agriculture still remains the major contributor to the livelihood of the coastal community of the concerned area. Tourism activities are mainly concentrated in the sea beach resort town Cox's Bazar, which is renowned for the sea beach that globally regarded as the longest natural sandy beach. The recent government policies are the development of an exclusive tourist zone (ETZ), use of virgin beach areas and introduction of beach activities for international tourists. The

financiers are investing huge capital in this sector primarily for building various hotels and resorts along the coastline. There is an ample opportunity for developing Cox's Bazar as a Tourism city with the provision of necessary tourism related services, However, problems arise due to unplanned residential hotels/motels, shops, squatter settlement, and other overlapping administrative anomalies etc. Realizing the importance of tourism sector, very recently the Government has taken an initiative to prepare an integrated tourism development plan for Cox's bazar.

Apart from the tourism sector, coastal fisheries sector contributes significantly to the national economy of Bangladesh. Cox's Bazar has a local sea fish landing station where hundreds of sea going fishing trawler anchors for the delivery of the catch fish. Apart from raw fish, the dry fish processing centers are also abundantly available that meet the local demand and export demand as well.

Salt farming is overwhelmingly concentrated in Cox's Bazar district. It meets bulk of the demand for raw salt in the country. The salt farmers work under various adverse conditions. They are in close proximity to the open sea and often face frequent hazards coming from the sea. The shrimp sector in Bangladesh has become very important for its potential to develop the economy of the country. The sector contributes significantly to the country's foreign exchange earnings, employment generation and community development in the coastal region. However, shrimp culture in Bangladesh has been unplanned and led to environmental degradation.

In the present scenario, almost all the economic sectors in the study site are exposed to various natural and anthropogenic threats e.g. coastal storms, sea water intrusion during high tides, improper waste disposal, running heavy vehicles on the beach.

Phase II data collection commenced with a questionnaire provided from Indian collaborators after pilot testing through interviewing 19 individuals from different economic activities across the entire Indian study site Digha-Sankarpur-Mandarmoni. The main rounds of primary data collection were done in two phases from August to November 2014 and again gap filling in February, 2015.. In main rounds of survey 78 samples were collected from 8 economic activities as primary occupations across the five locations (namely Cox's Bazar Town/Sadar, Kolatoli, Laboni beach, Moheshkhali, Sonadia Island) of the study site. The methodology of

sampling used for primary data collection was random. The number of samples collected depending on the extent of the economic activities in each location. Apart from that, all the 8 economic activities were not there in all the five locations specified. Several government offices in the study site and some local community level organizations were visited for collection of information at various levels.

Table A 3: Economic activities studied in Phase II

Sl. No.	Primary Occupation	Sample Size
1	Agriculture	8
2	Fishing	14
3	Salt-shrimp farming	8
4	Hotel and restaurant	12
5	Fish drying	12
6	Hawking	8
7	Photography on sea beach	6
8	Shop business	10
	Total	**78**

Table A4: Government Departments and community level organizations consulted

Government Organization	Autonomous bodies/corporation	Associations/NGOs
1. Department of Fisheries, Ministry of Fisheries and Livestock 2. *Cox's Bazar South Forest Division, Department of Forest, Ministry* of *Environment* and *Forests* 3. **Department of**	1. Fish harbors, landing and distribution centers, ice plants and processing plants, **Bangladesh Fisheries Development Corporation (BFDC),** Ministry of Fisheries and Livestock	1. Cox's Bazar Hotel-Motel and Guesthouse Owners Association 2. Climate Resilience Ecosystem and Livelihood (CREL) project of Winrock International funded

Government Organization	Autonomous bodies/corporation	Associations/NGOs
Agriculture Extension, Cox's Bazar, Ministry of Agriculture 4. *Chittagong coastal forest division, Department of Forest, Ministry* of *Environment* and *Forests* 5. *District Office, Cox's Bazar, Department of Environment*, *Ministry* of *Environment* and *Forests*	2. Marine Fisheries and Technology Station, Cox's Bazar**, Bangladesh Fisheries Research Institute (BFRI)** 3. Hotel Shaibal, Parjatan Holiday Complex Bangladesh, Parjatan Corporation, Motel Road, Cox's Bazar 4. *Development of Salt Production Project* , Bangladesh Small and Cottage Industries Corporation (*BSCIC*)	by USAID, Cox/s Bazar Region, Bangladesh. 3. Dried Fish Traders' Association, *Nazirartek, Cox's Bazar*

Koggala, Sri Lanka

An assessment was made of the various ecosystems found at Koggala and surrounding villages and economic activities carried out within the study site. The main economic activity is tourism which depends largely on the wide sandy beach found at Koggala extending up to Habaraduwa and Ahangama on the west and east, respectively. A large number of hotels have been built within this area to cater for the tourists who come to enjoy the tropical sun and sea. The anticipated sea level rise is a potential threat to the tourist industry.

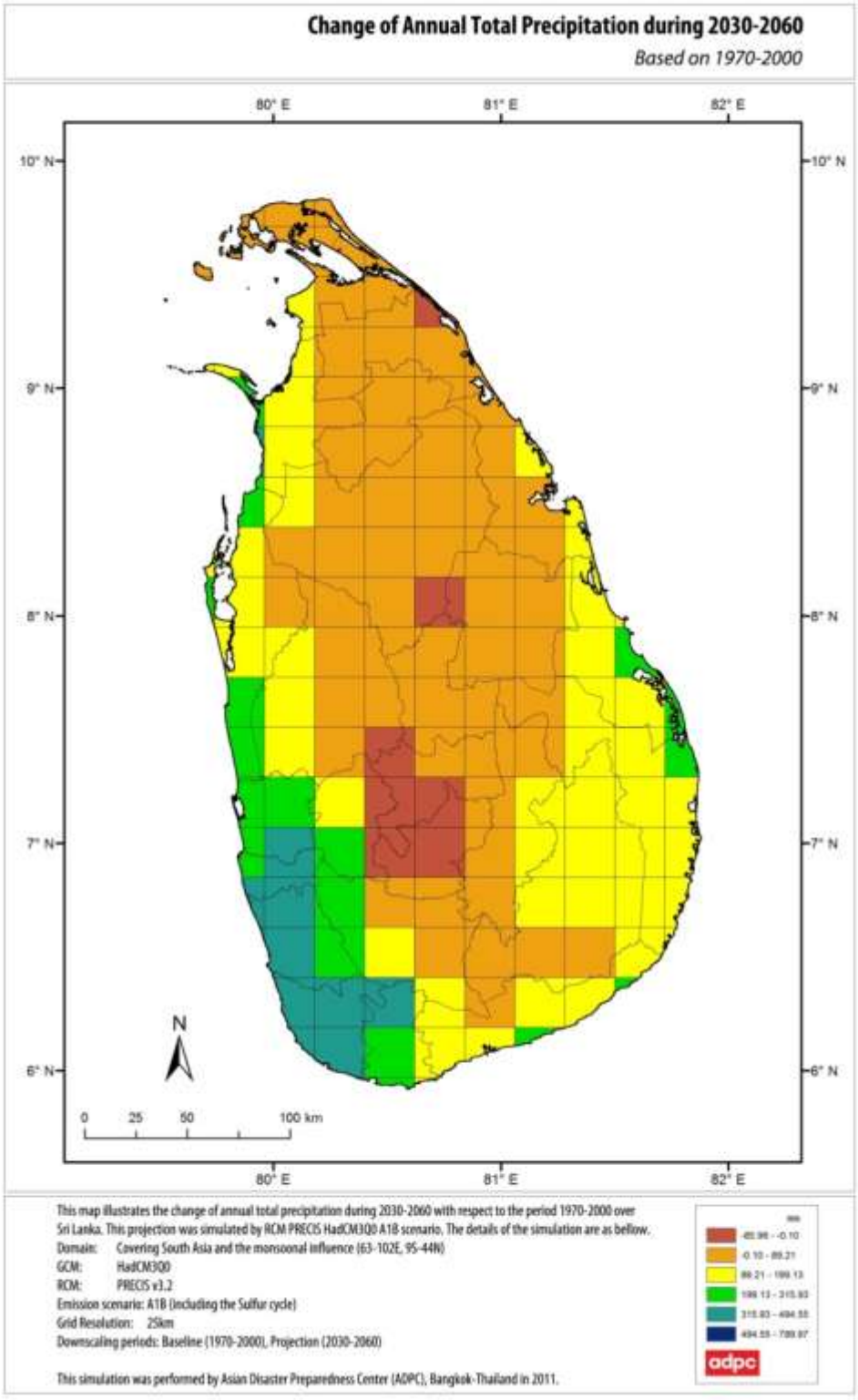
Most of the minor staff employed in the tourist accommodations in Koggala and neighbouring areas are residents of the area. Their fathers had been engaged in traditional activities such as agriculture and fisheries. The hardships encountered in these occupations and their poor monitory benefits had prompted the children of their families to pursue employment in these new economic activities. Lack of cooperation from both the large hotels and industries, it was not possible to interview their staff to gather more information about their shift to new economic activities from their fathers' traditional activities. The other significant activity is the industrial zone comprising many garment and apparel industries

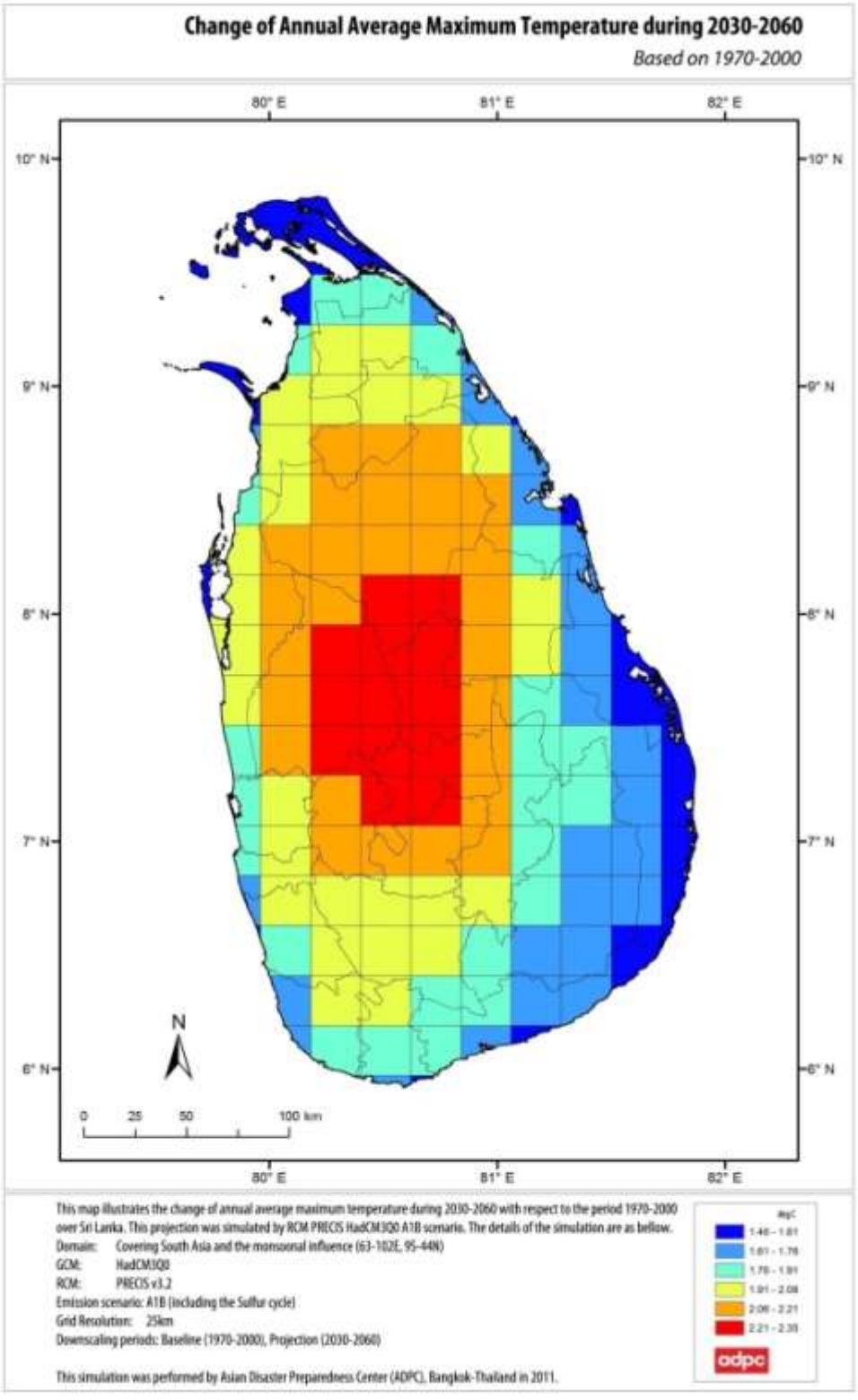
employing a large number of female workers. These workers are also residents of the neighbouring villages and had pursued employment in garment factories as it brings in a regular income unlike in the case of self-employment in cultivation or fishing. Fishing is a less significant activity in the coastal area as priority has been given for the promotion of tourism for which a clean environment is a pre-requisite. This has also prevented local people from enjoying the beach and its environs and as a result there is hardly any economic activity such as vendors on the beach at Koggala. Also, motor cycle riding on the beach is not permitted in Sri Lanka.

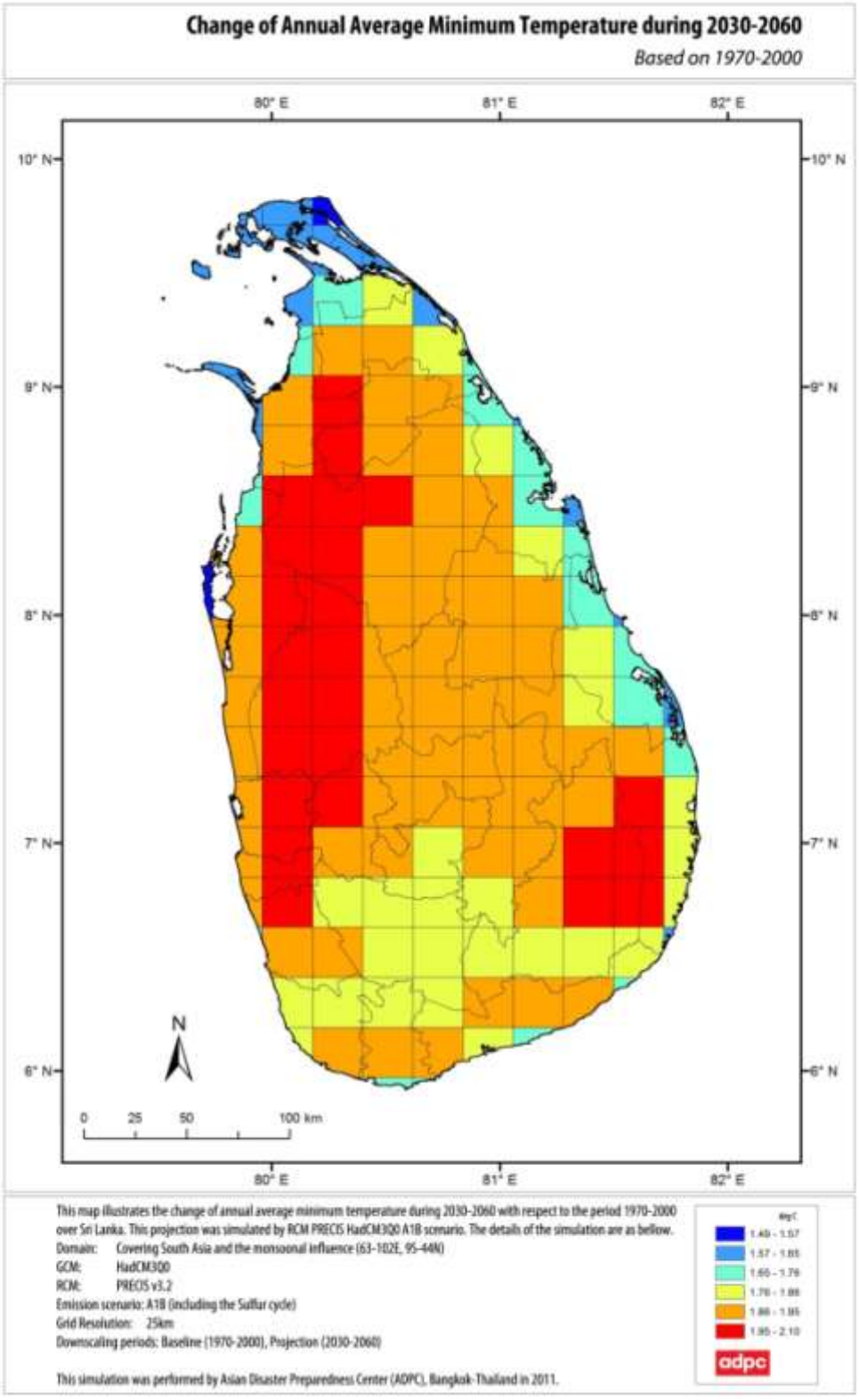
Most people engaged in agricultural and fishing activities make only a subsistence living with the middlemen marketing of their produce earn a substantial share. They also feel that the harvest both on the land and in the lagoon is declining over the years due to increase in salinity and lack of adequate fresh water for agriculture. The high salinity observed apparently is the cause for many of the ills, which unfortunately has been a man-made phenomenon. Both farmers and fishers prefer their children move away from their traditional occupations into government or private sector employment. This would give them more security particularly during late years in life when they are unable to practice their traditional occupations. Sri Lanka lacks a satisfactory social security system on which the self-employed could depend on when they are no longer in a position to look after them.

Though the government has recently launched a safety plan for fishermen, the implementation of its recommendation is yet to be undertaken. Currently, fishers venturing into deep sea receive weather information through national media channels from the local weather station applicable only for the coastal areas. Though there are several websites giving multi-day weather forecasts for the Indian Ocean region, no effort has been made to make this information available to local fishers and farmers. The Southern Coast of the country is vulnerable to cyclonic storms and similar extreme events originating frequently in the Bay of Bengal. The fishermen venturing into the sea from Koggala area too often get caught in such events. They are of the opinion that the occurrence of such events has increased in recent times compared to what it was many years ago.

Appendix II : Projections of future climate over Sri Lanka




Change of Annual Average Maximum Temperature during 2030-2060
Based on 1970-2000
80° E
81° E
82° E
10° N
9° N
8° N
7° N
6° N
N
0 25 50 100 km
This map illustrates the change of annual average maximum temperature during 2030-2060 with respect to the period 1970-2000 over Sri Lanka. This projection was simulated by RCM PRECIS HadCM3Q0 A1B scenario. The details of the simulation are as bellow.
Domain: Covering South Asia and the monsoonal influence (63-102E, 95-44N)
GCM: HadCM3Q0
RCM: PRECIS v3.2
Emission scenario: A1B (including the Sulfur cycle)
Grid Resolution: 25km
Downscaling periods: Baseline (1970-2000), Projection (2030-2060)
This simulation was performed by Asian Disaster Preparedness Center (ADPC), Bangkok-Thailand in 2011.
deg C
1.40 - 1.61
1.61 - 1.76
1.76 - 1.91
1.91 - 2.06
2.06 - 2.21
2.21 - 2.35
odpc


Change of Annual Average Minimum Temperature during 2030-2060
Based on 1970-2000
80° E
81° E
82° E
10° N
9° N
8° N
7° N
6° N
N
0 25 50 100 km
This map illustrates the change of annual average minimum temperature during 2030-2060 with respect to the period 1970-2000 over Sri Lanka. This projection was simulated by RCM PRECIS HadCM3Q0 A1B scenario. The details of the simulation are as bellow.
Domain: Covering South Asia and the monsoonal influence (63-102E, 95-44N)
GCM: HadCM3Q0
RCM: PRECIS v3.2
Emission scenario: A1B (including the Sulfur cycle)
Grid Resolution: 25km
Downscaling periods: Baseline (1970-2000), Projection (2030-2060)
This simulation was performed by Asian Disaster Preparedness Center (ADPC), Bangkok-Thailand in 2011.
1.49 - 1.57
1.57 - 1.65
1.65 - 1.76
1.76 - 1.88
1.88 - 1.95
1.95 - 2.10
adpc

Conferences/Symposia/Workshops

Agenda/Programme (including title, date and venue)

Participants list (comprising contact details of each participant, including organisation, address, phone number, fax number, and email address)

List of participants in Sri Lanka Workshop: January 8- 10, 2015 including field visit

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Government Officers present at the Sri Lanka Workshop Day 3 held on 10.01.2015

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1.	Mr. B.C. Dissanayaka	District Irrigation Engineer	Southern Irrigation Office Talbet Town Galle	Office: 94 912234876 Mobile: 94 773163780 chatudissa@yahoo.com
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3.	Mr. Lasantha Manoj	Disaster Relief Officer	Divisional Secretariat Habaraduwa	Office: 94 91 2283238
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APN Regional Workshop on

Coastal ecosystem and changing economic activities:

Challenges for sustainability transition along the South Asian coasts

Long Beach Resort, Koggala, Sri Lanka

8-10th January, 2015

Programme

Day 1, Thursday, January 08		
09:00 -17:00	Field Visits Suggested Places: Fisheries Harbours at Galle, Mirissa & Tangalle	
Day 2 , Friday, January 09		
	Topic	**Speaker**
09:00 - 09:30	Registration	
09:30 - 09:45	Welcome and Introductions	Janaka Ratnasiri
09:45 - 10:00	Workshop Goals and Overview	Joyashree Roy
10:00 – 10:30	**Tea Break**	
10:30 - 13:00	Field Work progress report by GCP, India	Joyashree Roy
13:00 – 14:00	**Lunch Break**	
14:00 – 15:15	Presentations by Sri Lanka	Janaka Ratnasiri
15:15 – 15: 45	**Tea Break**	
15:45 – 17:00	Presentations by Bangladesh	Giashuddin Miah

Day3 , Saturday, January 10		
09:00 – 09:30	Registration of Govt. Officers	
09:30 – 10:00	Briefing of the Govt. Officers	Joyashree Roy
10:00 – 10:30	Integration of Climate Change results and Discussion of field observations	Moderator: Joyashree Roy Presenter: Sandhya Rao
10:30 – 11:00	**Tea Break**	
11:00 – 13:00	Identifying and Planning future work	Joyashree Roy
13:00 – 14:00	**Lunch Break**	
14:00 - 15:30	Way forward for finishing the report by February	Moderator: Joyashree Roy
15:30 – 16:00	**Tea Break**	
16:00 – 16:30	Open Forum and Conclusion	Moderator: Janaka Ratnasri

Funding sources outside the APN

Institutional contributions as originally mentioned in the project proposal.

List of Young Scientists

The following young scientists worked on the project in India

Name	Institution Affiliation	E-mail/ Mobile number
Debabrata Mandal	Under-Graduate student, Department of History, Jadavpur University and worked as a field investigator in APN project	Mobile no.: +91 9093035093
Debojit Das Mohapatra	Under-Graduate student, Ramnagar College, Purba Medinipur and worked as a field investigator in APN project	Mobile no.: +91 9800349163
Md. Taimur Bin Kashim Khan	Secretary, Bilchatra Anneshan Janakalyan Samity (NGO), Murshidabad and worked as a field investigator in APN project	E-mail: taimur.khan.bajs@gmail.com
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Preeti Kapuria	Postdoctoral Fellow, Global Change Programme, Jadavpur University	E-mail: pkapuria@gmail.com
Rajesh Bhattacharya	Field investigator, Global Change Programme, Jadavpur University	Mobile no.: +91 9433186819

Satabdi Datta	Project Fellow, Global Change Programme, Jadavpur University and Ph.D Scholar, Department of Economics, Jadavpur University	E-mail: sdatta.eco@gmail.com
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Surojit Bhandari	Field investigator, Global Change Programme, Jadavpur University	E-mail: bhandusfi@gmail.com
Uttam Bhuian	Under-Graduate student, Ramnagar College, Purba Medinipur and worked as a field investigator in APN project	Mobile no.: +91 9647112294

Debojit Das Mohapatra:

"Since I worked for Census of India, so I am finding this work somewhat similar. But this will help me for future field work."

Md. Taimur Bin Kashim Khan:

"While doing field survey for the research project I experienced a number of things. The way fishermen in the coastal area struggle to make a living by taking risks has attracted me. Also I have seen people from several other occupations and came to know about the story of their daily survival along with the natural threats. I enjoyed these learning experiences that will help me in my future work. "

Nandan Karan:

"I am born and brought up in Digha coastal area of Purba Medinipur. While doing the field work I got to know about the ground realities and the hardships that the local people of my hometown are facing. Also I developed skills to do field survey for research work that I find very interesting."

Preeti Kapuria:

As a Postdoctoral fellow at the Global Change Programme and also a team member of the research group on this project, I made key contributions to the project. I was actively involved in the preparation of the concept note and periodical reports, designing and revisions of the questionnaire from time-to-time, and an extensive literature review on concepts discussed in the project. The field exposure was as insightful and enriching as was the analysis of the field data. Though I have worked with coastal communities earlier on somewhat similar issues, this work has set me off to an area of research which is not only

exciting but also challenging because of the interdisciplinary nature of the work. I am thankful to the Asia Pacific Network and the Global Change Programme of Jadavpur University for the financial support I received during the entire duration of the project.

Rajesh Bhattacharya:

"I was involved as a field investigator in socio-economic survey done for this research project in Digha- Sankarpur area. In the course of this survey work I had the opportunity of interacting with large number of local residents coming from different cross sections of the society."

Satabdi Datta:

"I was involved in the project with the capacity of Project Fellow. My prime responsibilities included literature study, structuring part of the conceptual framework, questionnaire designing, data collection, data entry and analysis, providing inputs in report writing and administrative works as well. It was indeed a valuable opportunity for me to work with a multidisciplinary team involving all collaborating countries, enrich my understanding and research capabilities and gain new skills in conducting field based research and administrative work. The exposure I got while working in the research project enabled me to broaden my scope of thinking, analyzing things and to build my confidence in proceeding with my own research interests in future."

Suman Dutta:

"Since the very beginning of this research work I was one of the field investigators in the primary survey done in Digha- Sankarpur- Mandarmoni coastal area. During my several visits to the field I met a number of people, got the scope to interact with them and had an in depth view of the area. This work helped me to enrich my skills in organizing primary survey and dealing with people."

Surojit Bhandari:

"I was a part of the team doing primary data collection in Digha- Sankarpur- Mandarmoni area for this research project. This work gave me the scope to meet and interact with people from various occupational statuses. It helped me to learn how to extract information from unknown people, know about their livelihood and state of living. This work experience has made me more confident in doing field survey."

The following young scientists worked on the project in Bangladesh

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Md. MezanurRahman MS student	Department of Agroforestry and Environment, BSMRAU	Shaon_pstu@yahoo.com

Md. HelalUddin MS student	Department of Agroforestry and Environment, BSMRAU	helal.bsmrau@gmail.com

The following young scientists worked on the project in conducting the interviews with the respondents in Sri Lanka including members of the public and government officials and collecting the necessary data. They also spent time in analyzing the data collected.

Name	Address	E-mail
Mr. H.M.TharinduN.B.Herath, BSc (Hons)	Department of Fisheries and Aquaculture, Faculty of Fisheries and Marine Science, University of Ruhuna, Matara	tharindunimantha09@gmail.com,
Ms. K.P.G.K. PiyumiGuruge, BSc (Hons)	Department of Oceanography and Marine Geology,Faculty of Fisheries and Marine Science, University of Ruhuna, Matara	piyumiguruge87@gmail.com,
Ms. P.A. KushlaniN.Dissanayake,BSc (Hons)	Department of Oceanography and Marine Geology,Faculty of Fisheries and Marine Science, University of Ruhuna, Matara	kushlanidissanayake@gmail.com,
Ms. Wathsala K. Suwandhahannadi, BSc (Hons)	Department of Limnology, Faculty of Fisheries and Marine Science, University of Ruhuna, Matara	wathsala05kk@yahoo.com,

Mr. B.M. MaleenRajapaksha, BSc (Hons)	Department of Limnology, Faculty of Fisheries and Marine Science, University of Ruhuna, Matara	maleen_flm@yahoo.com,
Mr. A.M.KasunA. Bandara,BSc (Hons)	Department of Fisheries and Aquaculture, Faculty of Fisheries and Marine Science, University of Ruhuna, Matara	kasuab87@gmail.com

P.A. Kushlani N. Dissanayake

“I worked as a research assistant in the project mainly involving in the data collection and analysis. This project made me realize the value of working together as a team and was a new experience in working environment, with challenges facing every minute. The experiences and knowledge that I have gained by participating in this survey are immeasurable. The exposure I received during my participation at the workshop with the Indian scientists was very useful. I do believe that from the experiences I gained from this I can easily step in to the practical management initiatives while contributing my effort to support the country with ecosystem management as well as to explore my career as a marine scientist. Thank you very much for giving me this opportunity to serve my country”.

A. M. Kasun A. Bandara

“I contributed to the project through data collection and data analysis. This project improved my experiences in social researches and ability in analyzing data and was a great opportunity to get a proper idea on implications of climate changes on livelihood of coastal communities in the southern region of the country”.

H.M.Tharindu N.B. Herath

“As a research assistant cum data analyst in the project, I have gained innumerable experience over climate change phenomenon in most practical way. Before delving into the research I have understood climate change impacts over coastal ecosystems only through literature. After I got involved into this research I could understand how much it impinges on

people's lifestyle and in day-to-day life. After I started work on this research I could learn many more about climate change effects and I am keenly interested in pursuing further research in the field; especially the climatic change assessment methods and how they could describe the existing situation".

K.P.G.K.Piyumi Guruge

"I worked in the APN project as a junior researcher. I was involved in data collection and analysis. It was great opportunity for me to gain practical experience in this field. During our undergraduate period, theoretical aspects about impacts of climate changes on people were studied. Practical experience of it was gathered during this survey. Also it helped me to develop some qualities in myself like communication skills with different stake holders, skills on statistical applications etc. I gave my fullest capacity to achieve goals in this survey according to best of my knowledge".

Glossary of Terms

AR4	Fourth Assessment Report
AR5	Fifth Assessment Report
AML	Annual Monetary Loss
BL	Baseline
CC	Climate Change
CDD	Consecutive dry days
CORDEX	Coordinated Regional climate Downscaling Experiment
CSDI	Cold Spell Duration Indicator
CV	Coefficient of Variation
CWD	Consecutive wet days
DS	Divisional Secretariat
DTR	Diurnal Temperature Range
E	East
ETCCDI	Expert Team On Climate Change Detection And Indices
GCM	Global Circulation Models
GSOD	Global Surface Summary of the Day
HadAM3	Hadley Centre Atmospheric Model 3
HadCM3	Hadley Centre Coupled Model, version 3
IITM	Indian Institute Of Tropical Meteorology

IMD	Indian Metrological Department
IPCC	Intergovernmental Panel On Climate Change
JF	January, February
JJAS	June, July, August, September
LBCs	Lateral Boundary Conditions
LPA	Long Period Average
m	Meter
MAM	March, April, May
MC	Mid Century
mm	Millimeter
N	North
NE	North East
NW	North West
OND	October, November, December
PPE	Perturbed Physics Ensemble
PRCPTOT	Wet-day precipitation
PRECIS	Providing Regional Climates For Impact Studies
QUMP	Quantifying Uncertainty In Model Predictions
R	Rainfall
R10mm	Heavy precipitation days
R20mm	Very heavy precipitation days
R95p	Very wet day precipitation
R99p	Extremely wet day precipitation
RClimDex	Climate Index calculator using statistical package R
RCM	Regional Climate Models
RCP	Representative Concentration Pathway
RP	Recall Period
RR	Daily Rainfall
RX1day	Max 1-day precipitation
RX5day	Max 5-day precipitation
SDII	Simple daily intensity index
SMHI	Swedish Meteorological and Hydrological Institute
sq km	Square Kilometer
SRES	Special Report On Emission Scenarios
SW	South West
SWAT	Soil And Water Assessment Tool
TG	Daily mean temperature

TN	Temperature - Minimum
TN10p	Cool night frequency
TN90p	Hot night frequency
TNn	Coolest night
TNx	Hottest night
TX	Temperature - Maximum
TX10p	Cool day frequency
TX90p	Hot day frequency
TXn	Coolest day
TXx	Hottest day
W	West
WSDI	Warm Spell Duration Indicator
°C	Degree Centigrade

In the Appendix section, the report may also include:

- *Actual data or access to data used in the study*

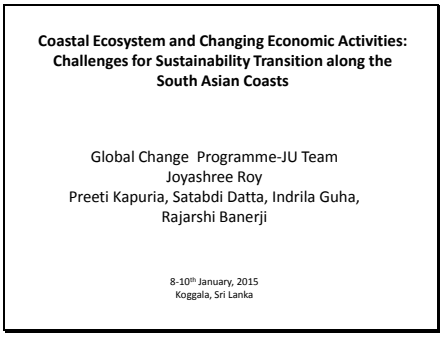
The study data can be assessed at:

https://www.dropbox.com/sh/p6jezed0ebf51zh/AABuH4hE-7iSwlBPZGIQMheja?dl=0

- *Abstracts, Power Point Slides of conference/symposia/workshop presentations*

Sri Lanka Workshop: Day 1: Presentation slides of Prof. Joyashree Roy

Slide 1



Slide 2

Slide 3

2. Workshop Goals and Overview

- Field study done to identify:
  - Current economic actor specific approach
  - Resilience building? Risk enhancing? How?
  - Risk [in outcome] reduction and /or vulnerability [to threat] (exposure-f, Sensitivity –intensity, Adaptive capacity-intervention) reduction
  - Current situation and direct beneficiary stakeholder assessment/awareness level

Slide 4

3. Workshop Goals and Overview

- Resilience Building and Risk Reduction experiments/scale up/ success stories/barriers?
  - Of direct stakeholders ?
  - Of Government ?
    - Plan for involving policy makers? –group work
    - How long they will be present?
    - What composition: dept.s?
    - What is their expectation?
    - How is policy formulated: involves whom?

Slide 5

4. Workshop Goals and Overview

- To conclude Most threatened coastal system , community, in study area: (By NT, AT)
- Metric to show link between ESS and Eco Act
- Specific sustainability actions?
- video film to **show problem complexity** of coastal system based activities/communities

- **Resilience score**
- **By today we are to finish to verify with policy makers in SL**
  - Bangladesh
  - India
  - Sri lanka

Slide 6

Study Objectives:

1. Identification and characterisation of the coastal ecosystems in SA
2. Identification and understanding of the traditional and new economic activities
   1. actors along the coast line
   2. changing pattern through first hand recall method
   3. mapping to ecosystem services
3. Preparation of Inventory of ecological functions based economic activities
   1. Resilience level.
4. Generation of historical data on climate parameters in order to predict future scenarios for each specific study site.
5. Application of stakeholder behaviour analysis in ecology–economy interaction framework.

Slide 7

Year 2: Objectives

1. Assessment of resilience level of various economic activities given their ecosystem dependence structure identified in year 1.
2. Historical data on climate parameters in order to predict future scenarios for each specific study sites.
3. Stakeholder behavior analysis in ecology –economy interaction framework.

Slide 8

Selection of study sites: Two main criteria for site selection adopted in year 1

1. Sites that are highly vulnerable to anthropogenic actions (both direct and indirect), and natural phenomenon impacting the flow of ecological services which in turn changes the livelihood patterns, lifestyles or poses threat to associated communities or to the system itself, and
2. Sites drawing favoured policy attention because of their importance in meeting regional developmental goals in respective countries.

Slide 9

Specific goals in Year 2

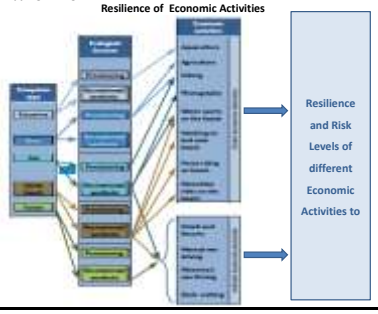
*To study the Resilience and Risks of **anthropogenic and natural threats** on the socio-economic system parameters of the study site specific stakeholders*

Box 1: Specific goals :

1. identifying threats to natural and social (economic) systems
2. identifying vulnerabilities of the social-natural system to these threats
3. opportunities for reducing risks

Slide 10

Mapping Ecological functions to Economic Activities and the assessment of Resilience of Economic Activities



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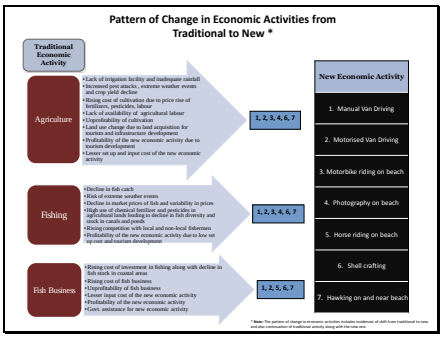

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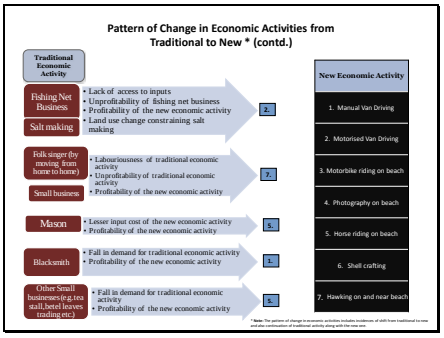


Slide 13

The Study Site in India

- The study site of India is Digha- Sankarpur – Mandarmoni coastal belt.
- It is located in Ramnagar I and II blocks of Purba Medinipur district in West Bengal, India corresponding to the coastline from latitude 21.66° N and longitude 87.70° E to latitude 22.72° N and longitude 88.22° E.
- It comprises beach areas of Dattapur, New Digha, Old Digha, Sankarpur, Tajpur and Mandarmoni.
- The study area has 51 mouzas (or villages) covering an area of 69 sq.km and has population density ranging from 10 to 10,000 persons per sq km.

Figure. 1: Digha and adjoining areas
Source: IL&FS, 2012

Slide 14

Frequently asked questions

Question 1: What are the major threats to different economic activities in the region?

Question 2: How can resilience of these activities to various threats be determined?

Slide 15

Major Steps in Phase II data collection

- Phase II data collection commenced with a pilot testing of questionnaire by interviewing 19 individuals from different economic activities across the entire Indian study site
- Pilot data collection : An overall understanding of the study site through observation and consultation with various stakeholders e.g. individuals from different economic activities, fisherman association, hotelier's association, govt. officials in the study site of the concerned departments and key informants in the study site, partner countries
- Analysis of pilot survey data and other information, revisions and final drafting of individual and official's questionnaire
- The main rounds of primary data collection were done in three phases from September till November 2014 and will be done finally after the workshop as well
- In main rounds of survey 113 samples were collected from 13 economic activities across six locations of the study site
- The methodology of sampling used for primary data collection was random. In each location it was targeted to collect at least two samples for each economic activity as identified previously. However, in some cases it was less than two due to unavailability of samples. Apart from that, all the 13 economic activities were not there in all the six locations specified
- Govt. offices and some organizations were visited for collection of information at various levels. How many we got feedback from

Slide 16

Interviewees ?

Sl. No.	Economic Activities studied
1	Agriculture
2	Aquaculture
3	Deep Sea Fishing In Trawler
4	Fishing In Mechanised Boat
5	Fishing In Manual Boat
6	Fish Drying
7	Hawking On And Near Beach
8	Shell Crafting
9	Manual Van Driving
10	Motorised Van Driving
11	Horse Riding On Beach
12	Photography On Beach
13	Hotels And Resorts

Govt. Departments and other organizations consulted	
Digha Sankarpur Development Authority (DSDA), Urban Development Dept, Govt. of West Bengal	Forest Ranger Office (Contai Section), Govt. of West Bengal
Irrigation and Waterways Dept (Contai Section), Govt. of West Bengal	Marine Aquarium & Research Centre, Zoological Survey of India, Govt. of India
State Fisheries Development Corporation Ltd (Alampur), Undertaking of the Govt. of West Bengal	Digha Science Centre & National Science Camp, National Council of Science Museums, Ministry of Culture, Govt. of India
Fisheries Department (Contai Section), Govt. of West Bengal	Fishermen's and Fish Trader's Association, Digha Mohona
Agriculture Department, Govt. of West Bengal	Hotellier's Association (Digha and Mandarmoni)

Slide 17

Questions asked:

1. List of major threats (natural and anthropogenic) to various ecosystem services and then on economic activities
   1. frequency of occurrence of these threats in the study site?
   2. How are different economic activities impacted due to various threats?
2. Importance of various adaptation strategies for different economic activities.
3. Categorize the impact of various threats on respondent's household in terms of fixed asset loss, income loss, health risk, property loss, risk to lives, etc.

Slide 18

Natural threats to ecosystem services:

- Coastal storms
- Sea water intrusion during high tide during full moon and new moon
- Flooding due to heavy rainfall
- Inadequate rainfall
- Coastal erosion

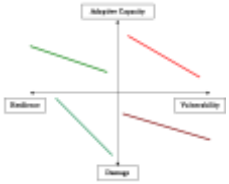
Slide 19

Anthropogenic threats to ecosystem services:

- Waste water from hotels and restaurants polluting the coast and the sea
- Pollution and other hazards caused by vehicles operating on the beach
- Sand mining

Slide 20

Conceptual frame

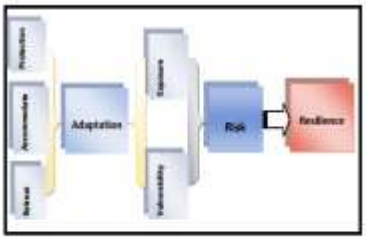


Slide 21

Conceptual Frame

Slide 22

Conceptual framework: Year 2



Slide 23

Question: How is Resilience Identified?

1. Identification of natural and anthropogenic threats to different economic activities based on stakeholders' perceptions

Natural threats :
- Coastal storms
- Sea water intrusion during high tide during full moon and new moon
- Flooding due to heavy rainfall
- Inadequate rainfall
- Coastal erosion

Slide 24

2. Vulnerability assessment of different economic activities to various threats based on stakeholders' perceptions

- Exposure : level of impact to an event
- Sensitivity : Intensity of impact
- Adaptive capacity :

Slide 25

Exposure Score

Frequency of occurrence of a threat

0- No exposure due to absence of threat,
1- Exposure is marginal due to absence of information or the exposure is very recent ,
2- Exposure to some extent as the threat exists from the last 3-5 years or time interval of the threat is 1-2 times every year / once in 4 years,
3- Exposure increasing as the existence of threat increases to 6-8 years or the time interval of the threat decreasing further to once in 3 years/once in 3 months
4- Exposure to the **threat exists** even after 9-10 years or the frequency of occurrence is high over a short period (alternate years/once in every 2 years),
5- Exposure is high over a short period or the exposure exists for a long period now (more than 10 years) ,
6- Exposure is very high over a short period (3-4 times in a month/ multiple times in a year).

Higher the exposure, greater the vulnerability to threats

Slide 26

Sensitivity score

Intensity of impact of various threats on different economic activities

1- no impact on economic activities; **not sensitive**
2- marginal impact on economic activities; **marginally sensitive**
3- medium impact on economic activities; **sensitive**
4- very significant impact on economic activities; **highly sensitive**

Greater the intensity of impact higher is the vulnerability to threats

Slide 27

Adaptive capacity score

Interventions/ strategies that have been implemented or are proposed in order to withstand the impacts of shocks/threats that may have occurred in the past or are likely to occur in the near future

These interventions/strategies can be categorized into one of the following:

- Technical
- Financial
- Institutional

Stronger/effective the adaptive capacity, lower is the vulnerability to threats

1- significantly beneficial strategy, 2- beneficial to some extent, 3- not relevant, 4- limited coverage, 5- absence of strategy, 6- not aware of the existence of strategy/intervention

Slide 28

3. Risks associated with various threats to different economic activities based on stakeholders' perceptions

Risk - in terms of Income loss due to the occurrence of a threat

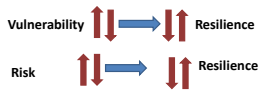
Based on the threat perception, risk score is formulated :

Percentage of sampled population	Risk grading	Risk score
1-30	Low risk	1
30-60	Medium risk	2
60-100	High risk	3

Slide 29

Resilience assessment

Vulnerability score X Risk score = Resilience score/level



Slide 30

Bottom up Approach
Stakeholder, community
supply side, demand side

Building up from
Observing the Behaviour
of direct stakeholders

Slide 31

Jadavpur University

Thank you

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Sri Lanka Workshop: Day 1: Presentation slides of Dr. Janaka Ratnasiri:

Slide 1

Coastal ecosystem and changing economic activities: Challenges for sustainability transition along the South Asian coasts

8-10th January, 2015
Koggala, Sri Lanka

Presentation by
Janaka Ratnasiri

Slide 2

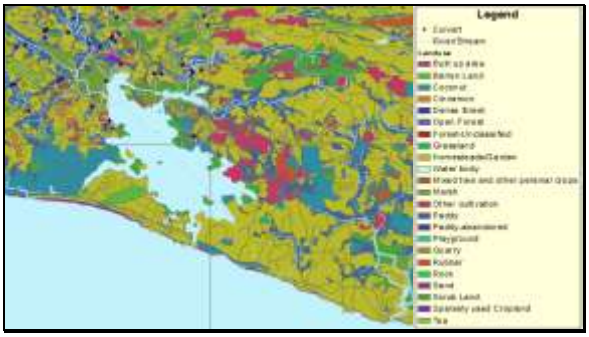
Sri Lankan Team
Janaka Ratnasiri
Terney Pradeep Kumar
Shamen P Vidanage
Chinthaka S. Lokuhetti

Indian Collaborating Team
Joyashree Roy,
Preeti Kapuria &
Satabdi Datta

31 October 2013

Slide 3

Slide 4



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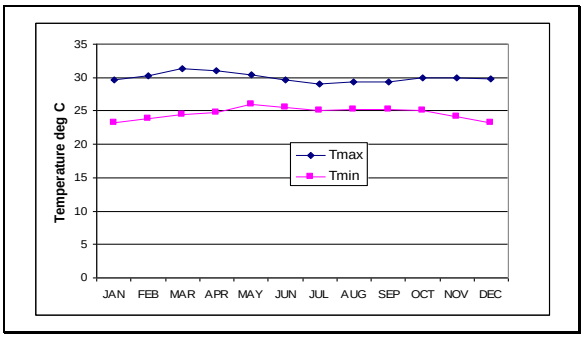

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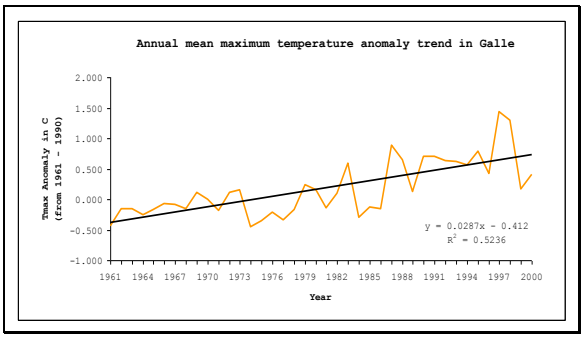

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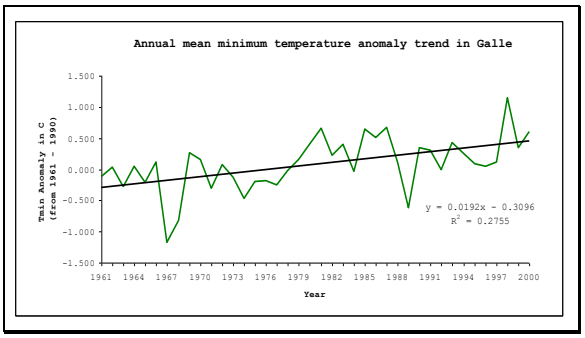

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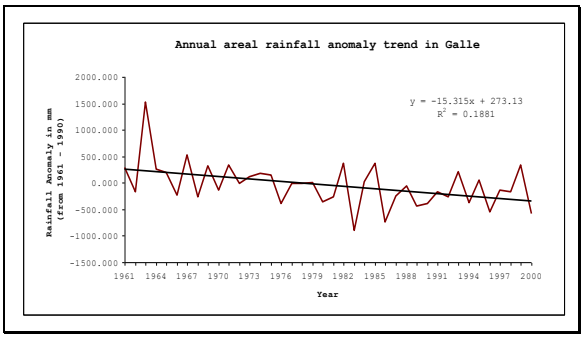

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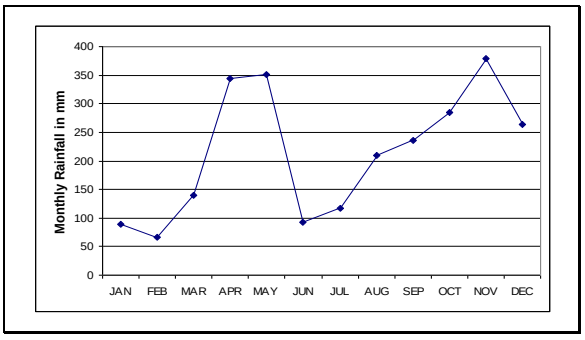


Slide 17

Scenario	Temperature Rise in °C in SWM months in 2100			
	HadCM3 +	CSIRO -	CGCM +	Mean
A1FI	2.5 - 3.0	2.2 - 2.4	2.0 - 2.2	2.4
A2	2.1 - 2.5	1.9 - 2.0	1.7 - 1.8	2.0
B1	1.1 - 1.4	1.0 - 1.1	0.9 - 1.0	1.1

Scenario	Change in Rainfall in SWM months in 2100			
	HadCM3 +	CSIRO -	CGCM +	Mean
A1FI	0 - 476	2 - 157	-190 - 6	-94 - 213
A2	0 - 403	2 - 133	-161 - 5	-80 - 180
B1	0 - 215	1 - 71	-86 - 3	-43 - 96

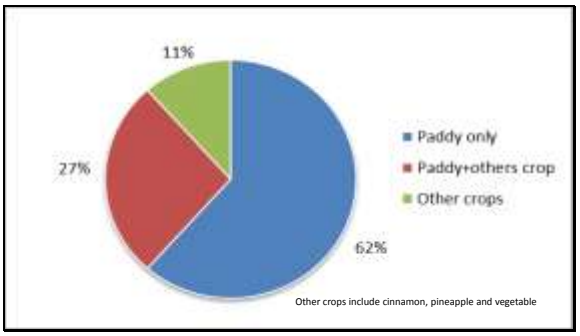
Slide 18

Year 1 Work

Socio-economic survey carried out in following 4 sectors among respondents living in and around the village of Koggala:

- Agriculture 30
- Fisheries 30
- Industries 23
- Hospitality 26

Slide 19



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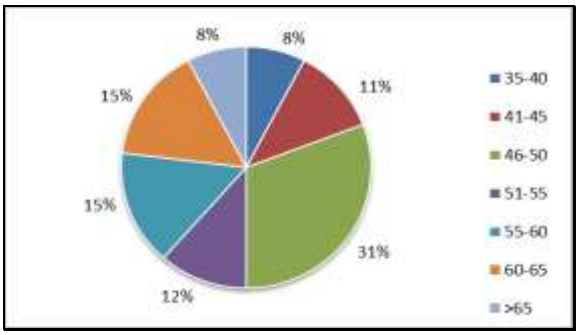

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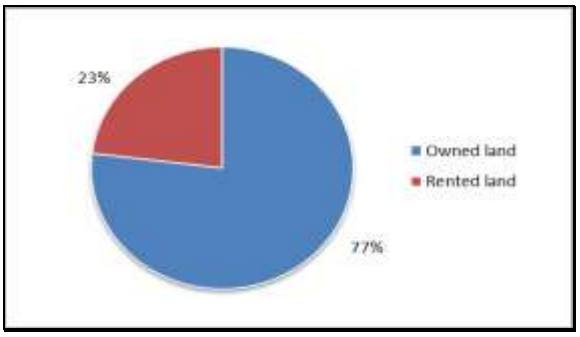

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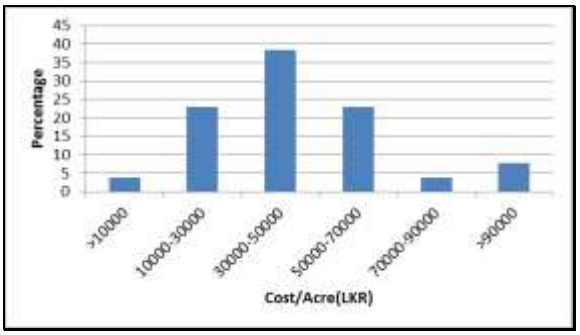

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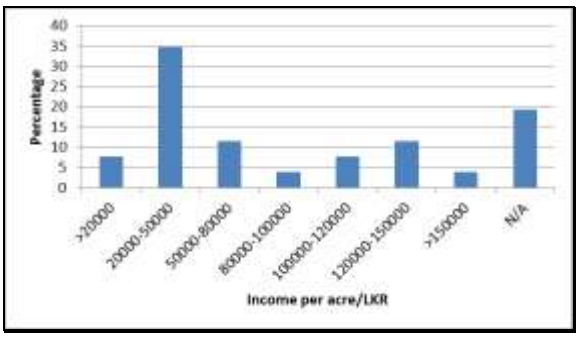

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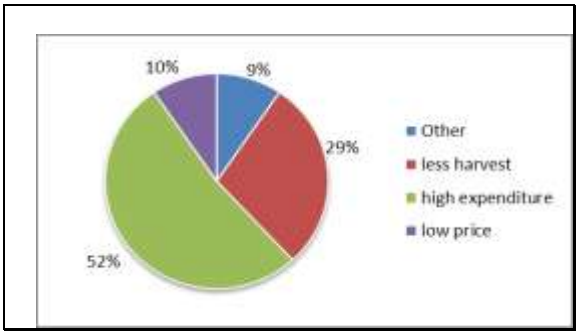

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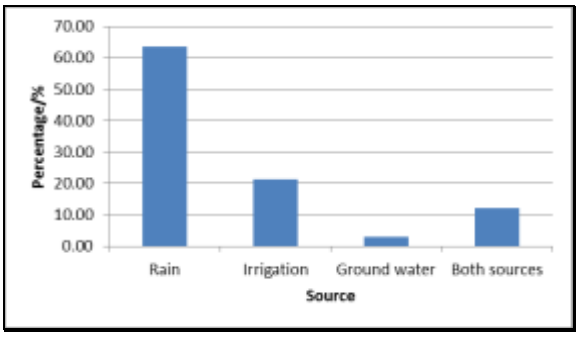

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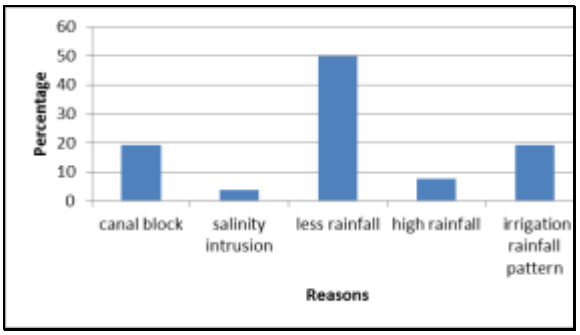

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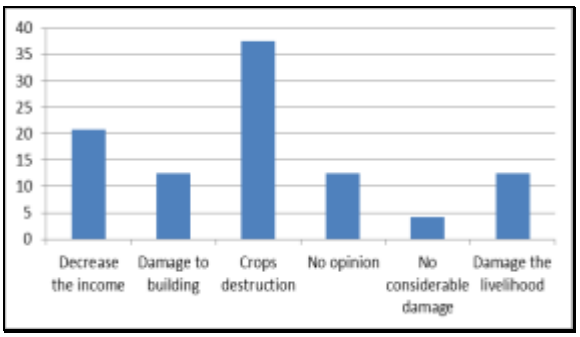

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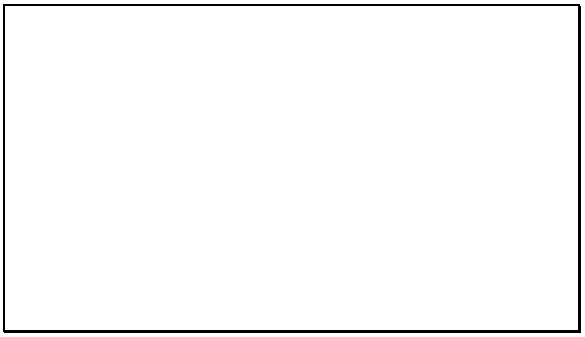

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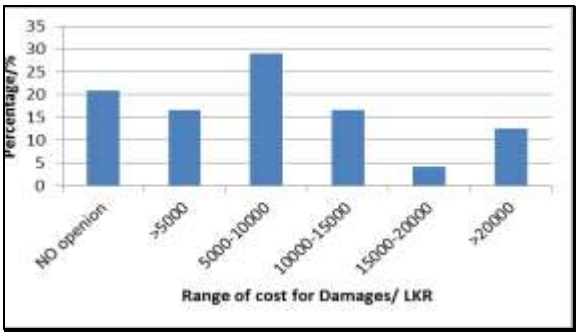

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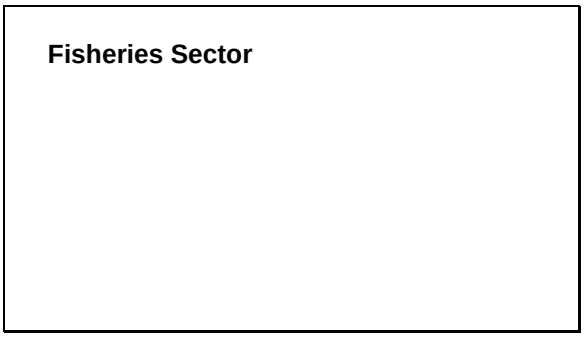

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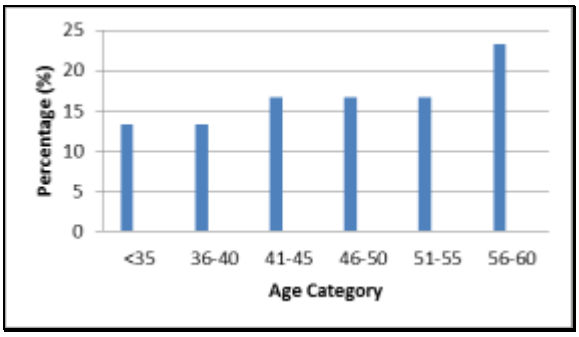

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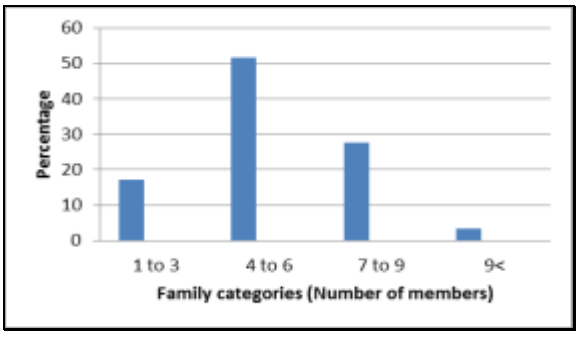

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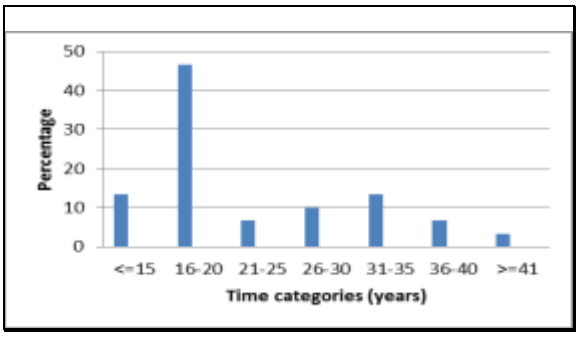

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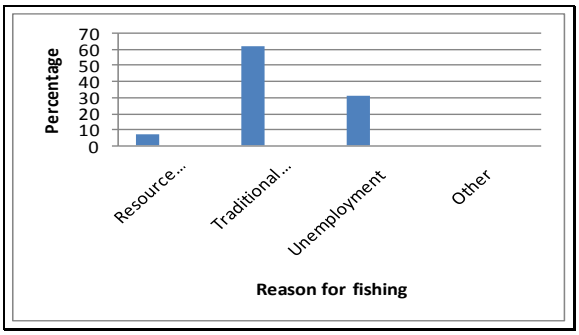

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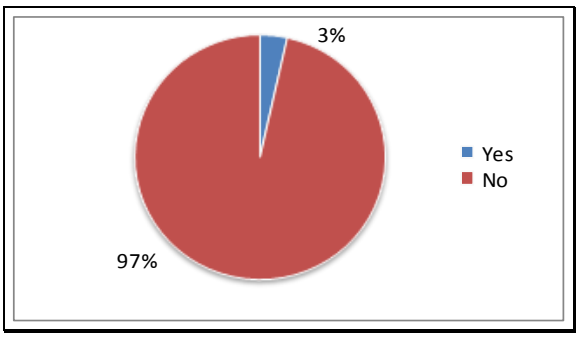

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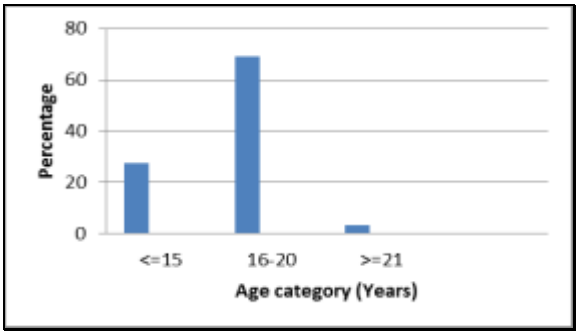

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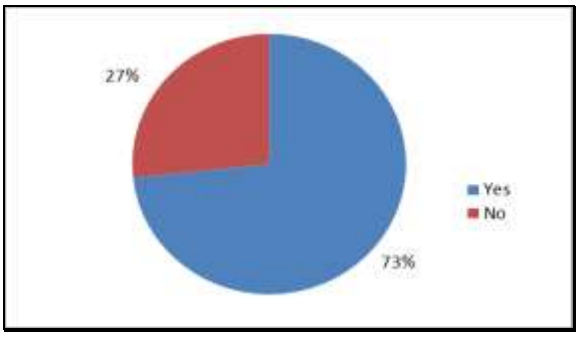

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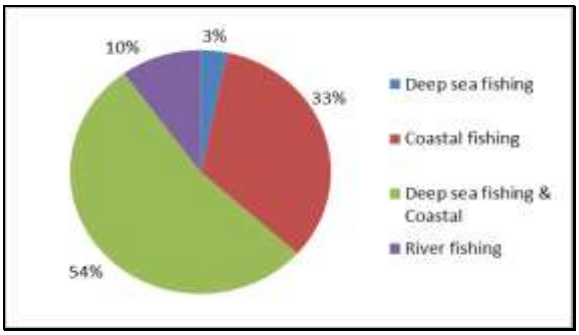

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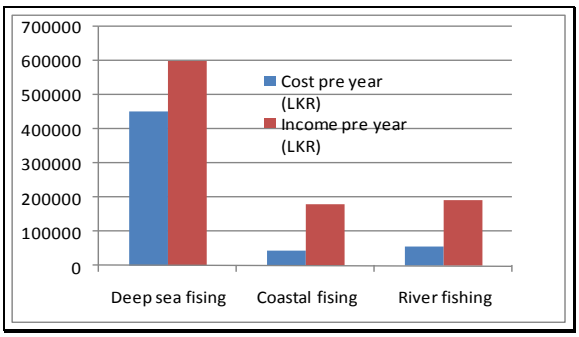

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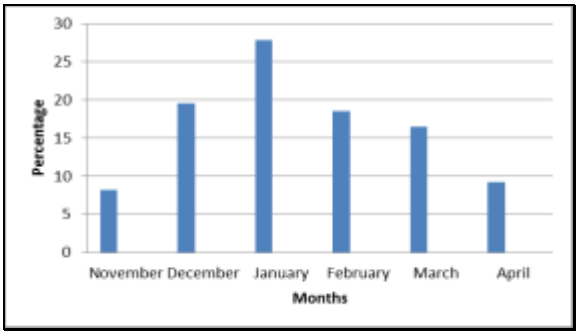

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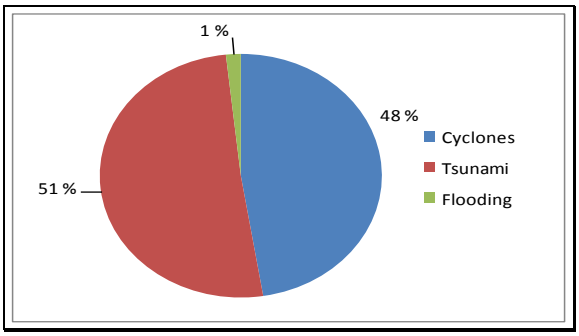

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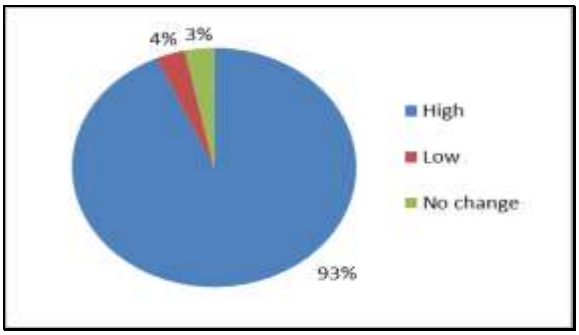

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Industrial Sector

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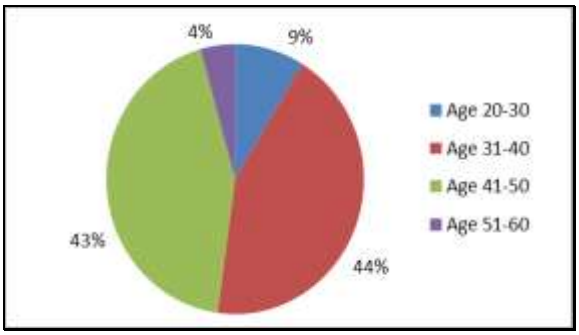

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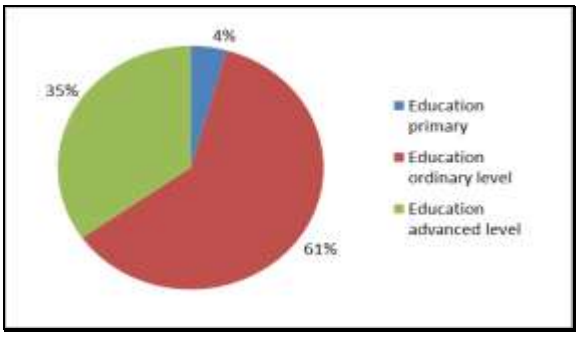

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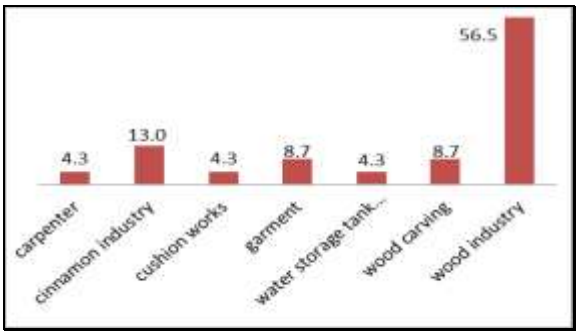

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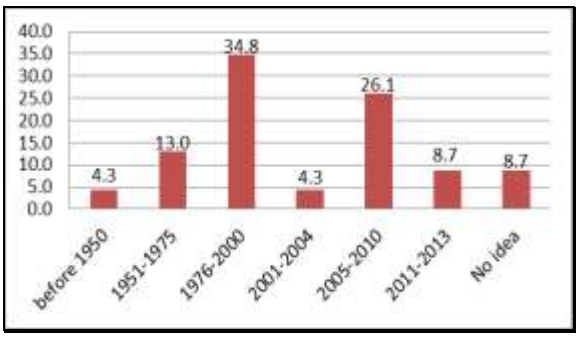

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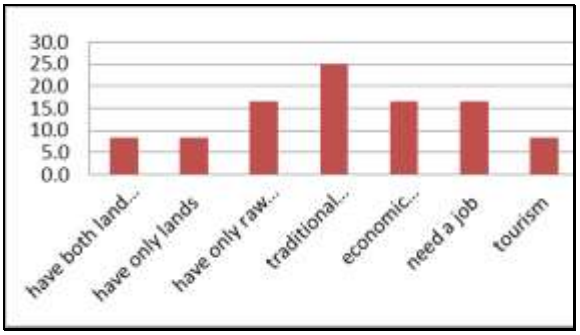

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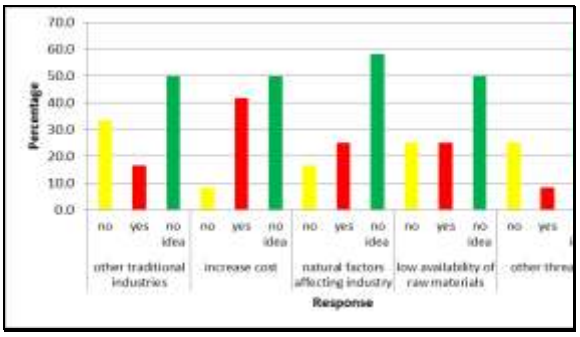

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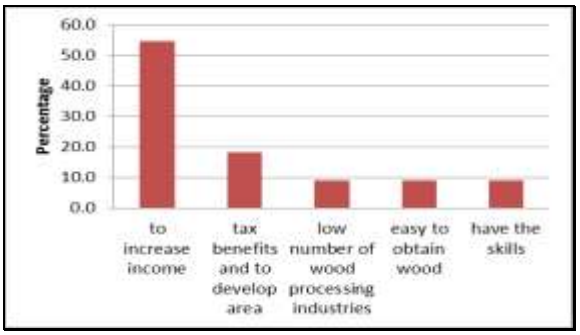

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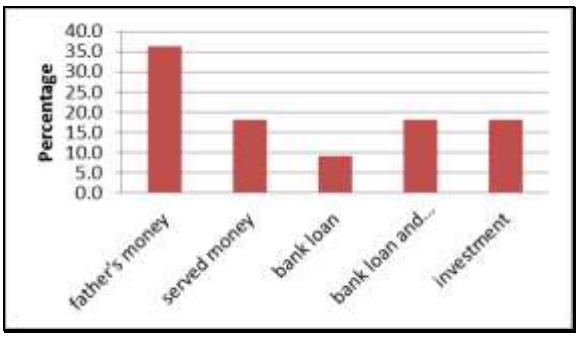

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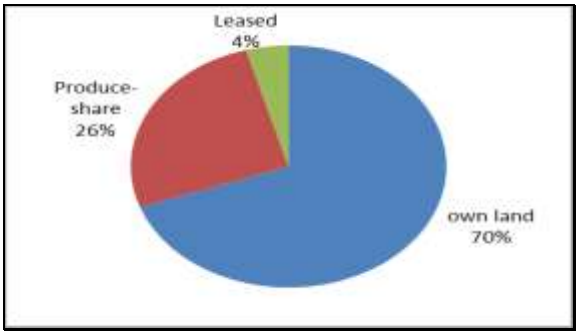

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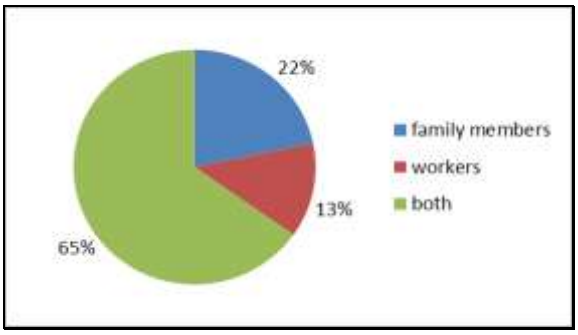

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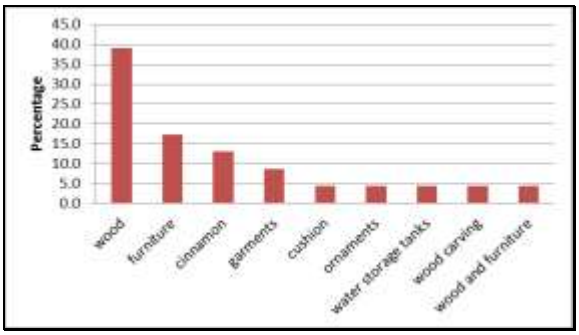

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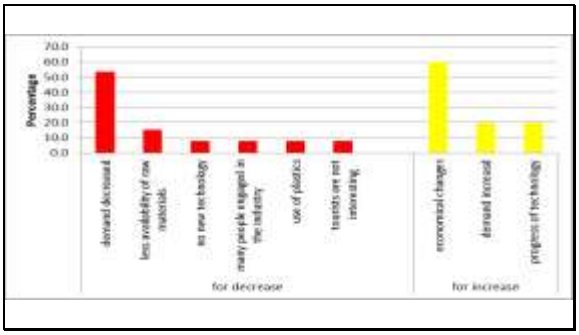

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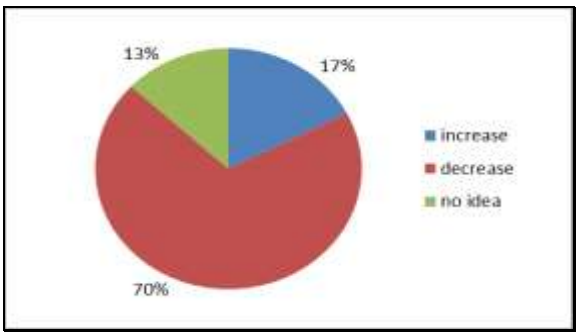

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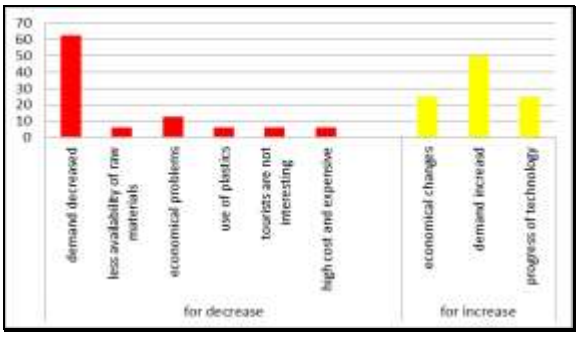

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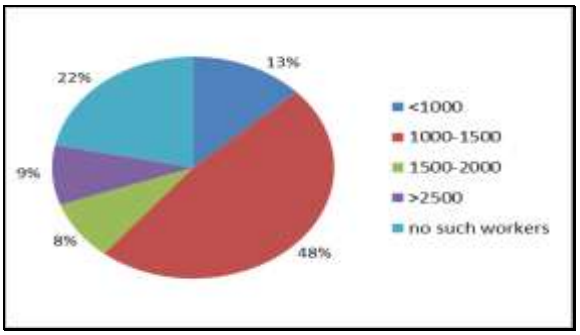

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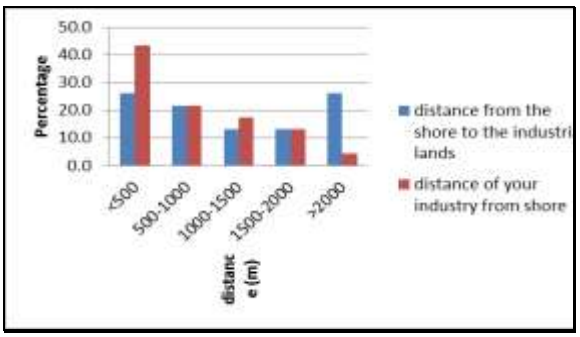

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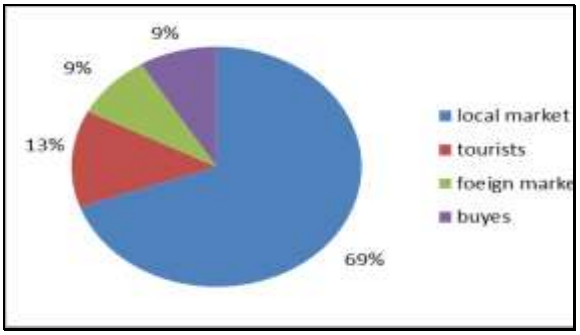

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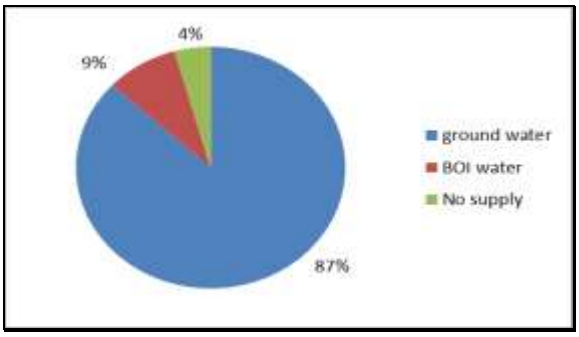

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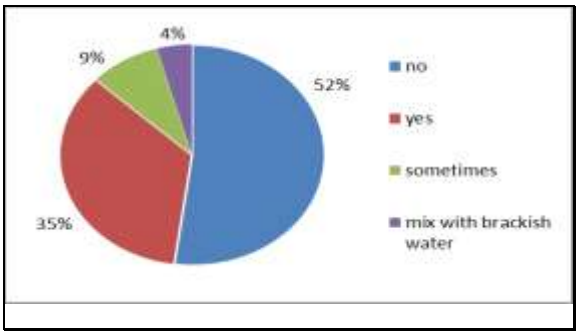

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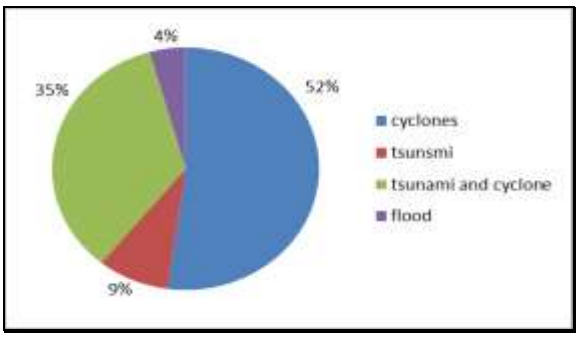

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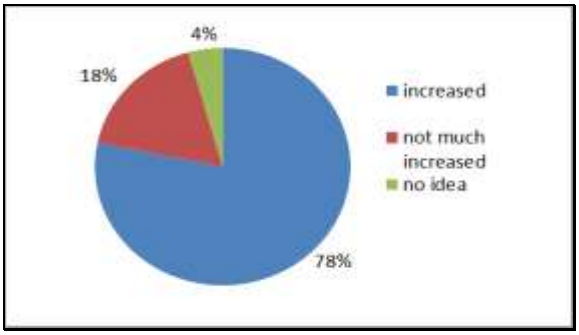

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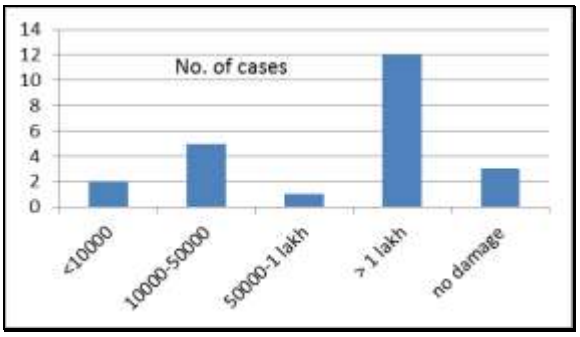

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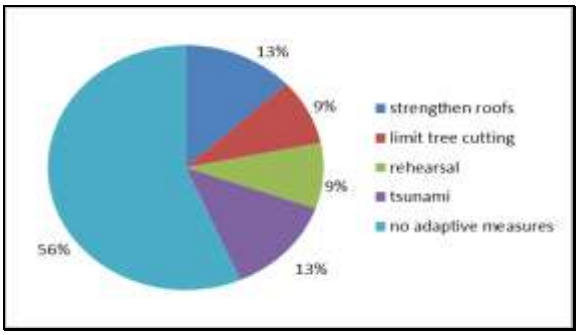

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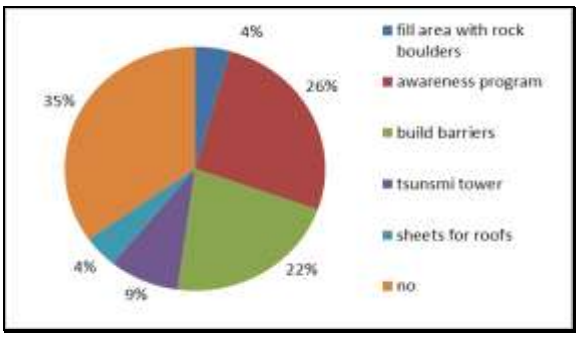

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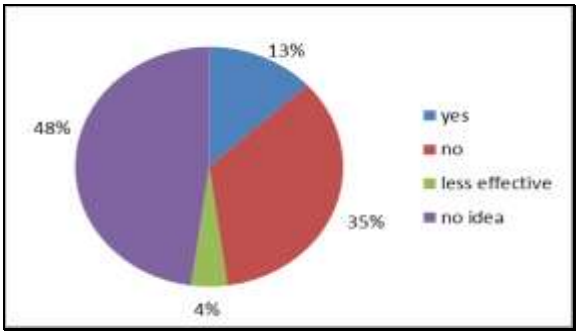

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Hospitality Sector

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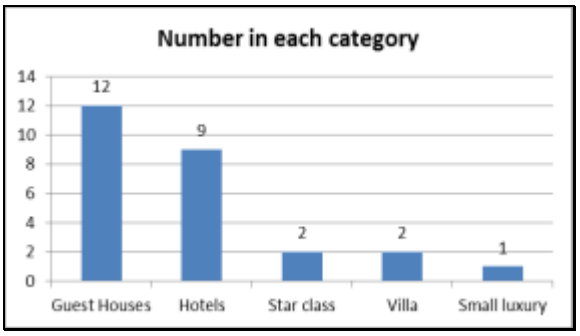

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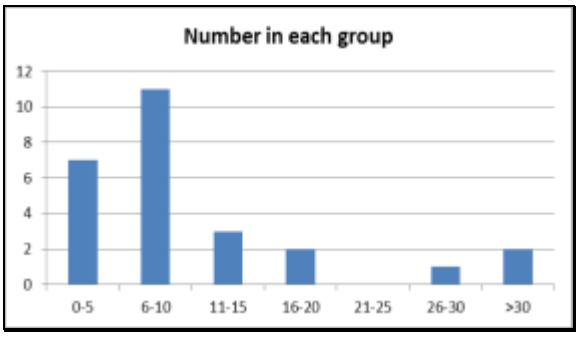

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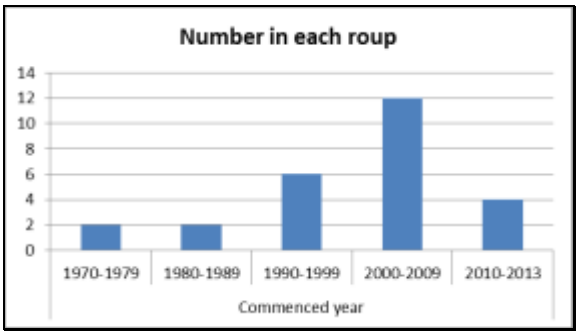

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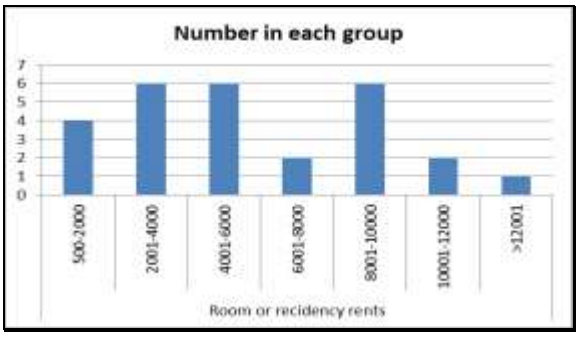

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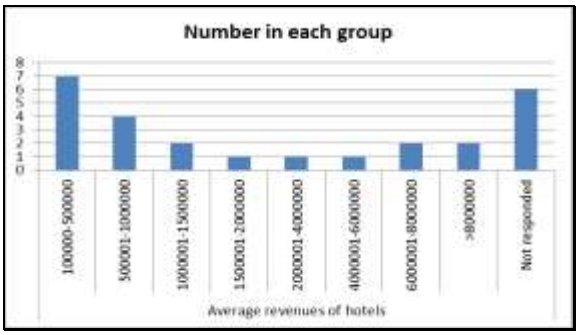

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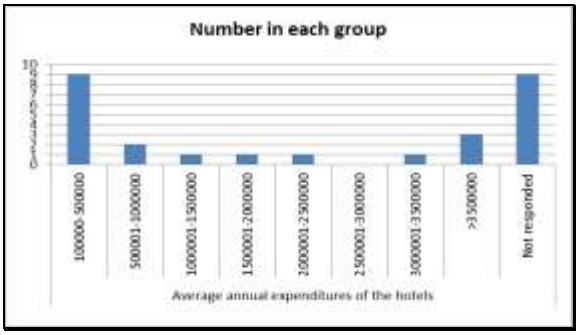

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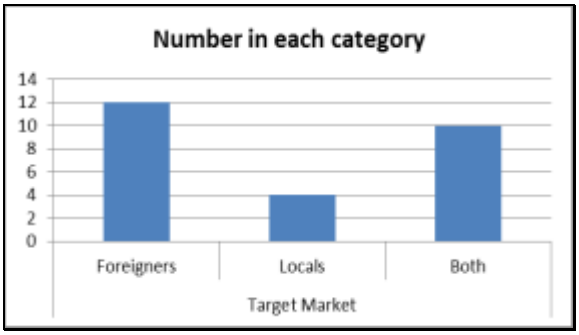

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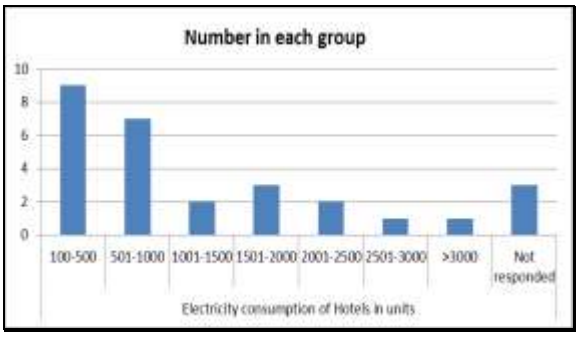

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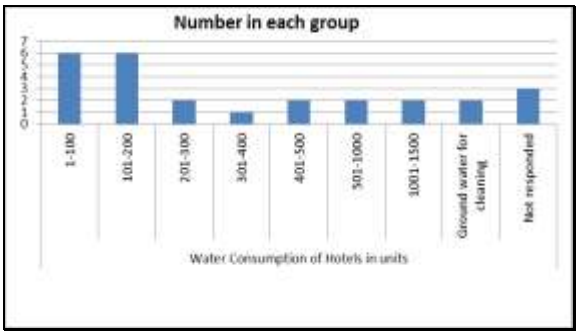

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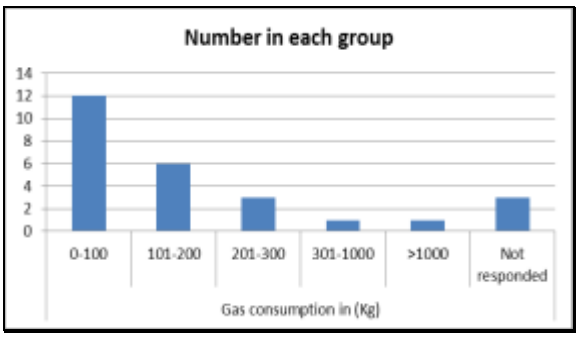

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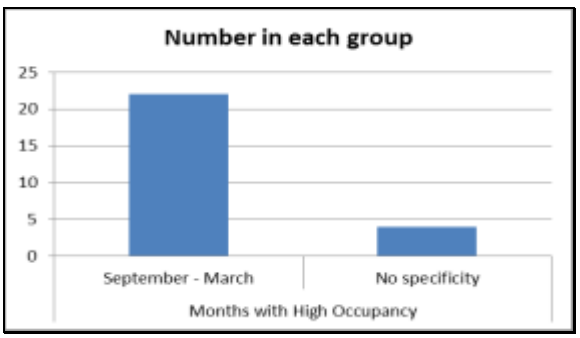

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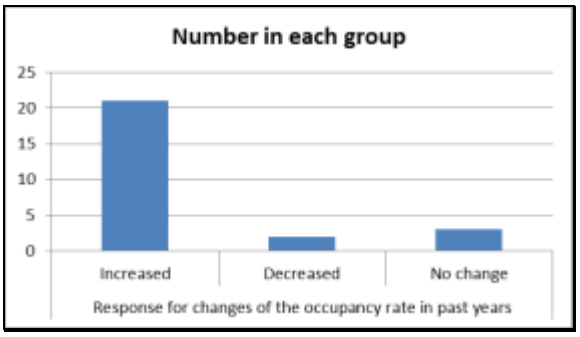

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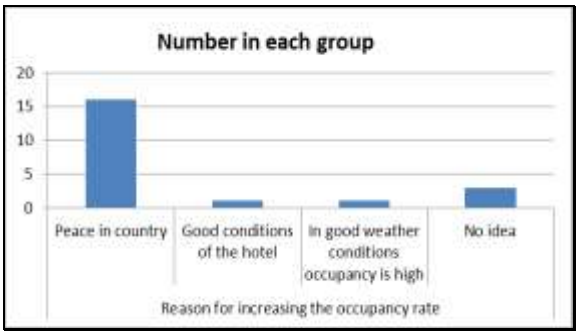

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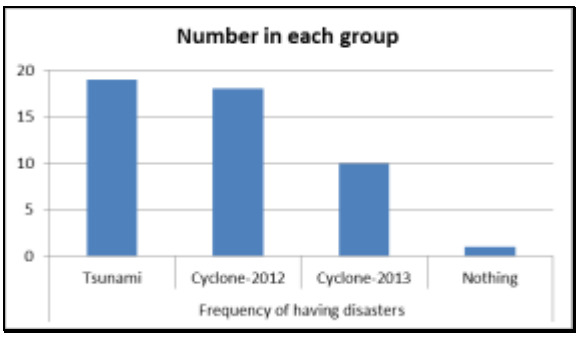

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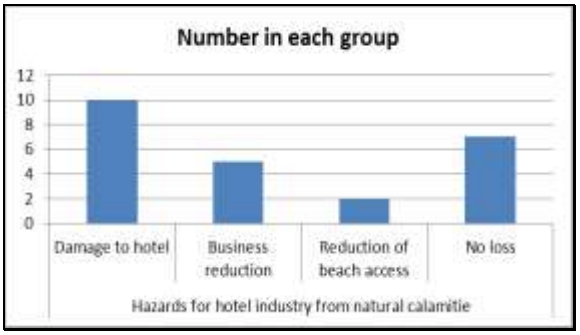

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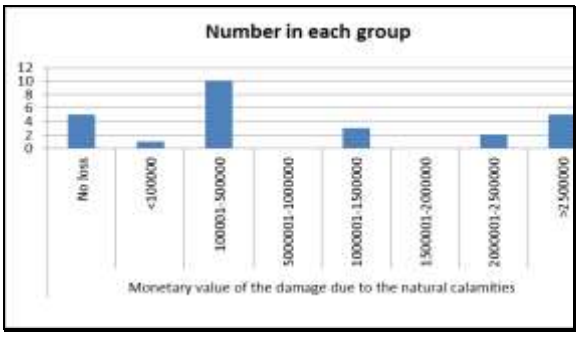

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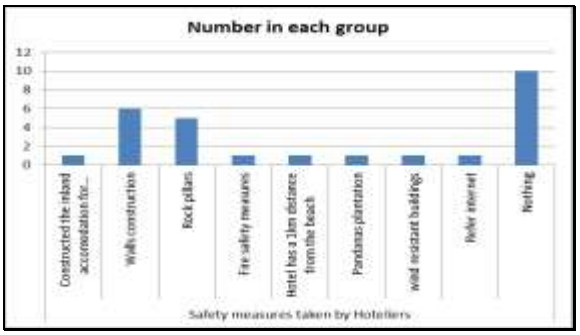

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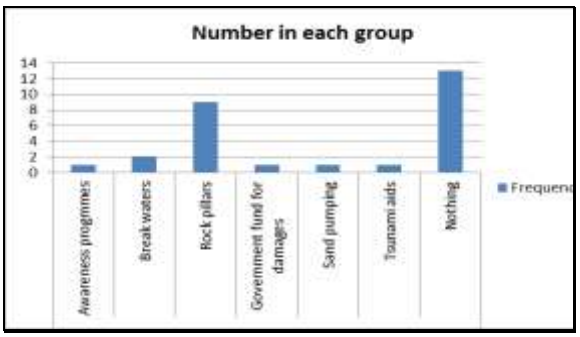

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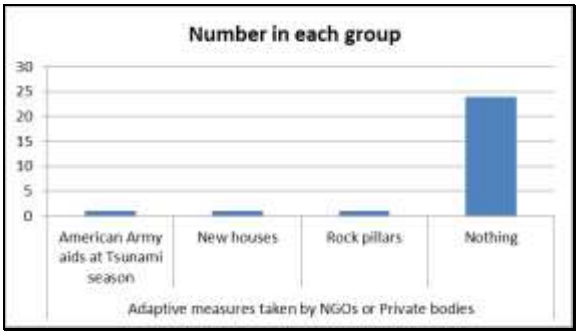

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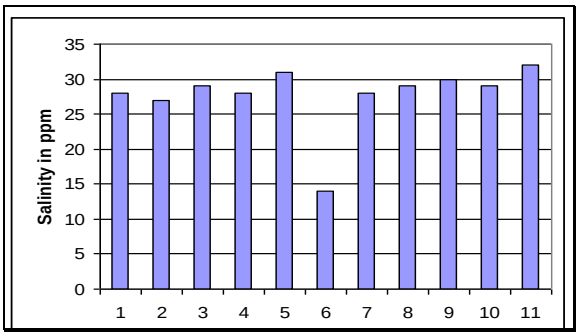

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Shift from traditional economic activities

- An assessment was made of the various ecosystems found at Koggala and surrounding villages and economic activities carried out within the study site.
- The main economic activity is tourism which depends largely on the wide sandy beach found at Koggala extending up to Habaraduwa and Ahangama on the west and east, respectively.
- A large number of hotels have been built within this area to cater for the tourists who come to enjoy the tropical sun and sea.
- The anticipated sea level rise is a potential threat to the tourist industry.
- Most of the minor staff employed in the tourist accommodations in Koggala and neighbouring areas are residents of the area.

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Shift from traditional economic activities - contd.

- Their fathers had been engaged in traditional activities such as agriculture and fisheries.
- The hardships encountered in these occupations and their poor monitory benefits had prompted the children of their families to pursue employment in these new economic activities.
- Lack of cooperation from both the large hotels and industries, it was not possible to interview their staff to gather more information about their shift to new economic activities from their fathers' traditional activities.

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- The other significant activity is the industrial zone comprising many garment and apparel industries employing a large number of female workers.
- These workers are also residents of the neighbouring villages and had pursued employment in garment factories as it brings in a regular income unlike in the case of self-employment in cultivation or fishing.
- Fishing is a less significant activity as priority has been given for the promotion of tourism for which a clean environment is a pre-requisite.
- This has also prevented local people from enjoying the beach and its environs and as a result there is hardly any economic activity such as vendors on the beach at Koggala.

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• Most people engaged in agricultural and fishing activities make only a subsistence living with the middlemen doing the marketing of their produce earn a substantial share.
• They also feel that the harvest both on the land and in the lagoon is declining over the years due to increase in salinity and lack of adequate fresh water for agriculture.
• The high salinity observed apparently is the cause for many of the ills, which unfortunately has been a man-made phenomenon.

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• Both farmers and fishers prefer their children move away from their traditional occupations into government or private sector employment.
• This would give them more security particularly during late years in life when they are unable to practice their traditional occupations.
• Sri Lanka lacks a satisfactory social security system on which the self-employed could depend on when they are no longer in a position to look after them.

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• Though the government has recently launched a safety plan for fishermen, the implementation of its recommendation is yet to be undertaken.
• Currently, fishers venturing into deep sea receive weather information through national media channels from the local weather station applicable only for the coastal areas.
• Though there are several websites giving multi-day weather forecasts for the Indian Ocean region, no effort has been made to make this information available to local fishers and farmers.

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• The southern coast of the country is vulnerable to cyclonic storms and similar extreme events originating frequently in the Bay of Bengal.
• The fishermen venturing into the sea from Koggala area too often get caught in such events.
• They are of the opinion that the occurrence of such events has increased in recent times compared to what it was many years ago.

Sri Lanka Workshop: Day 1; Presentation slides of Dr. Janaka Ratnasiri

Slide 1

Distribution of respondents among occupations

Category	Number of respondents	Percentage response %
Agriculture	32	26.67
Coir Industry	05	4.17
Fisheries	48	40
Handicraft	04	3.34
Restaurant	03	2.5
Three-Wheel Driving	21	17.5
Hotel	7	5.83
Total	120	100

Slide 2

AGRICULTURE

Village	Number	Ages Years	Average Income LKR/month	Average Working Days per month	Average Active months a year
Mattegoda	13	40-80	25,000	20	09
Dickumbura	12	30-40	25,000	15	12
Habaraduwa	02	30-50	20,000	25	09
Kathaluwa	05	25-50	20,500	15	09

Slide 3

AGRICULTURE

Concern	Number Responding				
	Nil	Marginal	Moderate	Significant	Highly Signi't
Storms with Rain	-	-	5	-	-
Storm w/o Rain	-	-	-	12	5
Flooding & SW intrusion during high tide	-	3	5	10	-
Flooding due to RF	-	-	12	11	-
Inadequate Rain	-	-	-	32	-
Sea approaching	32	-	-	-	-

Slide 4

COIR INDUSTRY

Village	Number	Ages Years	Average Income LKR/month	Average Working Days per month	Average Active months a year
Mattegoda	03	40-60	35,000	20	12
Dickumbura	02	30-40	30,000	20	12

Slide 5

COIR INDUSTRY

Concern	Number Responding				
	Nil	Marginal	Moderate	Significant	Highly Signi't
Storms with Rain	-	-	5	-	-
Storm w/o Rain	-	-	-	12	5
Flooding & SW intrusion during high tide		3	5	10	-
Flooding due to RF	-	-	12	11	-
Inadequate Rain	-	-	-	32	-
Sea approaching	32	-	-	-	-

Slide 6

FISHERIES

Village	Number	Ages Years	Average Income LKR/month	Average Working Days per month	Average Active months a year
Ahangama	25	40-60	15,000	20	10
Habaraduwa	12	45-50	20,000	25	11
Kathaluwa	11	30-50	25,500	30	10

Slide 7

FISHERIES

Concern	Number Responding				
	Nil	Marginal	Moderate	Significant	Highly Signi't
Storms with Rain	40	-	8	-	-
Storm w/o Rain	4	-	-	-	-
Flooding & SW intrusion during high tide	-	-	15	-	-
Flooding due to RF	-	-	-	-	-
Inadequate Rain	48	-	-	-	-
Sea approaching closer	-	-	25	-	-

Slide 8

HANDICRAFT

Village	Number	Ages Years	Average Income LKR/month	Average Working Days per month	Average Active months a year
Ahangama	03	40-60	25,000	25	12
Habaraduwa	01	40-60	30,000	28	12

Slide 9

HANDICRAFT

Concern	Number Responding				
	Nil	Marginal	Moderate	Significant	Highly Signi't
Storms with Rain	-	1	3	-	-
Storm w/o Rain	4	-	-	-	-
Flooding & SW intrusion during high tide	4	-	-	-	-
Flooding due to RF	4	-	-	-	-
Inadequate Rain	4	-	-	-	-
Sea approaching	4	-	-	-	-

Slide 10

RESTAURENT

Village	Number	Ages Years	Average Income LKR/month	Average Working Days per month	Average Active months a year
Habaraduwa	02	30-50	30,000	25	12
Ahangama	01	32	30,000	25	12

Slide 11

RESTAURENT

Concern	Number Responding				
	Nil	Marginal	Moderate	Significant	Highly Signi't
Storms with Rain	3	1	-	-	-
Storm w/o Rain	3	-	-	-	-
Flooding & SW intrusion during high tide	3	-	-	-	-
Flooding due to RF	4	-	-	-	-
Inadequate Rain	4	-	-	-	-
Sea approaching	4	-	-	-	-

Slide 12

THREE WHEEL DRIVING

Village	Number	Ages Years	Average Income LKR/month	Average Working Days per month	Average Active months a year
Mattegoda	02	20-40	10,000	20	12
Dickumbura	02	25-40	10,000	25	12
Habaraduwa	06	30-45	15,000	25	12
Kathaluwa	05	25-50	20,000	25	12
Ahangama	06	25-50	15,000	25	12

Slide 13

THREE WHEEL DRIVING

Concern	Number Responding				
	Nil	Marginal	Moderate	Significant	Highly Signi't
Storms with Rain	20	1	-	-	-
Storm w/o Rain	20	-	-	-	-
Flooding & SW intrusion during high tide	21	-	-	-	-
Flooding due to RF	21	-	-	-	-
Inadequate Rain	21	-	-	-	-
Sea approaching	21	-	-	-	-

Slide 14

HOTEL

Village	Number	Ages Years	Average Income LKR/month	Average Working Days per month	Average Active months a year
Habaraduwa	01	45	40,000	30	12
Kathaluwa	01	45	45,000	30	12
Ahangama	05	25-30	45,000	30	12

Slide 15

HOTEL

Concern	Number Responding				
	Nil	Marginal	Moderate	Significant	Highly Signi't
Storms with Rain	7	-	-	-	-
Storm w/o Rain	7	-	-	-	-
Flooding & SW intrusion during high tide	7	-	-	-	-
Flooding due to RF	7	-	-	-	-
Inadequate Rain	7	-	-	-	-
Sea approaching	05	-	02	-	-

Sri Lanka Workshop: Day 1; Presentation slides of Dr. Janaka Ratnasiri

Slide 1

Ecosystems and Changing Economic Activities in the Southern Coast of Sri Lanka

Phase II

Slide 2

Year 2 Study

- Research Assistants of University of Ruhuna

H.M. Tharindu .N.B. Herath
K.P.G.K. Piyumi Guruge
P.A. Kushlani.N. Dissanayake
W.K. Suwandhahannadi
B.M. Maleen Rajapaksha
A.M. Kasun A. Bandara

Slide 3

Table 1. Percentage respondents who identified a particular concern as a threat

Threat	Percentage response
Natural:	
Storms during rains	75
Storms during other seasons	10
Flooding and sea water intrusion during high tide	80
Flooding due to heavy rainfall	20
Inadequate rainfall	37
Coastal erosion and sea approaching closer	43
Anthropogenic:	
Wastewater from hotels and restaurants polluting the coast and the seawater	60

Slide 4

Table 2 Respondents who identified a particular concern as a threat in each occupation category

Threats	Percentage of total number responded						
Natural Event	**Agriculture**	**3-wheeler Driving**	**Coir industry**	**Fisheries**	**Handicraft**	**Hotel Industry**	**Rest'rant**
Coastal storm	0	15	0	75	5	5	10
Sea water intrusion	25	0	2	95	0	55	23
Flooding due to heavy rainfall	83	0	15	8	0	0	0
Inadequate rainfall	92	0	53	0	0	0	16
Coastal erosion	0	0	0	87	0	82	86
Anthropogenic							
Wastewater from hotels & restaurants	0	0	0	35	0	0	0

Slide 5

Table 3. Exposure to Threat (Scale 0 - 6 (No exp: 0, Very High exposure : 6))

Threats	Exposure Index						
Natural	**Agri'ture**	**Three wheel Driving**	**Coir industry**	**Fisheries**	**Handicraft**	**Hotel Industry**	**Rest'rant**
Coastal storm	0	2	0	6	5	5	5
Sea water intrusion	2	0	2	6	0	2	2
Flooding due to heavy rainfall	5	0	2	2	0	0	0
Inadequate rainfall	6	0	3	2	0	0	0
Coastal erosion	0	0	0	5	0	0	0
Overall exposure to natural threats	**4.3**	**0.4**	**1.4**	**4.5**	**1**	**1.4**	**1.4**
Anthropogenic							
Wastewater from hotels and restaurants	0	0	0	6	0	0	0
Overall exposure to anthropogenic threats	**0**	**0**	**0**	**6**	**0**	**0**	**0**

Slide 6

Table 4

Threat	Extent of sensitivity of different economic activities to various threats (median values). Higher the score greater is the sensitivity of an economic activity to a particular threat.						
Natural	**Agri'ture**	**3- wheel Driving**	**Coir industry**	**Fisheries**	**Handi-craft**	**Hotel Industry**	**Rest'nt**
Coastal storm	2	1	1	4	1	2	1
Sea water intrusion	2	1	2	4	1	4	1
Flooding due to heavy rainfall	3	1	2	2	1	1	1
Inadequate rainfall	4	1	1	1	1	1	
Coastal erosion	1	2	1	4	1	4	3
Overall sensitivity to natural threats	2.5	1.5	1.4	3	1	2.4	1.5
Anthropogenic							
Wastewater from hotels and restaurants	-	-	-	4	-	-	-
Overall sensitivity to anthropogenic threats	-	-	-	4	-	-	-

Slide 7

Table 5 - Overall assessment of importance of various adaptation strategies for different economic activities

Categories of adaptation strategies against threats	Assessment Index						
Natural threats	**Agri'ture**	**3-wheeler Driving**	**Coir industry**	**Fisheries**	**Handi-craft**	**Hotel Industry**	**Rest'ant**
1. Technical	2	3	2	1	3	3	2
1. Financial	2	4	5	2	2	2	2
1. Institutional	2	3	2	2	2	2	2
Overall ranking of strategies against natural threats	**2**	**3.3**	**3**	**1.6**	**2.5**	**2.3**	**2**
Overall score of strategies used against anthropogenic threats	**6**	**6**	**6**	**5**	**6**	**6**	**6**

Sri Lanka Workshop: Day 2; Presentation slides of Dr. Sandhya Rao:

Slide 1

Summary - Climate Change Analysis

Coastal Ecosystem, Ecosystem Services and Changing Economic Activities
Koggala, Sri Lanka
January 10, 2015

INRM Consultants , New Delhi
www.inrm.co.in

Slide 3

Bangladesh Summary

Observed

- Maximum temperature
  - statistically insignificant negative trend (No appreciable change in observed)
- Minimum temperature
  - statistically significant positive trend (increase 1.2^{o}C /33 years)
- Annual Rainfall
  - Statistically insignificant positive trend
- 1 day maximum rainfall
  - Positive trend, statistically not significant
- Number of rainy days
  - Positive trend, , statistically not significant

Projected - towards 2030s

- IPCC AR4 (PRECIS, A1B)
  - Max/Min Temperature projected increase
    - Maximum :1.6^{o}C
    - Minimum : 1.8^{o}C
  - Annual average rainfall projected to increase
    - 23 % (514 mm)
- IPCC AR5 (SMHI, RCP 4.5)
  - Max/Min Temperature projected increase
    - Maximum :1.1^{o}C
    - Minimum : 1.4^{o}C
  - Annual average rainfall projected to increase marginally
    - 5 % to 9 %
- % of warm days and warm nights
  - projected to increase
- % of cool days and cool nights
  - projected to decrease

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Slide 2

Bangladesh - Study Site

- 2.2% out of 24.67% population of Bangladesh living in coastal areas
- Area of 512.8 sq km
- Population density
  - Cox's Bazar Sadar is high - 2011 persons per sq. km against 919 persons per sq. km in Cox's Bazar district as a whole
  - Moheshkhali is 887 persons per sq.km

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Slide 4

India - Study Site

- Comprises beach areas of
  - Dattapur, Digha, Sankarpur, Tajpur and Mandarmoni.
- Digha Planning Area
  - a coastal tract adjoining the Bay of Bengal in the south and border of West Bengal - Orissa in the east
- Study area has
  - 51 mouzas
  - area of 69 sq. km
  - population density ranging from 10 to 10000 persons/sq km

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Slide 5

India - Summary

Observed

- Maximum temperature
  - Statistically significant negative trend (0.6°C /37 years)
- Minimum temperature
  - Statistically significant positive trend (0.8°C /37 years)
- Annual Rainfall
  - Statistically Significant positive trend
- 1 day maximum rainfall
  - Negative trend, statistically not significant
- Number of rainy days
  - Positive trend, , statistically not significant

Projected - towards 2030s

- IPCC AR4 (PRECIS, A1B)
  - Max/Min Temperature projected increase
    - Maximum :1.9°C
    - Minimum : 1.9°C
  - Annual average rainfall projected to decrease marginally
    - 1.8 % (39 mm)
- IPCC AR5 (SMHI, RCP 4.5)
  - Max/Min Temperature projected increase
    - Maximum :1.1°C
    - Minimum : 1.5°C
  - Annual average rainfall projected to decrease marginally
    - 0.7% (20 mm)
- % of warm days and warm nights
  - projected to increase
- % of cool days and cool nights
  - projected to decrease

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Slide 6

Sri Lanka- Study Site

- Planning Area
  - bounded by the Indian Ocean on the South, district boundary on the East, Taple village on the west and Imaduwa division on the North
- Study area has
  - 23 villages
  - area of 39sq. km
  - population density; 1250 persons/sq km

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Slide 7

Sri Lanka Summary

Observed

- Maximum temperature
  - Galle :2003-2013 (11 years); No trend (No appreciable change in observed)
  - Hambantota : 1969-2005 (37 years); statistically significant positive trend (increase 1.0°C /37 years)
- Minimum temperature
  - Galle :2003-2013 (11 years); No trend (No appreciable change in observed)
  - Hambantota : 1969-2005 (37 years); statistically significant positive trend (increase 1.15°C /37 years)
- Annual Rainfall
  - Statistically Significant positive trend
- 1 day maximum rainfall
  - Negative trend, statistically not significant
- Number of rainy days
  - Positive trend, , statistically not significant

Projected - towards 2030s

- IPCC AR4 (PRECIS, A1B)
  - Max/Min Temperature projected increase
    - Maximum :1.4°C
    - Minimum : 1.5°C /1.7°C
  - Annual average rainfall projected to decrease marginally
    - 6% to 8.3%
- IPCC AR5 (SMHI, RCP 4.5)
  - Max/Min Temperature projected increase
    - Maximum :1.1°C
    - Minimum : 1.3°C
  - Annual average rainfall projected to decrease marginally
    - 4.2% to 13%
- % of warm days and warm nights
  - projected to increase
- % of cool days and cool nights
  - projected to decrease

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Slide 8

Summary – Countries Characteristics

Parameter	Bangladesh	India	Sri Lanka
Area (sq km)	512.8	69	39
Population Density (persons per sq.km)	2011	10 to 10000	1250
Cox's Bazar Sadar Moheshkhali	887		
Max Temperature	30.2°C	31.5°C	29.9°C
Trend Max	Negative trend; Statistically not significant	Trend: Negative trend (0.6°C /37 years); Statistically significant	No trend (No appreciable change in observed)
Min Temperature	22.5°C	21.8°C	25.2°C
Trend Min	Positive trend (1.2°C /37 years); Statistically significant	Positive trend (0.8°C /37 years); Statistically significant	No trend
Rainfall	2400 to 3090 mm	1746 mm	2200 mm
Contribution	JJAS (77% approx), MAM (13%), OND (9%), JF contribution insignificant	JJAS (73.8%), MAM (12.5%), OND (11.7%), JF contribution insignificant	OND followed by JJAS and MAM, JF contribution insignificant
Trend Rain	Positive trend, Statistically not significant	Positive trend; Statistically significant	Negative trend, Statistically not significant
1 day max	Positive trend; Statistically significant	Positive trend; Statistically significant	Negative trend statistically not significant

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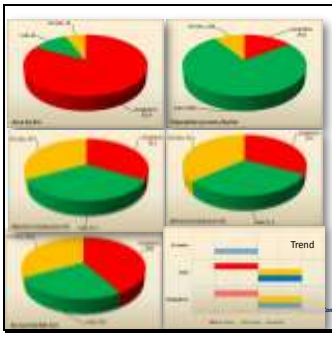
Slide 9

Country Summary



Slide 10

Summary – Natural Threats

Top 3 Threats

- Storm surge/cyclone during Rains
- Coastal erosion/sea water ingression
- Flooding and sea water intrusion* (GW?) during high tide
- Bangladesh stands out – flood
- Sri Lanka, India - Coastal dynamics
  - Erosion (sand mining?)
  - Sea water intrusion

* Seawater intrusion is the movement of seawater into fresh water aquifers due to natural processes or human activities

Slide 11

Summary of Climate Change

- Maximum and minimum temperature projected to increase
  - Minimum > Maximum
  - 1.5^{0}C to 2^{0}C (min), 1.0^{0}C to 1.4^{0}C (max)
- % of warm days and warm nights
  - projected to increase
- % of cool days and cool nights
  - projected to decrease
- Annual average rainfall projected
  - to decrease marginally – India, Sri Lanka
  - to increase – Bangladesh

Slide 12

Possible Impact

- Tourism
  - Narrow Diurnal temperature range
  - Cooling demand (low energy demand to high energy demand)
  - Reduction in Beach recreational time window
  - Erosion – degradation of beaches and coastal vegetation
  - eroded areas taken up for conservation will impose restriction on development projects
  - Flooding – Weather Services, safety, Health issues, EWS
  - Hazard, Risk, vulnerability mapping/shoreline mapping and monitoring
- Fisheries
  - Impact due to elevated water surface temperature
  - Increased salinity?
  - Need for quick transport or cold storage facilities
  - Storm – loss of fishing man hours
  - Link Fisheries to Tourism
    - matching fisheries areas' assets and markets
    - developing fisheries-related tourism products
    - promoting and marketing fisheries related tourism packages

Slide 13

Thank You

- ***Conference/symposium/workshop reports***

APN Regional Workshop
Coastal ecosystem and changing economic activities: Challenges for sustainability transition along the South Asian coasts
Koggala, Sri Lanka
8-10th January, 2015

Day 1: Thursday, January 08

The workshop in Sri Lanka was preceded by visit of Sri Lankan study site. Dr. Janaka Ratnasiri guided the Bangladesh and Indian collaborating team towards the Koggala study site and introduced them with it's distinctive as well as common features with that of other collaborating country study sites.

Day 2: Friday, January 09

The regional workshop in Sri Lanka started with a welcome address and introductory note delivered by Dr. Janaka Ratnasiri.

- Prof. Joyashree Roy spoke on the workshop goals and objectives. She focused on the proposed goals of conducting a collaborative research project, organizing workshops, framing policy guidelines, coming up with examples of local resilience building efforts towards sustainability transition. She specified that mostly the collaborative research goals have been achieved. The importance of participation of policy makers was acknowledged in her speech. It was further mentioned that one of the goals of the workshop is to brainstorm policy guidelines in interactive session and cross check it with policy makers who will also be participating in the workshop.

  The study and field survey goals were highlighted. The final objective of vulnerability, risk and resilience assessment was mentioned and analyzed in the presentation. The study looks into the aspects through a micro-level assessment and does not intent to arrive at any

generalization. She further pointed out that the expectations of the policy makers from such workshops are important to take into consideration.

In the comments and discussion session, the project partners pointed out the problems faced during data collection and had an elaborate discussion on the methodology. The conflicts between engineering professionals and environment people were pointed out that were exposed during the study. The session closed with comments from all the participants.

- In the next session Dr. Janaka Ratnasiri gave a brief overview of the Phase I report of Sri Lankan part and the specific features of the Sri Lankan study site. It was followed by analysis of primary data collected for the Sri Lankan study site in Phase II. The analysis was supplemented by maps, climate data collected from secondary sources and pictures. From a climate change point of view the characteristics of the study site were described.

  In the discussion session participants put forward the site specific questions and comments. Prof. Joyashree Roy commented on the policy perspectives and emerging conflict between provisioning service related activities and recreational service related activities and hence the conflict between fisheries and tourism. Prof. Giashuddin Miah spoke about similar conflict in Bangladesh study site. After an elaborate discussion with the other project members on these aspects Dr. Janaka Ratnasiri presented Phase II results derived from primary data collected in Sri Lankan study site and responded to the comments and questions raised by workshop participants.

- In the third session Prof. Md. Giashuddin Miah first presented Bangladesh study site geographical features, socio-economic characteristics and data analysis as obtained from phase I study. After responding to the comments and questions raised by participants, he moved on to phase II study. In Phase II presentation, Prof. Md. Giashuddin Miah elaborately discussed data tables calculated from primary data collected in Bangladesh study site. In the presentation he discussed the natural and anthropogenic threats to the study site economic activities, and also talked about exposure, sensitivity of various economic activities to the threats. He subsequently gave a brief overview of the adaptation strategies against various kinds of threats broadly categorized as natural and anthropogenic. Finally he

presented a summary of observed temperature and rainfall for the country study site Cox's Bazar Sadar-Moheshkhali.

The presentation was followed by an interactive session.

- Prof. Joyashree Roy in her presentation session started with highlighting the proposed study objectives, talked about the work accomplished in phase I of the study and subsequently moved on to phase II assessment done. She gave a brief overview of phase I study for Indian study site Digha- Sankarpur supported by study site general characteristics. After taking about Phase II data collection methodology she mentioned the types of interviewees across economic activities and administrative levels relevant to the Indian study site. The responses as obtained from individuals from different economic activities and government officials were discussed in brief. Also the problems faced while extracting information from government sources were highlighted. Later she moved on to main part of phase II data analysis for Indian study site along with an elaborate explanation of the structure of data analysis. The threats as identified in the Indian study site were described. From the identified list of natural and anthropogenic threats the methodology of calculating major scores e.g. exposure, sensitivity and finally coming up with vulnerability score were discussed along with that of risk score. Resilience level assessment procedure incorporating vulnerability and risk scores was discussed. In the concluding part of her presentation, Prof. Joyashree Roy talked about importance of assessment of adaptive capacities of different economic activities and policy interventions.

In the interactive session following the presentation of Prof. Joyashree Roy, collaborators from all partner countries raised questions about data analysis methodology and the inference which were answered by Prof. Joyashree Roy and supplemented by comments from some of the participants. It was followed by an interactive discussion of country specific and world policies relevant to the coastal system and availability of secondary data.

Day 3: Saturday, January 10

The ending day of the regional workshop in Sri Lanka started with self-introduction of the participants from various administrative bodies in Sri Lanka and the collaborating team from Bangladesh, India and Sri Lanka.

- Prof. Joyashree Roy welcomed the representatives from administrative bodies in Sri Lanka and gave a brief introduction about Ecosystem, Ecosystem Services, physical capital, human capital and natural capital. The relevance of protection of natural capital, promotion of tourism, water and waste treatment, protection from disaster were briefly discussed. Then she talked about the conflicts of interests between policy makers and local communities and even in between local communities. It was highlighted in her presentation that the problem of management of coast by taking care of the conflicts is important, the study of impact of climate change on coastal areas needs to be done apart from the identification of threats to the coastal economic activities. She talked about the significance of finding out ground realities from the field, understanding the challenges from the point of view of different stakeholders including policy makers. Then she requested the policy makers participating in the workshop to tell briefly about their expectations from the workshop.

  It was followed by observations of the policy makers as well as interactive discussion among the project team on different policy issues, role of the government, challenges faced in implementation, need for further implementation and so on.

- In the next session Dr. Sandhya Rao made a presentation on climate scenarios in the study sites of Bangladesh, India and Sri Lanka. It came out from her presentation that, in Bangladesh, both day and night temperatures are coming down, but there is an increase in minimum night temperature. Also number of rainy days has a positive trend in the country.

  In her presentation on Indian climate scenario, Dr. Sandhya Rao showed that there is a strong statistically significant increasing trend in minimum temperature. The intensity of rainfall was shown to be non-increasing. It got reflected from her presentation that annual rainfall is increasing in India but it’s intensity is coming down.

  In Dr. Sandhya Rao’s presentation on Sri Lankan climate scenario it was highlighted that there is no trend in minimum and maximum temperatures. Also it was shown that, annual

rainfall is increasing but intensity is coming down in Sri Lanka. The policy makers commented on the presentation observations and commented that the policy implementation must take into account climate scenarios. It was followed by comments from other participants as well and Dr. Sandhya Rao's take on it. Finally she concluded by presenting a summary of the entire presentation through tables and graphs. In that she pointed out the major natural threats in the country study sites.

In the interactive session following Dr. Sandhya Rao's presentation, participants from the project team discussed the existing policies and adaptive strategies with regard to the climate scenario, talked about possible impact of the policies on the coastal system. In the discussion some of the participating policy makers were also involved.

- After the session was closed, Prof. Joyashree Roy talked about having a Group Session involving all the participants from Sri Lankan policy makers and project team from Bangladesh, India and Sri Lanka. She put forward some questions that the Groups have to answer through discussion among the group members. Those are as follows:

1. Whether and how often people from different disciplines from each of the countries discuss about '*Ecosystem*', '*Ecosystem Services*' and '*Sustainable Development*'
2. What are the dominant traditional and new economic activities in coastal system
3. What are the major five policy actions for coastal system, the ecosystem groups and economic activities those concentrate on
4. Major barriers in pollution level monitoring, health and implementation of set-back line
5. Climate change parameters in the three countries
6. Current practices involving the coastal system that need to be changed

The participants were divided into three groups with representation from each of the three countries. After the group exercise was done each of the groups made presentation of the outcomes with reference to questions, as listed by Prof. Joyashree Roy. Each of the three presentations was followed by comments and inputs from other participants.

Finally the workshop closed with discussion among the project team about future direction of work related to the project and a vote of thanks.