CITIES AND CLIMATE CHANGE INITIATIVE

Negombo, SRI LANKA:

CLIMATE CHANGE VULNERABILITY ASSESSMENT

UN◉HABITAT
FOR A BETTER URBAN FUTURE

Negombo, Sri Lanka: Climate Change Vulnerability Assessment

Full Report on Climate Change Vulnerability in Negombo Municipal Council
Research, Analysis, Findings and Recommendations
December 2011

Submitted by..
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UN@HABITAT

Negombo, Sri Lanka: Climate Change Vulnerability Assessment

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First published: January 2013

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1. INTRODUCTION

This vulnerability assessment follows a toolkit based on the experience of a Participatory Climate Change Vulnerability and Adaptation Assessment of Sorsogon City, Philippines. This is a participatory process of selected stakeholders which builds citizens' capability to address city vulnerability to climate change scenarios and to develop adaptation strategies. Some of the steps in the original methodology have been modified to suit the local situation of the Negombo Municipal Council (NMC) area.

The main objective of this vulnerability assessment is to estimate the local area vulnerability to potential climate change impacts and provide a context for local government decision makers to develop local climate change adaptation and mitigation plans in response to the Sorsogon City Vulnerability Assessment and Adaptation (V&AA) results.

This study follows the same concept definitions adopted in the Sorsogon City V&AA report. Interpretations of key concepts are mentioned below for reference purposes.

Climate Change refers to any change in climate over time, whether due to natural variability or because of human activity.

Vulnerability is the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.

Adaptation is an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm of exploits beneficial opportunities (Third Assessment Report, Working Group II)

Exposure is what is at risk from climate change (e.g. population, resources, property) and the change in climate itself (e.g. sea level rise, temperature, precipitation, extreme events).

Sensitivity is the biophysical effect (e.g. flooding, strong winds, land inundation, etc) of climate change which also considers the socioeconomic context of the system being assessed.

Adaptive Capacity is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. The IPCC Third Assessment Report outlines that it is a function of wealth, technology, institutions, information, infrastructure, and 'social capital'.

This report explains the overall process flow of a Participatory Vulnerability Assessment with a description of each step and respective findings. Some of these initial steps which were briefly described in the inception report have been modified during this process.

OVERALL PROCESS FLOW

Phase One – Mobilization

Step: 1 Brief L/As and DSD on Climate Change	Step: 2 Mobilize assessment team	Step: 3 Field reconnaissance survey	Step: 4 Agree on assessment purpose and scope	Step: 5 Stakeholder Mapping

Phase Two – Data Collection

Step: 6 Secondary Data Collection	Step: 7 Mobilize field survey	Step: 8 Primary Data Collection

Focal Group Discussions
Semi-Structured Interviews
Field Mapping / GPS Survey
Participatory Mapping

Phase Three – Assessment

Step: 9 Identify Exposure	Step: 10 Element-at-Risk Mapping	Step: 11 Define Sensitivity	Step: 12 Identify Adaptive Capacity	Step: 13 Identify Hotspots

Delphi Technique
Barnstorming (core team)
Community-based Assessment

Phase Four – Validation and Presentation

Step: 14 Consolidate Findings	Step: 15 City Validation Meeting	Step: 16 Awareness and Discussion

Stakeholder workshop to share findings and knowledge of climate change

Note: the pale yellow coloured boxes illustrate the specific methods and techniques used for each step.

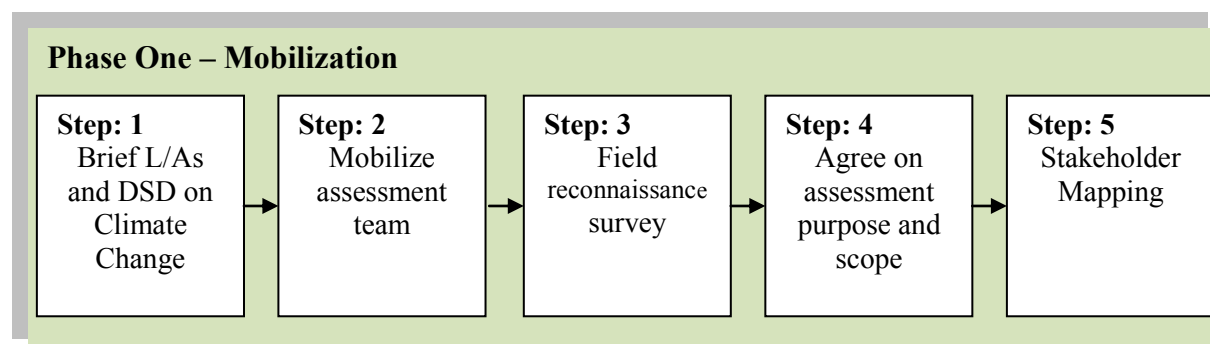## 2. PHASE ONE — MOBILIZATION

This phase is a pre-assessment stage to establish the assessment process. The process aims to influence local stakeholders, to obtain their acceptance and their willingness to participate in the development of local response actions.

Phase One – Mobilization

Step: 1 Brief L/As and DSD on Climate Change	Step: 2 Mobilize assessment team	Step: 3 Field reconnaissance survey	Step: 4 Agree on assessment purpose and scope	Step: 5 Stakeholder Mapping

There are five key steps in this phase are described in the following section.

2.1. Step: 01 Brief Local Authority (L/A) and Divisional Secretariat Division (DSD) on Climate Change

This step introduced the project to the city's key decision makers. The main objectives of this project are:

1. To give an overview of the vulnerability of cities to climate change.
2. To describe the importance of a vulnerability assessment in a sustainable city development process.
3. To recognize the views of stakeholders regarding vulnerable groups in the local area.
4. To develop a partnership (to ensure the support and commitment of stakeholders to succeed in the above task) between stakeholders and the project team through mutual understanding and interaction.

This was the first time that Sri Lankan local authorities took part in conducting a city-level climate change study. It required a strong foundation to identify and reconcile the aims and objectives, nature, expected contributions and usefulness of this project. Accordingly, the two key administrative bodies of the local authority: Negombo Municipal Council (NMC) and Negombo Secretariat Division (NSD) were selected for the initial discussions.

The key objectives and a brief explanation were given for each objective below.

a. *Climate change is a key concern of the Sri Lankan government and there have been a number of actions taken to address the impacts of climate change for the country.*

- The United Nations Framework Convention on Climate Change (UNFCCC) was adopted at the Rio summit in 1992 and the Government of Sri Lanka ratified the UNFCCC on the 23rd of November, 1993. In order to achieve the objectives of the UNFCCC, a binding protocol was adopted at the 3rd Conference of Parties (CoP 3) by the UNFCCC held in Kyoto, Japan in 1997 and Sri Lanka acceded to the Kyoto Protocol on the 3rd of September, 2002.

- The Ministry of Environment and Natural Resources is the national focal point of the UNFCCC, and has the responsibility of implementing the provisions in the Convention and to take the initiative to pursue the decisions made at sessions of the COP and its subsidiary bodies. The Ministry of Environment and Natural Resources and the UNFCCC have established a Climate Change Secretariat and a Climate Change Coordinating & Steering Committee (CCC&SC) to undertake the above tasks.

- Sri Lanka, as a party ratifying the UNFCCC, was required to prepare a national communication report by the year 2000. Following the guidelines provided by the UNFCCC, (partly funded by the Global Environmental Facility), the report was produced and submitted to the UNFCCC in October 2000. The report consists of information ranging from a GHG emission inventory, climate change impacts and vulnerability, and mitigation options to adaptation responses. Subsequently, Sri Lanka developed policy recommendations on the basis of UNFCCC guidelines to address the need for the nation to engage in climate change mitigation and adaptation measures.

b. *Adapting to climate change may be more important for Sri Lanka than mitigation.*
- Sri Lanka falls into the UNFCCC and IPCC's category of 'vulnerable' small island nations (Small Island Developing States) under serious threat from various climate change impacts, such as sea-level rise, severe floods and droughts (UNFCCC 1992;

IPCC 2001). These threats are considered to have significant negative consequences on various sectors within Sri Lanka (Sri Lanka 2000).

- Most policy measures emphasize adaptation measures which a country needs due to its vulnerability to frequent and prolonged droughts, high intensity rainfall, increased storm activity and sea-level rise, which represents a significant threat to coastal habitats.

c. *Cities are more vulnerable to climate change impacts than any other type of human settlement.*

- Urban settlements, with their overcrowded populations and continuous rapid urbanization are vulnerable to climate change impacts. If the world continues on its present path, tropical countries in the developing world such as Sri Lanka, could possibly experience growing flood risks, sudden downpours and storms, extreme heat in summer, and sea-level rise. In turn, these lead to additional stresses on municipal services, public health services and are a threat to a city′s economy.

- Climate change is already leading to an increased frequency in extreme weather events bringing floods, landslides and droughts, whilst melting glaciers threaten the drinking water supply of large cities. Sea-level rise will affect many large cities located along coastlines. Many countries see that the urban poor suffer most from the impacts of climate change. Adapting to the dramatic implications of climate change is a monumental challenge facing cities in the 21st century.

d. *Recognizing the significance of Sri Lanka as a developing nation, UN-HABITAT is working with the Ministry of Environment and Natural Resources in developing a national policy on climate change as a part of the CCCI programme.*

- This project is a pilot study of two cities in Sri Lanka selected by UN-HABITAT in coordination with the University of Moratuwa under the UN-HABITAT programme of Cities in Climate Change Initiative (CCCI).

- UN-HABITAT has established a global Sustainable Urban Development Network (SUD-Net) to raise awareness and assist with the application of the principles of sustainable urbanization, at a global, regional, national and city level. As an initial component of UN-HABITAT's Sustainable Urban Development Network (SUD-Net),

the Cities in Climate Change Initiative (CCCI), seeks to enhance climate change mitigation and adaptation of cities in developing countries. The key objectives of the Cities and Climate Change Initiative (CCCI) are:

1. To promote active climate change collaboration of local governments and their associations in global, regional and national networks.
2. To enhance policy dialogue so that climate change is firmly established on the agenda.
3. To support local governments in making these changes.
4. To foster the implementation of awareness, education, and capacity building strategies supporting the implementation of climate change strategies.

- UN HABITAT introduced the Cities and Climate Change Initiatives (CCCI) programme in September 2008. Several CCCI have been implemented in nine pilot cities around the world and further pilots are being developed in five more countries: Sri Lanka, Vietnam, China, Indonesia and Mongolia.

This step also included an introduction to the basic terminology of climate change and its importance to a sustainable city development process. Projected climate change impacts on cities and the critical role of local governments in climate change adaptation were key items in the discussion. A project brochure was given to stakeholders to introduce the aims of the project and gave details of the planned activities.

The term 'climate change' was not new to either administrative officers or elected members of government, yet it was essential to emphasize that addressing climate change is of extreme importance. 'Local actions' are needed even though climate change is a global issue. At the end of the discussion, the Mayor, the Municipal Commissioner and local government officials agreed to take part in the project whilst the Divisional Secretariat also expressed its willingness to provide its full co-operation in future activities.

Location	Negombo MC
Participant	Mayor and Elected Members of MC

Location	Negombo MC
Participant	PHI

Location	Negombo DSD
Participant	Divisional Secretariat

Location	Negombo DSD
Participant	Development Officer

Location	Negombo MC
Participant	Municipal Health Officer (MOH)

Views

I agree that increasing temperature will increase the risk of spreading diseases.

But, we should not forget the fact that unlike many other developing countries in the world, Sri Lanka has a strong adaptive capacity.

High literacy rate, qualified physicians, high doctor patient ratio, good sanitary habits and facilities, health policy and government services are the key factors of a high adaptive capacity.

2.2. Step: 02 Mobilize Assessment Team

The core assessment team comprised three parties to represent local decision makers, technical advisors and academic/research institutions. The composition of the team consisted of additional members from Non-Governmental Organizations (NGOs) and older citizens were also extensively involved in the field studies.

Accordingly, an assessment team was mobilized and included academic and research members from the University of Moratuwa, technical advisory members from UN-HABITAT and a principal stakeholder member from the Negombo urban council area.
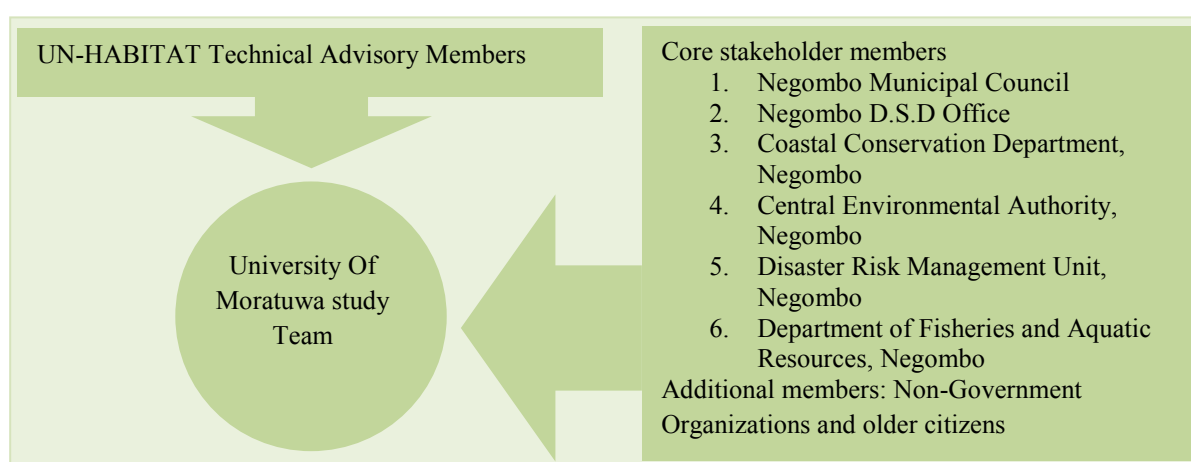
The University of Moratuwa study team comprised university academics, graduate and undergraduate students from multi-disciplinary backgrounds with special interests in the areas of urban planning and management, participatory planning, disaster management, and climate change studies. This included university students from each particular geographic area, in order to incorporate local knowledge.

UN-HABITAT technical advisers provided an insight to CCCI project methodologies and shared their experiences, and lessons learned from previous projects implemented in Sri Lanka.

Core stakeholder groups were selected as per suggestions from the Municipal Council and other members of the study team. All members agreed to develop a strong partnership with the project team to work together to accomplish the aims of this initiative.

The Coastal Conservation Department (CCD) was established under the Coastal Conservation Act and functions within the declared Coastal Conservation Zone of the country. The CCD is involved in spatial decision making as part of the Coastal Area Master Plan.

Both the Central Environmental Authority (CEA) and the Ministry of Environment and Natural Resources were established under the National Environmental Act in 1980. The CEA examines Environmental Impact Assessments (EIA) of development projects, formulates environmental regulations and guidelines as per the provisions of the National Environmental Act and thereby contributes to the city-level decision making process. The Disaster Risk Management Unit, Negombo is a local branch under the umbrella of the Disaster Management Centre (DMC). The DMC prepares disaster management plans and enhances city level adaptive capacities to prevent or reduce the adverse impacts of disasters. During initial discussions, the fisheries sector was identified as one of the most vulnerable sectors to climate change. Therefore, the Department of Fisheries and Aquatic Resources, Negombo was also selected as an additional member of the core stakeholder team of Negombo.

Senior members of technical staff for each of the abovementioned decision making bodies were appointed by the respective heads with an Executive Order (EO) to co-operate, support, and provide necessary inputs to the assessment team.

The core team members were selected after assessing their commitment to this assessment process, their analytical skills, communication abilities and other capabilities to enable an efficient and effective process. Furthermore, the team included representatives from ethnic and gender groups. This team was chosen to bridge local knowledge and scientific and technical know-how and to propose ways and means to reduce/prevent the anticipated impacts of climate change.

2.3. Step: 03 Field Reconnaissance Survey

The field reconnaissance survey was conducted in two steps: an initial windshield survey; and a detailed reconnaissance survey. The initial windshield survey was carried out within the municipal boundaries and the nearby vicinity. The key aims of the survey were to:

- Identify the municipal council boundaries;
- Become familiarized with the main road networks of the city

The windshield survey was extended beyond the municipal boundaries along the coastal belt in both southern and northern directions. This survey was specifically carried out in the nearby vicinity to better understand the city status at a macro level.

Field survey conducted by the team

Detailed reconnaissance surveys were conducted within the municipal boundaries. The key aims of the surveys were to identify vulnerable groups likely to be affected by climate change scenarios. The geographic areas of the municipalities included in the survey are depicted in the map below.
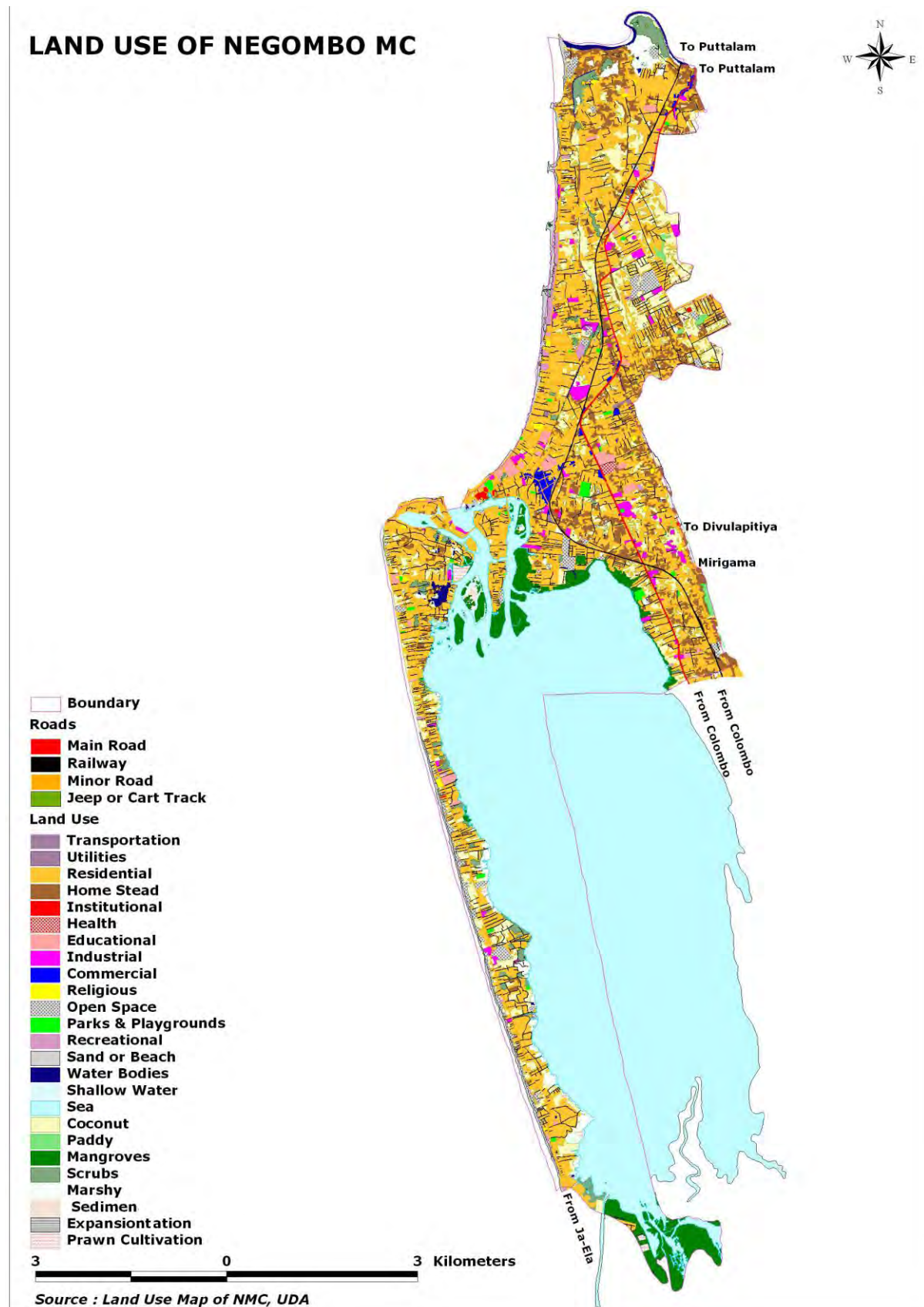
Negombo Municipal Council Area

The municipality of Negombo has a strong economic base in the industry of fisheries. Fishery activities are carried out at the Lagoon, offshore and out at deep sea. A considerable proportion of the local population depends on fisheries and fishery-related livelihoods. The fishery community predominantly lives in shelters adjacent to the coast and to lagoon banks.

Negombo Town, Fishery harbour

Pitipan, Fishery harbour

This community needs to be considered as a highly vulnerable group to expected climate change scenarios due to the insecure nature of local housing and the availability of alternative livelihood options.

Furthermore, those communities settled adjacent to the sea are heavily dependent on natural resources for their fisheries activities.

Species	Number	Endemic
Fish	46	5
Snakes	23	-
Amphibians	17	4

The Negombo Lagoon is a habitat for a number of indigenous mangroves and migrant bird species. Therefore, bio-diversity became the next key concern of the vulnerability assessment.

Lagoon Fishery Activity

Species	Number
Mangroves	6
Green algae	Available
Reed beds	Available

Species	Number	Endemic
Birds	96	5
Migrant birds	44	
Reptiles	39	8
Snakes	23	4
Amphibians	17	4
Insects	72	5

Source: Master Plan of Muthurajawela
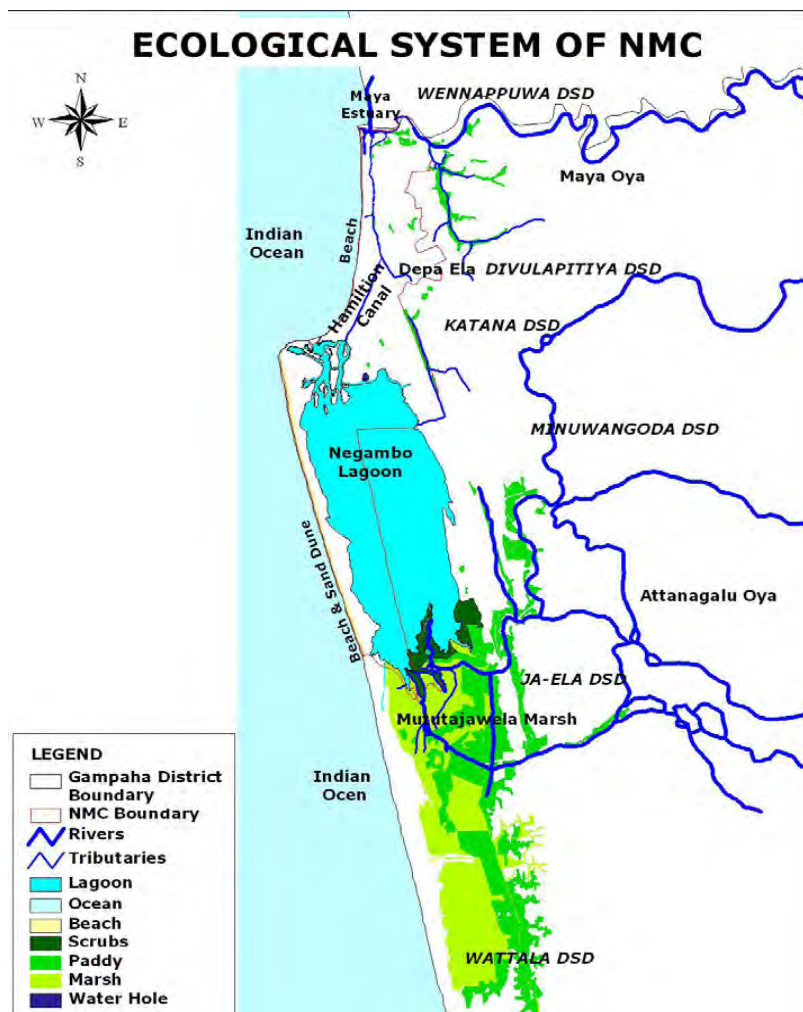
Negombo has a sound tourist base which caters for local as well as foreign tourists for sun and sand tourism. Small and medium hotels and tourism-based local jobs are attached to this sector. The coastal stretch from Palangathure to Kudapaduwa is the main tourism area in Negombo.

Type	Number	Total rooms
Registered hotels	12	882
Unregistered hotels	3	29
Committed		435
Guest houses	18	135
Sub total	33	1481

Source: Resource Profile - NDS

Negombo Tourism Area

A brief understanding of the region was obtained during this study and was very important for the next steps of the project to define the scope of assessment and to select stakeholders.

2.4. Step: 04 Agree on Assessment Purpose and Scope

A common agreement among key stakeholders is necessary to determine the purpose and scope of the study. This is good practice and should precede any vulnerability assessment.

The very first consensus reached was the need to demarcate the geographic area for the study. Clearly defined boundaries avoid overlapping and exclusions of spatial units. The local authority boundary of the city was taken as the geographic area of the city for the purposes of this study. The key reasons for the selection are:

- Local authority boundaries are legally defined administrative boundaries. (There are two such local level boundaries: the local authority boundary and the D.S. Division boundary.)

- Local authority boundaries (municipal council boundaries) are often considered as city limits for revenue purposes.

- Local authorities have decision-making powers and political authority to make robust decisions to reduce vulnerability within city boundaries.

To determine the scope of the study, the assessment team and local government authority (LGA) officials discussed the following guiding questions outlined in the Sorsogon City V&AA toolkit.

1. What are the key development assets and issues of the city and what does the Local Government Authority want to get out of the V&AA in relation to these assets and issues?

2. Where should the focus of the assessment be? Should the assessment focus on the city as a whole, on specific population groups, on specific locations, on the economy or on specific sectors, etc

3. What resources are available to be used for the assessment?

4. How far into the future should the assessment look into? Are there available climate change models that could be used?

5. Which part of the local governance structure is critical to be assessed — the whole system or only specific groups?

'The most important thing to keep in mind in conducting an assessment of vulnerability and adaptation is that the assessment is meant to serve the needs of those asking questions, such as stakeholders, not the needs of the analyst. The assessment must be designed to provide information useful to stakeholders to understand vulnerability to climate change and adaptation options. The assessment therefore should begin by identifying the questions stakeholders would like to have a vulnerability and adaptation assessment answer'.

- UNFCCC Vulnerability and Adaptation Handbook Chapter 1
  http://unfccc.int/resource/cd_roms/na1/v_and_a/index.htm

Local government officials suggested carrying out the vulnerability assessment with a focus on key concerns such as the occurrence of natural disasters, (flood and cyclones) and damage to: coastal activities; resources; and settlements due to sea-level changes. In this regard, local government officials expressed their willingness to be a part of the vulnerability assessment, but they highlighted budgetary constraints and a lack of expertise/resources/personnel in order to proceed.

2.5. Step: 05 Stakeholder Mapping

The stakeholders of this project are the people, groups, and organizations who have significant and legitimate interests in specific issues related to climate change. Stakeholders play a key role in local co-operation and their support is critical to the success of the project. Stakeholder mobilization can ensure good governance through transparency, participation and partnership. Stakeholders provide a local link to project activities. Therefore, stakeholders should be carefully identified to include representative groups and to avoid vested interest groups.

Stakeholder mapping is a challenging task which should include all relevant stakeholders in assessing, programming, planning and implementation of any desired actions to adapt to climate change and its impacts. Climate change is an ongoing phenomenon which may result in significant cumulative impacts on a wide-range of stakeholders. Therefore, the early involvement and commitment of all relevant stakeholders is very important.

The steps that were followed for stakeholder selection are given below.
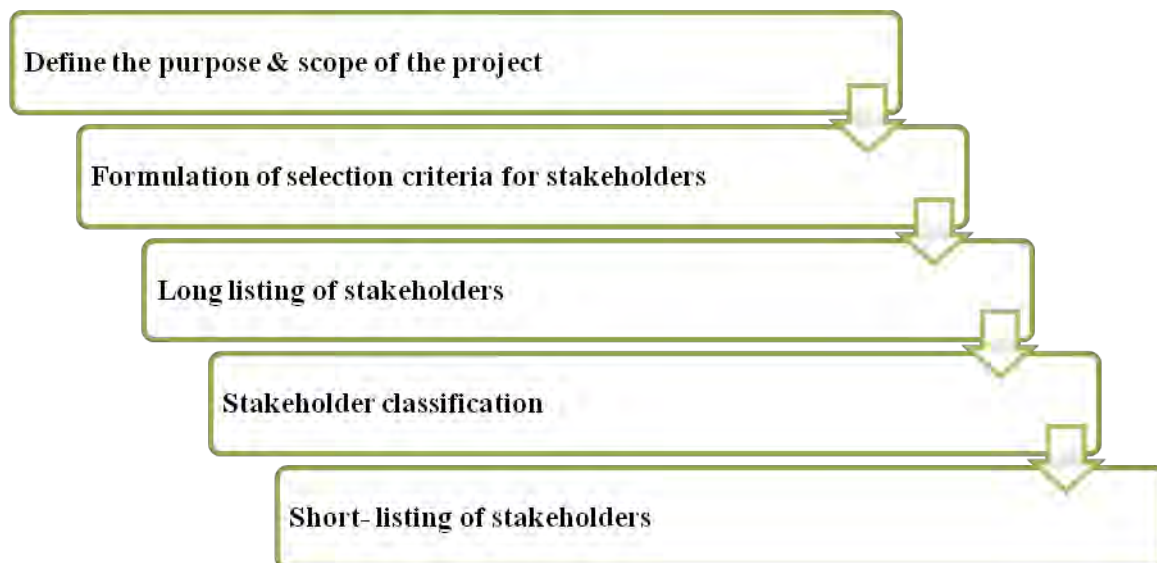
Step 1: Define the purpose and scope of the project

The project is divided into two main tasks and stakeholders were defined on the basis of each sector.

1. Preparation of vulnerability assessment with the involvement of
   - Vulnerable groups; Community Based Organizations, NGOs, Older Citizens
2. Preparation of an adaptation Strategy
   - Planning and implementing agencies; local level officers and Citizens

Stakeholders were selected based on the above framework and the key considerations are mentioned in the next step.

Step 2: Criteria for selection of stakeholders

- Community groups who might be negatively or positively affected by climate change
- A core team to co-ordinate and manage vulnerable sectors
- Planning and development decision-makers, (administrative officers, heads of institutions) and local government technical officials
- Representatives of civil society organizations and volunteers (including Community-Based Organizations (CBOs), and Non-Governmental Organizations (NGOs))
- Institutions, private sector entrepreneurs with control over resources
- Older citizens and political leaders who act as local hosts

Step 3: Long-listing of stakeholders

The long-listing of stakeholders is based on secondary sources accessed from websites, local authority registry records and the Divisional Secretariat office registry.

Steps 4: Stakeholder Classification

Stakeholders were classified into five groups by type of interest.
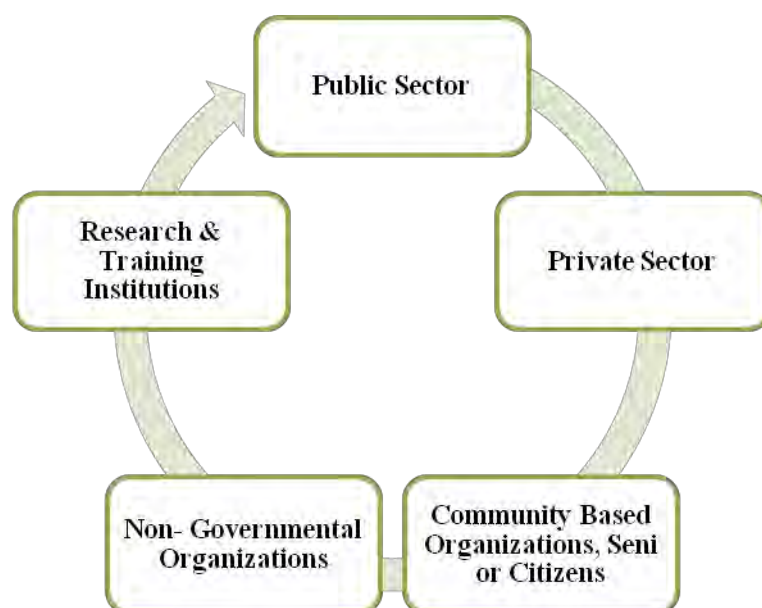
Step 5: Short-listing of stakeholders

The short-listing of stakeholders was undertaken through a mapping exercise to determine high and low stakes and influence of each group on the list. This activity involved a discussion with the core stakeholder team. The format below, used in the Sorsogon City Vulnerability Assessment was directly adapted to this assessment.

	Low influence	**High Influence**
Low Stake	(least priority)	(useful for decision making and opinion formulation)

High Stake	(important stakeholder groups perhaps in need of empowerment	(most critical stakeholder group)

Stakeholders who have a high stake and high influence are ideal partners for the project. In addition, stakeholders with a high stake yet low influence were also included on the list as a way of increasing empowerment of low-influence groups. Stakeholders with low stakes and low influence were given the lowest priority during the short-listing process.

All of the short-listed stakeholders were personally interviewed by the study team. Their interest in becoming involved in this process was ascertained as well as their capacity to deliver activities. Additionally, special consideration was given to vulnerable groups to climate change based on gender concerns, sensitive age groups and low income. Their interest is considered a key factor and therefore their capacities were not assessed during short-listing process.

The stakeholder assessment was conducted at the inauguration session of the project. The details of the session are outlined in the inception report. The findings of the assessment are given below.

A survey revealed that local level administrative officers including municipal council officers have a better understanding of climate change scenarios when compared to the general public. On a positive note, the majority of community representatives have a basic understanding of climate change. This assessment creates a base to develop a future road map for the project through a participatory process.

**Level of Awareness about Institutions Working on
Climate Change Programmes in the Sri Lankan Context**

Organization	Level of Awareness
Ministry of Environment and Natural Resources	94%
Climate Change Secretariat Sri Lanka	73%
National Ozone Unit	75%
UN HABITAT	67%
UNDP	75%
United Nation Framework Convention for Climate Change (UNFCCC)	53%

Level of Awareness about Climate Change Scenarios, Based on Stakeholder Meetings and KII's – Negombo

Group	Description	Very Low	Low	Moderate	High	Very High
Negombo MC	Basic knowledge of climate change				■	
	Causes of climate change				■	
	Impacts of climate change			■		
	Adaptation/mitigation measures			■		
Key Stakeholders - Negombo DSD - CEA - CCD - Dep. Fishery - DRMU	Basic knowledge of climate change					■
	Causes of climate change				■	
	Impacts of climate change					■
	Adaptation/mitigation measures				■	
Fishery Community	Basic knowledge of climate change		■			
	Causes of climate change		■			
	Impacts of climate change			■		
	Adaptation/mitigation measures		■			
Tourism Sector Organizations	Basic knowledge of climate change			■		
	Causes of climate change		■			
	Impacts of climate change			■		
	Adaptation/mitigation measures			■		
General Public	Basic knowledge of climate change				■	
	Causes of climate change			■		
	Impacts of climate change			■		
	Adaptation/mitigation measures			■		

3. PHASE TWO - DATA COLLECTION

Phase two is the data collection phase of the project. This includes collection of data from secondary sources such as local governmental departments and other local and national institutions. Information is also collected from primary sources. (This is mainly due to a lack of secondary data and out of date sets of data.) Field surveys to collect primary data were organized in a systematic way.

Phase Two – Data Collection

Step: 6	Step: 7	Step: 8
Secondary Data Collection	Organize field surveys	Primary Data Collection

Focal Group Discussions
Semi Structured Interviews
Field Mapping / GPS Survey
Participatory Mapping
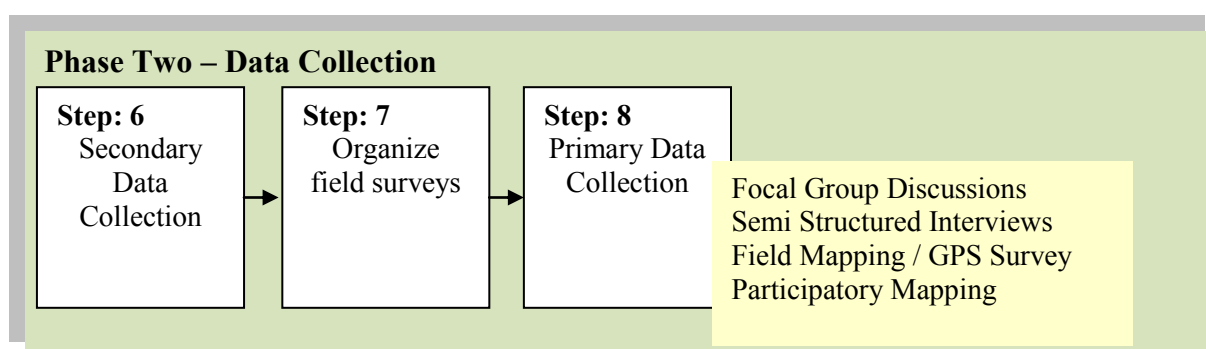
The table below presents a checklist of basic data requirements and sources planned to support the data collection and analysis process.

Assessment Factor	Key Data Needed	Purpose	Source/s
Climate Change Exposure (current and future)	a. Climate data (e.g. cyclones, droughts, flooding events)	Show trends, and possibly indicate how CC is manifesting locally	- Meteorological Station, Katunayaka - Meteorological Department (Head office) - Climate Change Secretariat, Sri Lanka
	b. Climate scenarios/ projections (local/ national/ global)	Show as adequately as possible what can be expected at a local level over the next 10, 30, 50 years or by the end of century	- Not available at either a local or national level - Global projections of IPCC
	c. Impact reports of previous disasters	Validate exposure to threats of CC bio-physical effects	- Disaster Management Centre, Negombo (DMC) - Disaster Risk Management Unit, Negombo (DRMC) - Social Service Division, DSD Negombo
Assessment Factor	Key Data Needed	Purpose	Source/s
Climate Change Sensitivities	a. Hazard map/s	Identify bio-physical effects of Climate Change (e.g. *drought, flooding, cyclones, etc.*)	- Disaster Management Centre, Negombo - Climate Change Secretariat, Sri Lanka

	b. Socio-economic profile	To show who will be affected in given current and future conditions	- Resource profile, Negombo DSD - FGDs with communities - Community-based survey results
Adaptive Capacity	a. Socio-economic profile	Validate the thresholds of people at risk	- Resource profile, Negombo DSD
	b. Key physical characteristics	Validate the thresholds of people at risk - present resources and conditions	- Resource profile, Negombo DSD - Land cover map, Negombo DSD - Topography Map, Survey Department
	c. Land use plan	To present spatial information for comparison with hazard maps and projected areas at risk	- Land use plan, UDA Gampaha
	d. Local economic activities	To present the economic activities that might be at risk	- Resource profile, Negombo DSD - Land use map, UDA Gampaha
	e. Local development strategy	Provide information on the relevance of at risk areas/sectors/ resources to city development priorities	- Resource profile, Negombo DSD - Budget report, Negombo MC - FDG's KII's with relevant officers
	f. City investment program/ Annual resource streams	Provide information on the risk to areas/sectors/ resources of the city's development priorities	- Resource profile, Negombo DSD - Budget Report, Negombo MC - FDG's KII's with relevant officers
	g. Copies of local Disaster Risk Reduction plan/program	To present current actions and if possible, determine existing capacity	- Disaster Management Centre, Negombo - FDG's KII's with relevant officers

3.1. Step: 06 Secondary Data Collection

Secondary data collection was conducted to obtain data from the abovementioned sources. The data sourced from key stakeholders' institutions was collected by the appointed team members. A trained team engaged in data collection from the remaining institutions. These were informed about the project by the University of Moratuwa and sent formal request

letters wherever necessary. This data was collected in both soft and hard copy format when available.

3.2. Step: 07 Mobilize Field Survey

Field surveys were conducted to collect primary data, and survey teams were trained for this task. Team members were assigned with respective data collection tasks, and each member was supplied with a set of data to be collected, methods to follow, and the format of data recording.

A field identification card was issued for each member, with a signature of the team leader, and details about the team member. The police station and municipal council were informed about this survey. Grama Niladhari officers of the particular GN Divisions where the survey was carried out, were informed in advance of the tasks involved. A field working team supplied with sound-recorders and cameras reported the findings.

3.3. Step: 08 Primary Data Collection

The primary data collection used four types of survey methods.

1. Focus Group Discussions
2. Semi Structured Interviews
3. Field Mapping / GPS Survey
4. Participatory Mapping

A F**ocus Group** Discussion is a qualitative research method in which a group of people are asked about their perceptions, opinions, beliefs and attitudes towards a product, service, concept or idea. Questions are asked in an interactive group setting where participants are free to talk with other group members. This method was considered useful to collect data on specific topics related to climate change with select groups of people such as fishermen, tourist hotel/resource owners, residents close to the shoreline and so on.

A semi-structured interview is another method of research. While a structured interview is formalized, with a limited set of questions, a semi-structured interview is flexible, allowing new questions to be brought up during the interview as a result of what the interviewee says. The interviewer in a semi-structured interview generally has a framework of themes to be explored. This method was applied at Key Informant Interviews (KII's) conducted with particular officers and institutions.

Field-Mapping is an integrated tool designed for computer aided field data collection. This tool is used mainly for mapping of data collected during field surveys. This application works with a multi-level relational database and also provides communication with external devices such as a GPS. This is employed to map locations which are vulnerable to climate change impacts.

Participatory maps are those created by local or indigenous groups, usually for the purposes of defining and defending landmarks and boundaries. This was used effectively to identify vulnerable areas through interviews. Interviewees identified disaster-prone areas, and the team collated this information using GPS point data and satellite images.

4. PHASE THREE – ASSESSMENT

The vulnerability assessment is carried out during phase three. Following the toolkit based on the Sorsogon City Vulnerability Assessment, the term 'Vulnerability' is considered as a function of three factors namely: Exposure, Sensitivity, and Adaptive Capacity. Accordingly, the assessment incorporates three consecutive steps: 1 — Identify exposure; 2 — Define sensitivity; and 3 — Identify the adaptive capacity.

Vulnerability = f (Exposure, Sensitivity, Adaptive Capacity)

The most vulnerable locations were classified as local hotspots.

Phase Three – Assessment

Step: 9 Identify Exposure	**Step: 10** Element at Risk Mapping	**Step: 11** Define Sensitivity	**Step: 12** Identify Adaptive Capacity	**Step: 13** Identify Hotspots

Delphi Technique
Barnstorming (core team)
Community-Based Assessment
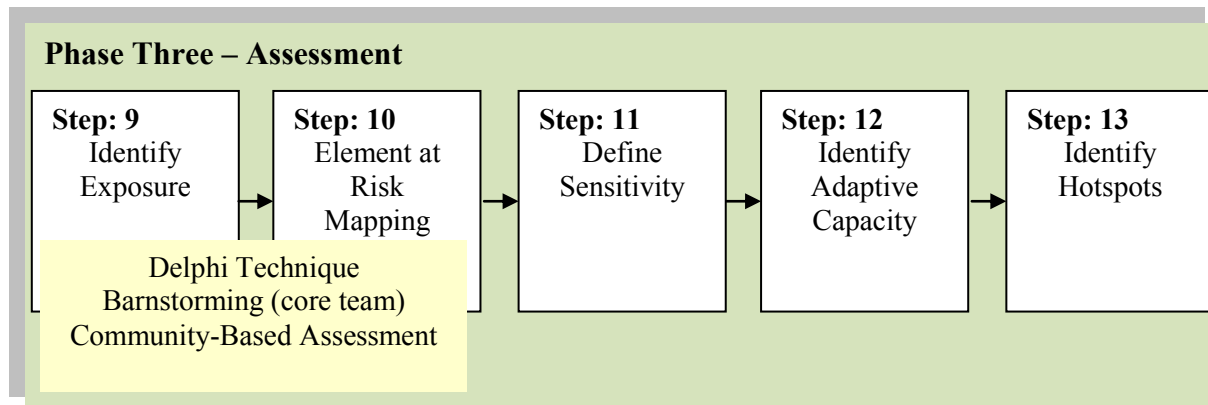
The assessment looked at these three factors, given that vulnerability to climate change impacts increases with exposure and sensitivity yet can be off-set by an increased adaptive capacity. For instance, even though there is a significant increase in rainfall, if the area affected has robust adaptive capacity (i.e. a well established and maintained drainage system), then there will be lower vulnerability compared to an area of poor adaptive capacity (i.e. with an obsolete drainage system).

Active stakeholder participation is a key requirement throughout the assessment. The level of understanding, local knowledge and analytical capabilities of stakeholders are key factors of

a successful assessment. The participatory nature of the assessment is expected to enable broad-based decision making that increases the ability of local governments to mobilize effective local actions.

Two key additions were made to the initial method, explained in the toolkit based on Sorsogon city V&AA. First, this includes the 'element-at-risk mapping' component, which comprehensively assesses the impact to the overall city. This is partially an extension to the participatory mapping process introduced in the toolkit. This is important for physical planners to visualize overall impact to the city and for decision makers to formulate spatial oriented decisions on city development. Second, in addition to community-based climate change scenario assessments, climate variables have been assessed based on the records of observatory stations. This is a technical input but the community were duly impressed giving them a strong basis to emphasize the need for an adaptation plan based on the findings. The community enthusiastically compared their statements to the findings from observatory records. This in turn led to more active participation on the part of the community in later stages of the project.

4.1. Step: 09 Identify Exposure

Degrees of exposure to climate change impacts are often assessed through climate change scenarios. There are several types of climate change scenarios:

- Arbitrary climate change scenarios (scenarios that are devised arbitrarily based on expert judgment)
- Analogue climate change scenarios (scenarios based on past climate)
- Scenarios based on climate model outputs

Locally-specific climate models are extremely useful in the preparation of adaptation plans for cities. However, writing a climate change scenario is a costly exercise which needs expertise inputs on climate science. Therefore, in CCCI toolkits it has been often suggested to use scientific observations available at global, regional and national levels as the basis for defining a city climate change exposure analysis. There are no scientifically established comprehensive climate change scenarios at a national level available in Sri Lanka. Therefore, this assessment directly follows the IPCC global predictions as key concerns for assessment. The IPCC has developed storylines to narrate qualitative (e.g., political, social, cultural and educational conditions) emissions drivers, and scenarios on how climate may evolve in the future by using General Circulation Models (GCM).

The most important factor to note is that these models need an acceptable ground-truth to relate available local observations with global/regional projections. In this assessment, this has been attempted with two alternative methods by conducting FGDs with communities and stakeholder workshops as well as accomplishing statistical analysis of past climate records. In other words, this study attempted to relate global predictions using local accounts of historical data/previous events to emphasize the evidence of climate change impacts in the city. The global projection in the table used climate change projections of the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report.

The challenge for the assessment team was to understand how the global and national climate change projections apply to the city:

- Average surface temperature increased by 0.74°C (1960-2005)
- Global average sea levels rose (due to increase in average surface temperature) at an average of 1.8mm per year during the period from 1961-2003
- Projected increases for further warming from 1.4°C to 5.8°C during the 21st century leading to a further increase in sea-level rise projected from 18-59cm in 2010 and from 1m to 2m (worst case scenario) by the end of the 21st century

Secondary data collected at a previous stage was used to develop an understanding of the local situation.

Hazardous Events		Return Period
Flood	Flash Floods	Every Year (Southwest Monsoon Period, May-Sep)
	Minor Floods (100-150mm)	1-2 year (2008 Nov, 2007 May, 2006 Nov, 2005 Oct, 2003 May, 2001 Jun, 1998 May, 1995 May, 1993 May, 1992 May, 1988 Jun, 1987 Oct, 1985 May, 1984 May, 1982 Mar, 1979 May, 1977 May, 1975 May, 1974 Sep, 1971 Sep, 1970 Sep)
	Major Floods (150-200mm)	3-5 year (2006 Oct, 2002 Oct , 2000 Oct, 1998 May, 1995 Nov, 1990 Nov, 1987 Oct, 1982 May, 1980 May, 1973 Oct)
	Critical Floods (200-250mm)	10-20 year (2005 Nov, 1999 April, 1996 Aug, 1977 Oct)
Cyclone	Cyclonic Storms (1967, 1913)	30 years
	Cyclones (1992)	

Sea-Level Rise - Costal Erosion	Every Day
Sea-Level Rise - Salinisation	No records

(Source: DMC Negombo, Negombo DSD, CCD Negombo)

The city's exposure to climate-driven phenomena such as changes in extremes (e.g. tropical cyclone/storm surges, extreme rainfall) and changes in means (e.g. temperature, precipitation, and sea-level rise) were assessed through FDG's & KII's. In this connection, the section below explains the:

4.1.1. Statistical analysis of changes in means

4.1.2. FDG's & KII's findings on city-level exposure to climate change

4.1.1. Statistical Analysis of Changes in Means

The climate scenario analysis is based on climate data obtained from Katunayaka observation Station of Meteorology Department from 1970 to 2009. This analysis refers to the changes observed in rainfall and temperature levels in that particular station.

4.1.1.1. Changes in Rainfall

The average annual rainfall of Katunayake Meteorological station is 2,075mm. During the last forty years, a maximum annual average rainfall of 3,236mm was recorded in 1999 and a minimum average rainfall of 1,441mm was recorded in 1983. According to the classification provided by Meteorological Department of Sri Lanka, the rainfall pattern of Sri Lanka is influenced by monsoon winds and is marked by four seasons.

- Southwest monsoon (mid-May to October)
  - Wind originates in the Southwest bringing moisture from the Indian Ocean and precipitation to the southern region of the country.
- Inter-Monsoon rain (October and November)
  - During this season, periodic squalls occur and sometimes tropical cyclones bring overcast skies and rains to the Southwest, Northeast, and Eastern parts of the island.

- Northeast monsoon (December to March)
    - Monsoon winds come from the Northeast, bringing moisture from the Bay of Bengal and heavy precipitation on Northeastern slopes of the mountains and the eastern region of the country
- Inter – monsoon rain (March to mid-May)
    - Another inter-monsoonal period occurs with light, variable wind and evening thunder showers.

Katunayake meteorological station records extensive rainfall during the inter-monsoon months of April-May and October-November when average monthly rainfall exceeds 200mm. The months immediately prior to and after these two peaks (i.e. March, June, September, and December) experiences relatively high rainfall which exceeds 100mm per month. July-August and January-February are the least rainy seasons of the year which record average monthly rainfall less than 100mm. The average annual and average monthly (mean, minimum and maximum) rainfall recorded by the Katunayake meteorological station is given below.

Rainfall Season		Min	Max	Average	Std
Annual		**1,441.10**	**3,236.30**	**2,074.59**	**368.69**
Southwest monsoon	June	48.00	325.20	160.22	74.98
	July	5.30	283.50	89.10	62.72
	Aug	0.50	300.30	87.19	76.19
	Sep	11.70	418.80	188.60	111.26
Inter-Monsoon rain	**Oct**	**69.50**	**826.60**	**350.01**	**184.04**
	Nov	**9.80**	**713.50**	**319.09**	**157.21**
Northeast monsoon	Dec	9.10	313.40	128.69	76.97
	Jan	0.00	296.40	59.11	70.99
	Feb	0.00	256.60	69.95	72.72
Inter-monsoon rain	Mar	0.00	419.50	124.58	93.54
	Apr	**35.30**	**628.00**	**221.77**	**131.78**
	May	**2.10**	**781.90**	**275.29**	**162.36**

Source: Based on Metrological Department Data

As illustrated in the graph below, the annual average rainfall recorded by the Katunayake observation station has fluctuations year by year but there is no significant increase or decrease during last forty years.
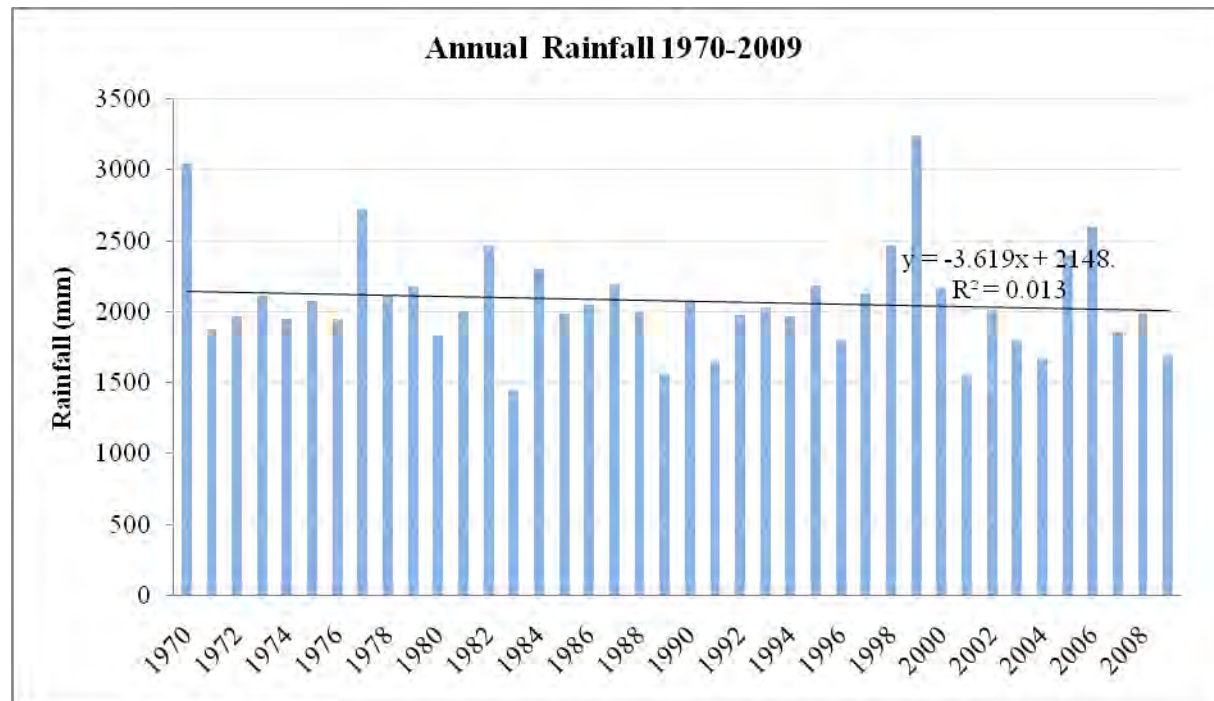
There is a significant variation of annual rainfall variability per decade recorded at Katunayake station. The standard deviation of each decade reveals an increasing trend, as depicted below.
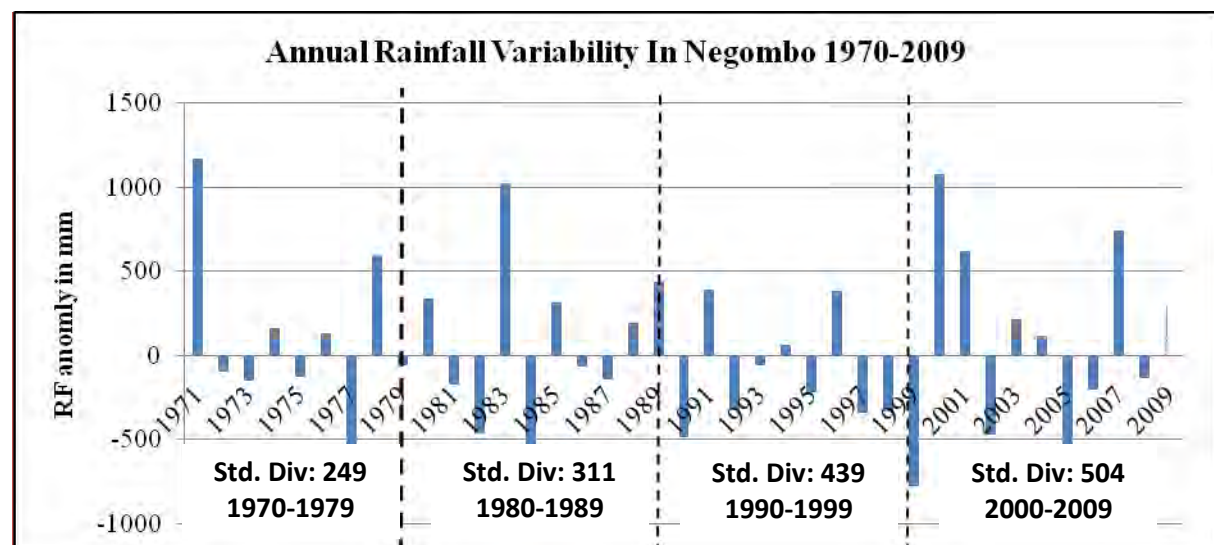
This high degree of variability may distort the long term cyclic patterns and regular predictable return periods of extreme climatic events.

The average rainfall per decade reveals a cyclic fluctuation by decade. Both high and low rainfall decades have been recorded by the Katunayake observation centre. When comparing these two peaks, it is noticeable that the second peak recorded higher values than the first. The following graph depicts the significant increase of rainfall in the last two decades when compared to the previous two decades.
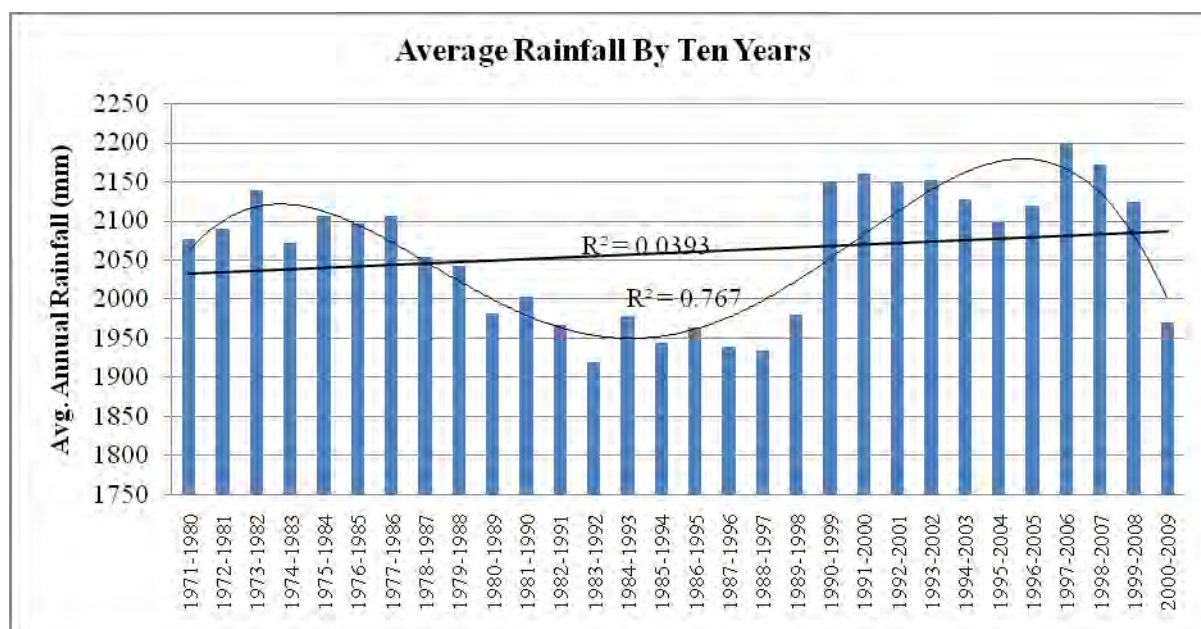
Source: Based on Metrological Department Data

Monthly rainfall analysis indicates that monthly rainfall received during four consecutive monsoons/inter-monsoon months (starting from April to July) has been decreasing over the past forty years. Correspondently, the rainfall received during the three consecutive months of the Northeast monsoon period (starting from December to February) has been increasing over the past forty years.

	Average monthly Rainfall (mm)				Percentage increase from (a) to (b)
	1980-1989	**1990-1999**	**1980-1999(a)**	**2000-2009(b)**	
January	4.58	5.35	**4.96**	**11.71**	**136%**
February	9.1	4.51	**4.16**	**11.75**	**64%**
March	11.37	9.37	**10.3**	**15.4**	**49%**
April	21.3	22.4	**21.9**	**27.8**	**27%**
May	26.1	33.6	**29.8**	**22.7**	**-24%**
June	22.1	19.8	**20.9**	**16.5**	**-21%**
July	7.3	14.8	**11.2**	**6.6**	**-40%**

August	13.6	9.4	**11.5**	**9.2**	**-20%**
September	22.8	23.6	**17.6**	**23.3**	**-24%**
October	31.1	33.9	**43.6**	**32.5**	**34%**
November	36.4	37.6	**31.8**	**37**	**-14%**
December	11.3	13	**15.8**	**12.1**	**30%**

Source: Base on Metrological Department Data

As stated in the above table, the average monthly rainfall recorded at Katunayake station has seen some changes during the last thirty years. There are two salient features noticeable in rainfall patterns:

a) Rainfall recorded in the month of January during the last decade has increased by almost two times when compared to previous decades. This is the peak incident of the five consecutive months of December through April that experience increasing monthly rainfall levels.

b) Rainfall recorded in the month of July, which is the peak of the Southwest monsoon, has dropped by about half during the last decade compared to the two previous decades. This can be considered as the peak incident of five consecutive months of the Southwest monsoon (May, June, July, August, September), which show a decreasing monthly rainfall.

The graph below indicates the changes in the amounts of rainfall recorded during monsoon rains (mid May to September) and non-monsoon rains (October to mid May). There is a significant increase in non-monsoon rains over the past two decades when compared to the previous two decades.

Rainfall Pattern Monsoon Period & Non- Monsoon Period 1970-2009

Equations shown on chart:
$$y = 3.162x + 1208.$$
$$R^2 = 0.010$$

$$y = -6.789x + 939.5$$
$$R^2 = 0.131$$

Legend: Monsoon Period, Non-Monsoon Period, Trendline Monsoon Period, Trendline Non-Monsoon Period
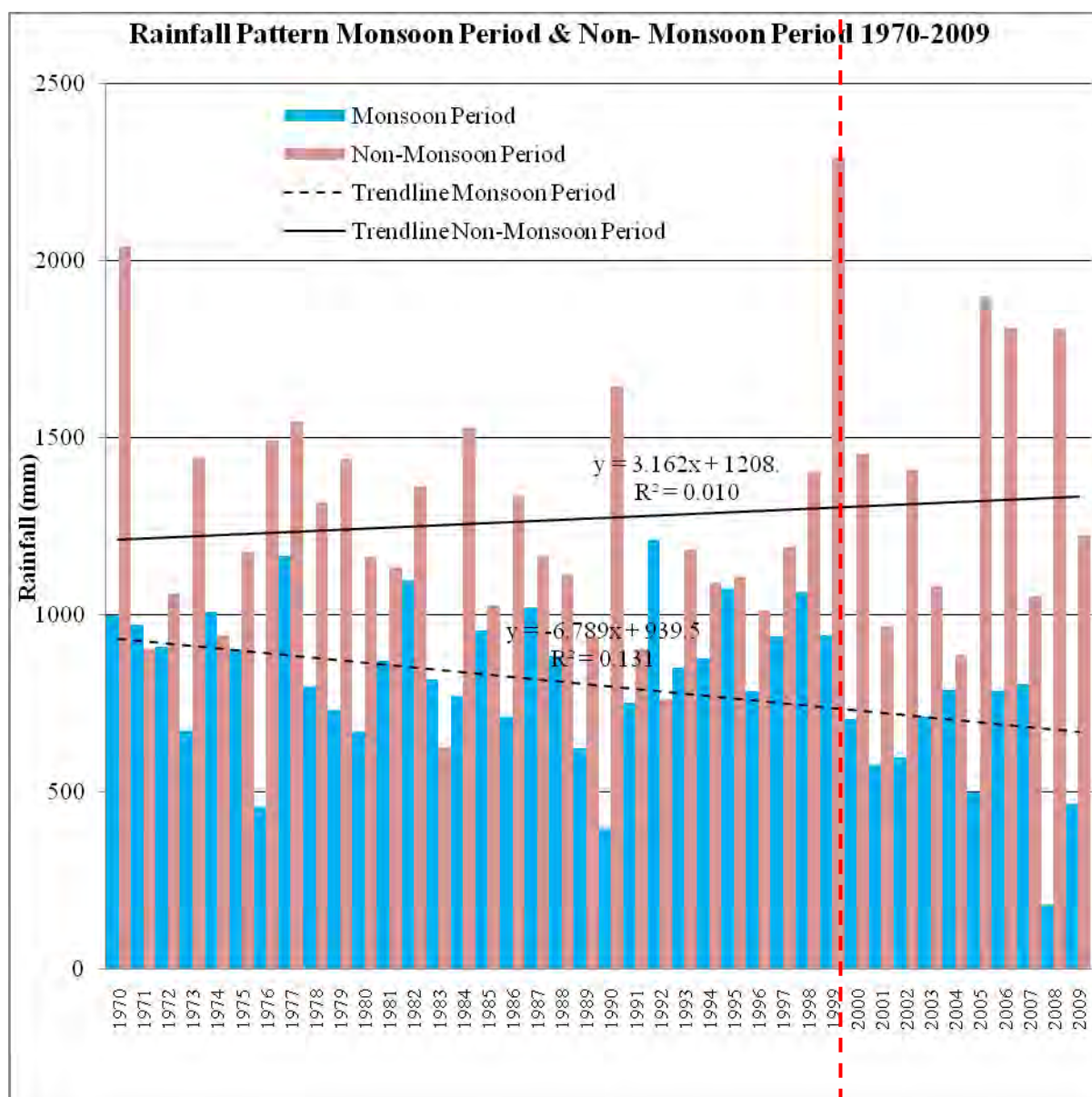
Source: Base on Metrological Department Data

There are some changes occurring in seasonal patterns of rainfall. Some of the changes noted in seasonal patterns are mentioned below.

There are two peaks of annual rainfall: one in May/June and the other in October/November.

- The first peak rainfall from May to June (refer to line 'A') was recorded from April during last decade (refer to line 'B').

- The second or the highest peak from October to November starting in the first/second week of October was recorded from the third/fourth week of September. The most intense rain of the peak used to stop by about the second week of November, but now it continues until the third/fourth week of November.

▪

Seasonal Changes in Rainfall Pattern
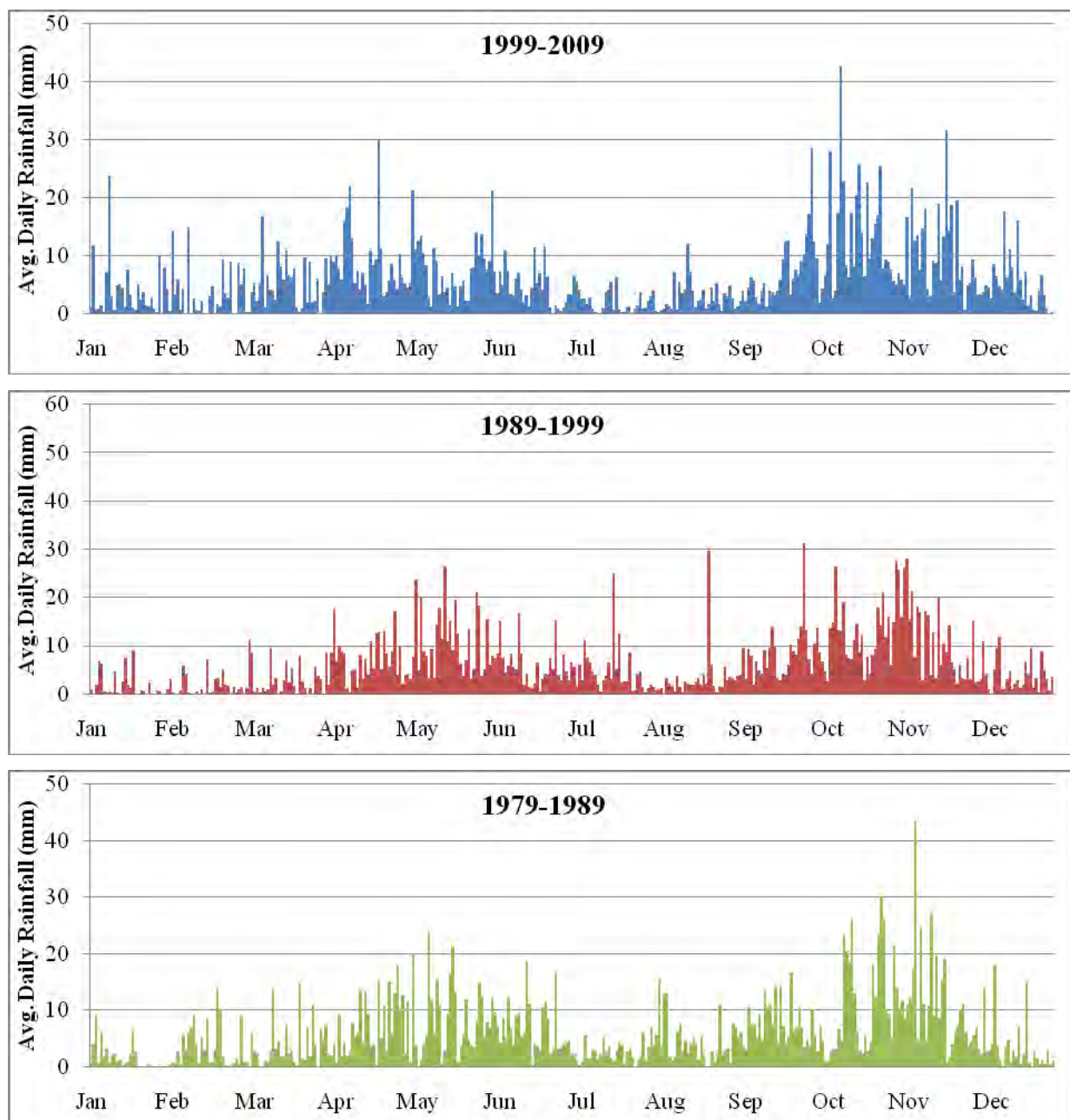
The average number of rainy days in Katunayake is 210 days per annum. An analysis of the number of rainfall days indicates that there is no significant variation in the number of days not experiencing any rainfall.

There is a significant increase in the number of days experiencing rainfall of more than 90mm per day. The following graph shows the number of heavy rainy days (average daily rainfall more than 90 mm) observed from 1970 to 2009. The graph shows a significant increase in the number of extreme events over the past few years.

Periods of intense rain, which used to happen once or twice a year, have increased to as many as five to six times a year. This may increase the probability of localized flooding.

No of Days Having Rainfall More Than 90mm
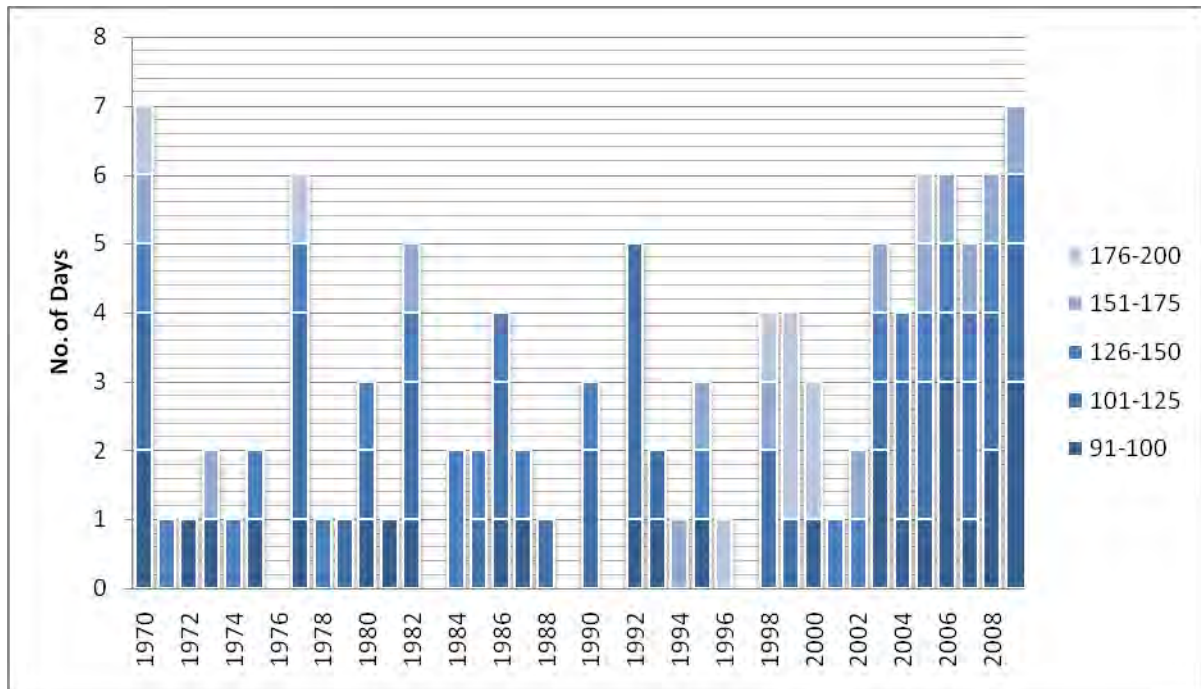
Source: Based on Metrological Department Data

4.1.1.2. Changes in temperature

The average monthly temperature of Katunayake observation station varies from 30^0C to 32^0C. During the past forty years, a maximum temperature of 38.4^0C was recorded in January 1980 and a minimum temperature of 27.9^0C was recorded in January 1978.

The months of June to October are cooler months with an average monthly temperature of about 30^0C. January to April are warmer months, with a recorded average monthly temperature of more than 32 ^{0}C.

	Min	**Max**	**Average**	**Std**
Annual	30.76	32.69	31.48	0.36
June	29.27	35.06	30.89	0.90
July	29.37	34.07	30.58	0.75
Aug	29.79	34.28	30.72	0.71
Sep	29.79	32.53	30.83	0.55
Oct	29.71	32.06	30.65	0.50
Nov	29.51	32.45	31.02	0.55
Dec	29.58	33.73	31.40	0.87
Jan	27.92	34.44	32.10	1.15
Feb	28.79	34.36	32.63	0.97
Mar	29.55	34.18	32.71	0.83
Apr	31.02	34.75	32.50	0.72
May	30.22	33.28	31.75	0.70

Source: Based on Metrological Department Data

The annual mean air temperature has showed a decreasing trend in recent decades in the Negombo area. The rate of decrease of mean temperature for the period of 1980-2009 is 0.01^0C per year.
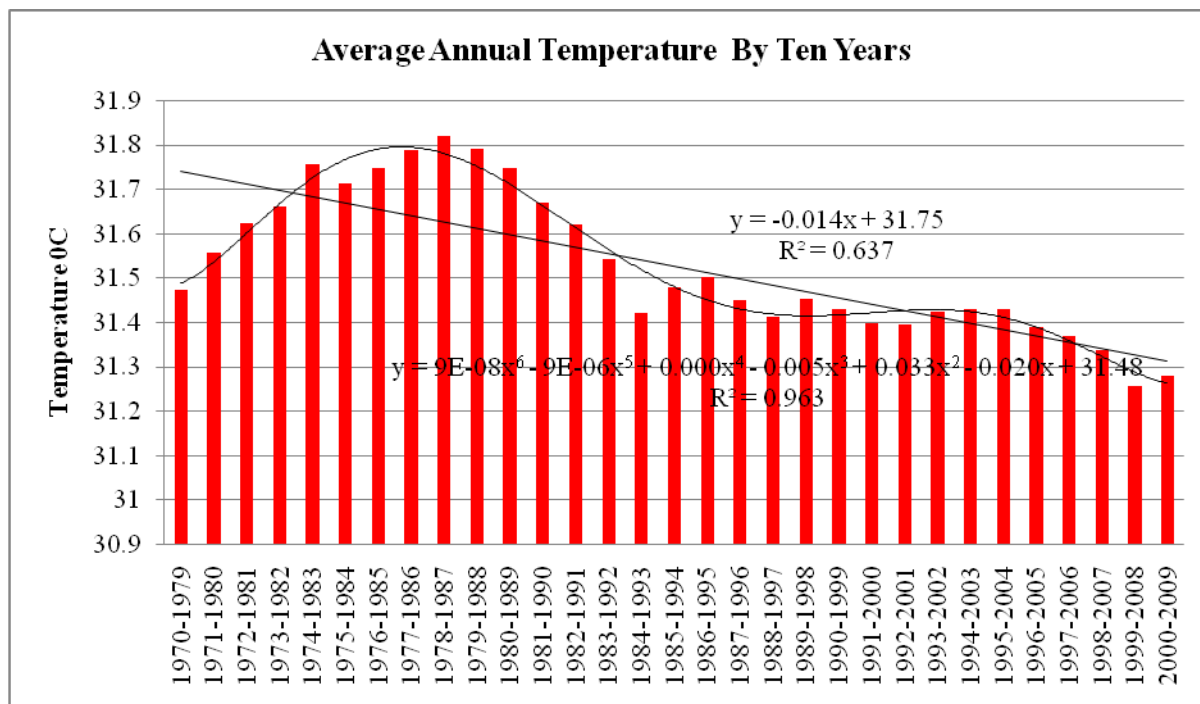
Source: Based on Metrological Department Data

The average annual temperature which was 31.75 ^{0}C from 1980 to 1990 has decreased up to 31.28 ^{0}C during 2000 to 2009 by 0.47 ^{0}C. Average temperature records per decade show a sharp decrease during the decades from 1990 to 2009 compared to 1980-1990. There is an increase, however, in the number of days experiencing temperatures reaching 30-32^{0}C in the last few decades when compared to previous decades.
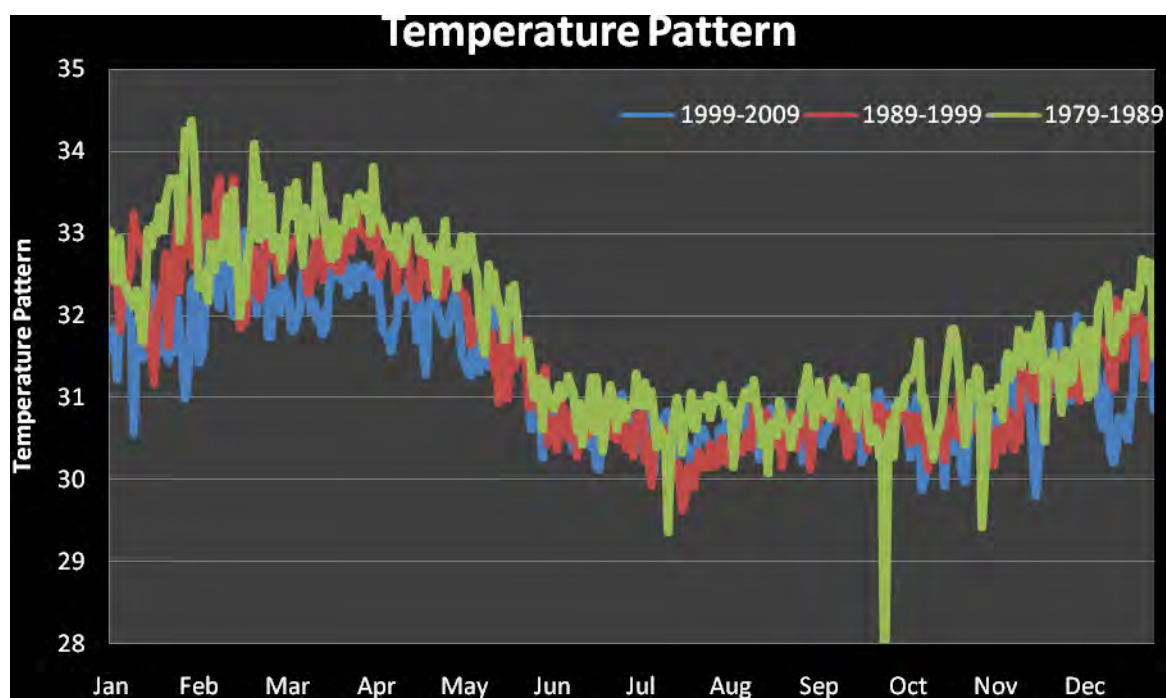
Source: Based on Metrological Department Data
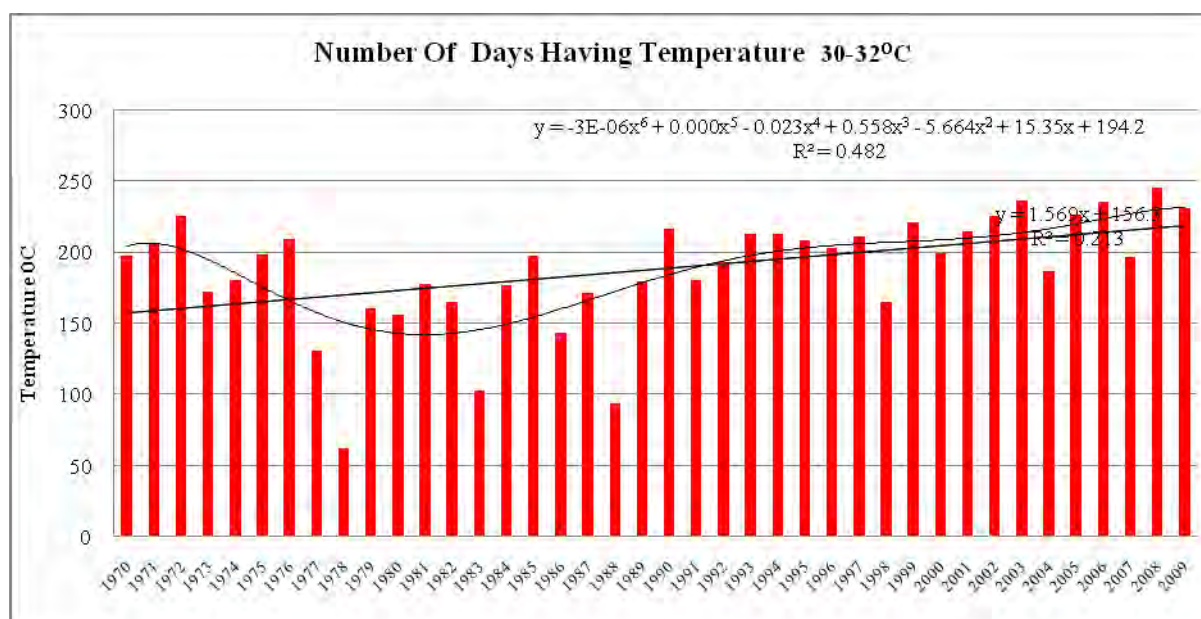
Source: Based on Metrological Department Data

Average monthly temperatures dropped in the last decade mainly in the five consecutive months of December to April.

	Percentage increase from 1980-1999 to 2000- 2009	
	Temperature (%)	**Rainfall (%)**
January	**-2.88**	**+136**
February	**-1.65**	**+64**
March	**-2.04**	**+49**
April	**-2.23**	**+27**
May	**-0.8**	**-24**
June	**-0.56**	**-21**
July	**-0.23**	**-40**
August	**0.7**	**-20**
September	**0.1**	**-24**
October	**-1.03**	**34**
November	**-0.32**	**-14**
December	**-0.18**	**+30**

Source: Based on Metrological Department Data

These five months have seen increasing monthly rainfall during the past decade compared to the previous two decades. There is a significant correlation between a decreasing monthly average temperature and an increasing monthly average rainfall. There is a strong positive correlation between these two sets of values. This relationship needs to be further established through a detailed analysis of changes in annual humidity levels.

In conclusion, it is noticeable that there is a significant change of climatic conditions (temperature and rainfall) as per the records observed by Meteorological station, Katunayake

4.1.2. FDG's & KII's findings on Local Exposure to Climate Change

The FDG's & KII's were designed to collect information from people's on-the-ground experience of climate change witnessed within Negombo Municipality. FDG's & KII's started with a brief introduction on: "What is climate change, CC scenarios, global/national/local impacts of climate change and the role of stakeholders in response to future climate change scenarios" thus providing the respondents with some background to engage in the discussion.

Stakeholders were divided into four groups before the assessment. The following table indicates the responses of stakeholders to changes in extremes and means as per local knowledge/experience. The first row of the table details the members of the group and the number of members (within brackets). Correspondent columns depict the number of members who observed each particular change.

	Group1 NMC & DSD(10)	Group 02 Local administrative institutions(20)	Group 03 Older Citizens(30)	Group 04 CBO's & NGO's(20)	Total (80)
Changes in Extremes					
Flood	10	20	29	19	78
Cyclone	3	5	8	3	19
Storms surges	5	8	11	7	31
Changes in means					
Increase in temperature & humidity	8	18	27	16	69
Increase in rainfall	6	11	17	11	45
Sea-level rise	7	13	13	6	39

Negombo city has experienced extreme events such as floods and storm surges. An increase in temperature and humidity was observed by a number of stakeholders. Older citizens and CBO groups were highly sensitive to the changes observable in temperature and rainfall. The following table contains the most highlighted consequences of the above changes as listed by the stakeholders.

	Changes in Means			Changes in Extremes		
	Increase in Temperature	Increase in Rainfall	Sea-Level rise	Flood	Cyclone /Storms	Drought
Coastal erosion		Y	Y	Y	Y	
Scarcity of water	Y	Y	Y	Y		
Salt water intrusion			Y			
Poverty				Y	Y	
Soil erosion		Y	Y	Y		
Loss of food security		Y		Y	Y	
Spreading of epidemic diseases	Y	Y		Y		

The occurrence of floods in Negombo was seen by stakeholders as the most devastating event related to climatic phenomena.

A list of future impacts was compiled. The items of the list (possible impacts) were prioritized based on the number of stakeholder opinions per item. Items which were mentioned by a higher number of stakeholders were taken to be the most likely events to occur. Those items mentioned by the fewest number of stakeholders were taken to be the least likely events to occur. A summarized list of these items is given below.

High	Disturbance to day to day life (floods)	Consequences of extremes
	Scarcity of drinking water (dried-up/salinisation)	Consequences of extremes
	Spreading of diseases	Consequences of extremes
	Temperature & humidity increase	Changes in Means
	Destruction to coastal habitat and houses	Consequences of extremes
Moderate	Sudden changes to rainfall/heavy rains	Changes in Means
	Loss of human lives (floods)	Consequences of extremes
	Coastal erosion	Consequences of extremes
Low	Urban heat islands	Consequences of extremes
	Losses to fisheries sector	Consequences of extremes

During the activity, people were asked to identify the specific areas where the community/property was affected by these events. A summary of this is depicted below.

Vulnerable groups	Where they stay
Fishermen	Ethukala, Palagathure, Pitipana, Aluth Kuruwa, Kepumgoda, Uswatakeiyawa, Dumgalpitiya, Munnakkara
Hotels	Beach Side
Coastal communities	Palagathure, Thalahena, Pitipana South, Kudapaduwa North, Coastal zone (especially in buffer zone)
People who may suffer from drinking water scarcity	Kammalthura, Palangthure, Ettukala, Kudapaduwa North, Wella Weediya, Well Weediya East, Periyamulla, Wella Weediya South, Muttakari North, Udayarthoppura, Udayarthoppwa South, Muttakari East, Thaladoowa, Doowa, Pitipana North, Pitipana Central Pitipana East, Pitipan South, Thalahena, Siriwardana Pedesa, Dungalpitiya, Settapaduwa, Kepunagoda
Government offices	NMC area (rainy days)
Students/schools	NMC area (rainy days)
People who livealong water bodies	Delathura, Depa ela, Peruwa, Kadirana, Bolawalana, Hunupitya
People who live along the Hamilton Canal	Pitipana North, Ettukala, Kurana
Species	Lagoon

A team of students from the University of Moratuwa, and residents of Negombo region, marked these locations on a map. The map was then shown to residents to verify the accuracy of the locations identified.

This exercise highlighted how communities currently respond to climate change phenomena and the need for involvement of the community in developing local climate change action.

4.2. Step: 10 Elements–at-Risk Mapping

The next phase of the process consisted of a participatory mapping of the identified vulnerable areas. The field mapping team visited the areas as per the map prepared during previous workshops (see above for location of vulnerable properties/people). The field mapping team was supported by the local participants when visiting these locations. KII's were conducted with vulnerable groups and areas were marked on satellite images to scale. GPS points were taken wherever necessary to verify the ground points. The fact sheet (given below) was prepared at the end of the previous exercise and used to plan the field survey.

Hazardous Events	Return Period		Vulnerable Areas
Floods	Flash Floods	Every Year (Southwest Monsoon Period, May-Sep)	■ High : Kochchikade,Ettukala, Ralangathure, Kattauwa, Udayarthoppuwa South, Pitipana South, Kepunagoda ■ Moderate : Kammalthura, Pallansena South, Daluwakotuwa, Dalupotha East, Kudapaduwa North , Kudapaduwa South, Kurana East, Muttakkaraya, Pitipana North, Doowa, Thalahena, Siriwardana Pedesa, Gungalpitiya, Settappaduwa ■ Low : Kudapadduwa, Dalupotha, Wella Weediya
	Minor Floods (100-150mm)	1-2 year (2008 Nov, 2007 May, 2006 Nov, 2005 Oct, 2003 May, 2001 Jun, 1998 May, 1995 May, 1993 May, 1992 May, 1988 Jun, 1987 Oct, 1985 May, 1984 May, 1982 Mar, 1979 May, 1977 May, 1975 May, 1974 Sep, 1971 Sep, 1970 Sep)	
	Major Floods (150-200mm)	3-5 year (2006 Oct, 2002 Oct , 2000 Oct, 1998 May, 1995 Nov, 1990 Nov, 1987 Oct, 1982 May, 1980 May, 1973 Oct)	
	Critical Floods (200-250mm)	10-20 year (2005 Nov, 1999 April, 1996 Aug, 1977 Oct)	
Cyclones	Cyclonic Storms (1967, 1913)	Some were agreed that this occurs once every 30 years. But, others mentioned it as non-cyclic effect.	■ High : Coastal belt ■ Moderate : Entire NMC Area
	Cyclones (1992)		
Sea-level rise / Coastal erosion		Experienced over many years but very significant in the last 10-15 years.	■ High : coastal belt along Palangathure, Kudapaduwa North, Wella Weediya, Muttakkarai North GN ■ Moderate : coastal belt along Settappaduwa, Kepunagoda GN ■ Low : coastal belt along Kammalthura, Pitipana North, Pitipana South, Thalahena, Dungalpitiy GN

Hazardous Events	Return Period	Vulnerable Areas
Sea-level rise - Salinisation	This has been significant during the last 10 years.	▪ Kammalthura, Palangthure, Ettukala, Kudapaduwa North, Wella Weediya, Well Weediya East, Periyamulla, Wella Weediya South, Muttakari North, Udayarthoppura, Udayarthoppwa South, Muttakari East, Thaladoowa, Doowa, Pitipana North, Pitipana Central Pitipana East, Pitipan South, Thalahena, Siriwardana Pedesa, Dungalpitiya, Settapaduwa, Kepunagoda

Field surveyed data was used to map vulnerable areas for flooding, cyclones and salt water intrusion. The following maps represent the maximum exposure locations for disasters.
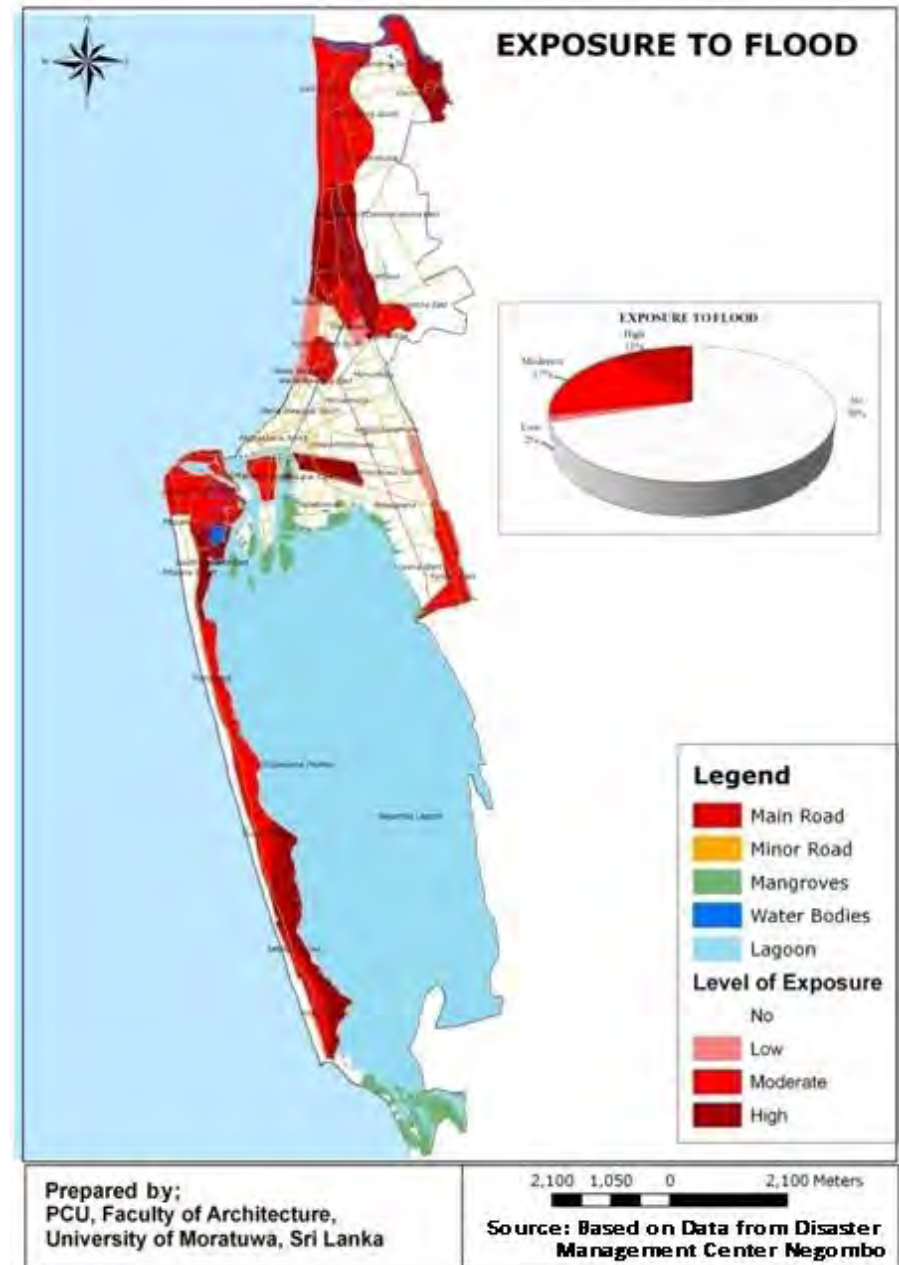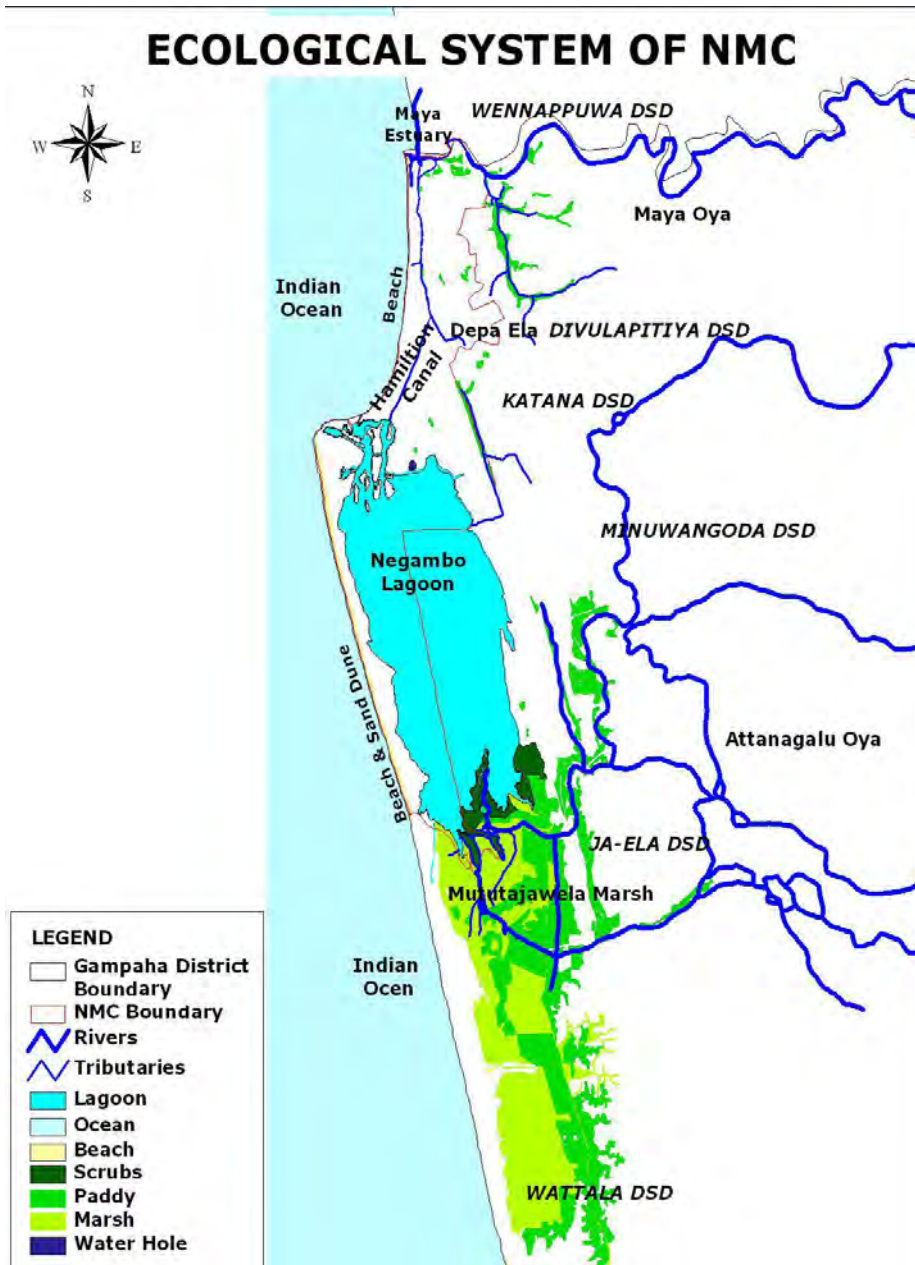
	Elements	Exposure to Floods	
		Amount	**As % of Total**
Areas (Ha)	People	40,486	28
	Houses	9,195	26
	Residential Areas	494	45
	Built up areas	565	48
	Forest/Scrubs	42	83
	Mangrove areas	5	5
	Agriculture areas	N/A	0
	Lagoon	N/A	0
	Beach	N/A	0
	Historical /Archaeological Places	16 (locations)	43
Activities	Trading & Commercial Activities	3 Ha	21
	Lagoon Fishery	N/A	0
	Coastal Fishery	N/A	0
	Tourism	N/A	0
	Agriculture	N/A	0

Infrastructure Systems	Roads
	    Main Road :
	    Minor Road :
	    Local Road :
		5km
		100-120km
		200-225km
			19
			47
			48

	Transportation	▪ Negombo-Ja Ela via Pitipana Public Bus Route ▪ Negombo-Kochchikade via Porutota Public Bus Route ▪ Papiliyana-Puttalm Rd at Kurana	-
	Electricity Supply	N/A	0
	Water Supply Network	N/A	0
	Domestic Water Source	▪ 822 Housing Units with unprotected wells (Dungalpitiya GND-657, Daluwakotuwa GND -102, Pallansena N GND -37, Kochchikade GND -17, Kammanlthura GND -7, Settappaduwa GND-2)	-
	Drainage	Hamilton Canal Road Side Drainage System	-
	Sanitary Facilities Domestic Toilets	▪ 1,244 Housing Units which having pit latrines (Daluwakotuwa GND-670, Ettukala GND-342, Kammalthura GND-150, Pallansena GND-41, Kattuwa GND-32,Kochchikade GND-9	-
	Hospitals/Medical Centers	2	3
	Schools/Educational Institutions	17	35

CYCLONES PATHS OF SRI LANKA

LEGEND
Tracks of cyclones
Tracks of cyclonic storms

Source:Meteorological Department

	Elements	Exposure to Cyclone	
		Amount	As % of Total
Areas (Ha)	People	Entire Population in NMC area (depending on speed, direction of cyclone)	vary
	Houses	Each housing unit is subject to some exposure to cyclones (depending on their speed, direction) but housing units made of the following materials have higher levels of exposure:	
		Housing units with Cadjan/ Palmyrah/ Straw as their main roofing material; 1,851	6
		Housing Units which have Mud/ Plank/ Metal sheets/Cadjan/ Palmyrah/ Straw as their main wall material: 3,443	11
	Residential Areas	All residential areas in NMC area (depending on speed, direction of cyclone)	vary
	Built up areas	All built up areas in NMC area (depending on speed, direction of cyclone)	vary
	Forest/Scrubs	All scrubs in NMC area (depending on speed, direction of cyclone)	vary
	Mangrove areas	All Mangrove areas in NMC area (depending on speed, direction of cyclone)	vary
	Agriculture areas	Coconut cultivation 260 Ha	100
	Lagoon	N/A	0
	Beach	N/A	0
	Historical /Archaeological Places	All Historical /Archaeological Places in NMC area (depending on speed, direction of cyclone)	vary
Activities	Trading & Commercial Activities	All trade & commercial activities in NMC area (depending on speed, direction of cyclone)	vary
	Lagoon Fishery	All Lagoon fishery activities in NMC area (depending on speed, direction of cyclone)	vary
	Coastal Fishery	All coastal fishery in NMC area & its surroundings (depending on speed, direction of cyclone)	vary
	Tourism	All tourism activities in NMC area (depending on speed, direction of cyclone)	vary
	Agriculture	Coconut cultivation 260 Ha	100
Infrastructure Systems	Roads Main Road : Minor Road : Local Road :	N/A	0
	Transportation	Entire transportation network in NMC area (depending on speed, direction of cyclone)	vary
	Electricity Supply	Entire electricity supply in NMC area (depending on speed, direction of cyclone)	vary
	Water Supply Network	Elevated water tanks (Kamachchode, Periyamulla, Katuwapitiya, Kurana, Booster Sonders Place (depending on speed, direction of cyclone)	vary
	Domestic Water Sources	N/A	0
	Drainage	N/A	0

Sanitary Facilities Domestic Toilets	Entire Sanitary Facilities in NMC area (depending on speed, direction of cyclone)	vary
Hospitals/Medical Centers	All hospitals/medical centers in NMC area (depending on speed, direction of cyclone)	vary
Schools/Educational Institutions	All schools/educational institutions in NMC area (depending on speed, direction of cyclone)	vary

EXPOSURE TO
SEA LEVEL RISE (1.14m)

Legend

- Exposure to Sea Level Rise(1.14m)
- Main Road
- Minor Road
- Mangroves
- Water Bodies

Prepared by;
PCU, Faculty of Architecture,
University of Moratuwa, Sri Lanka

2,300   1,150   0   2,300 Meters
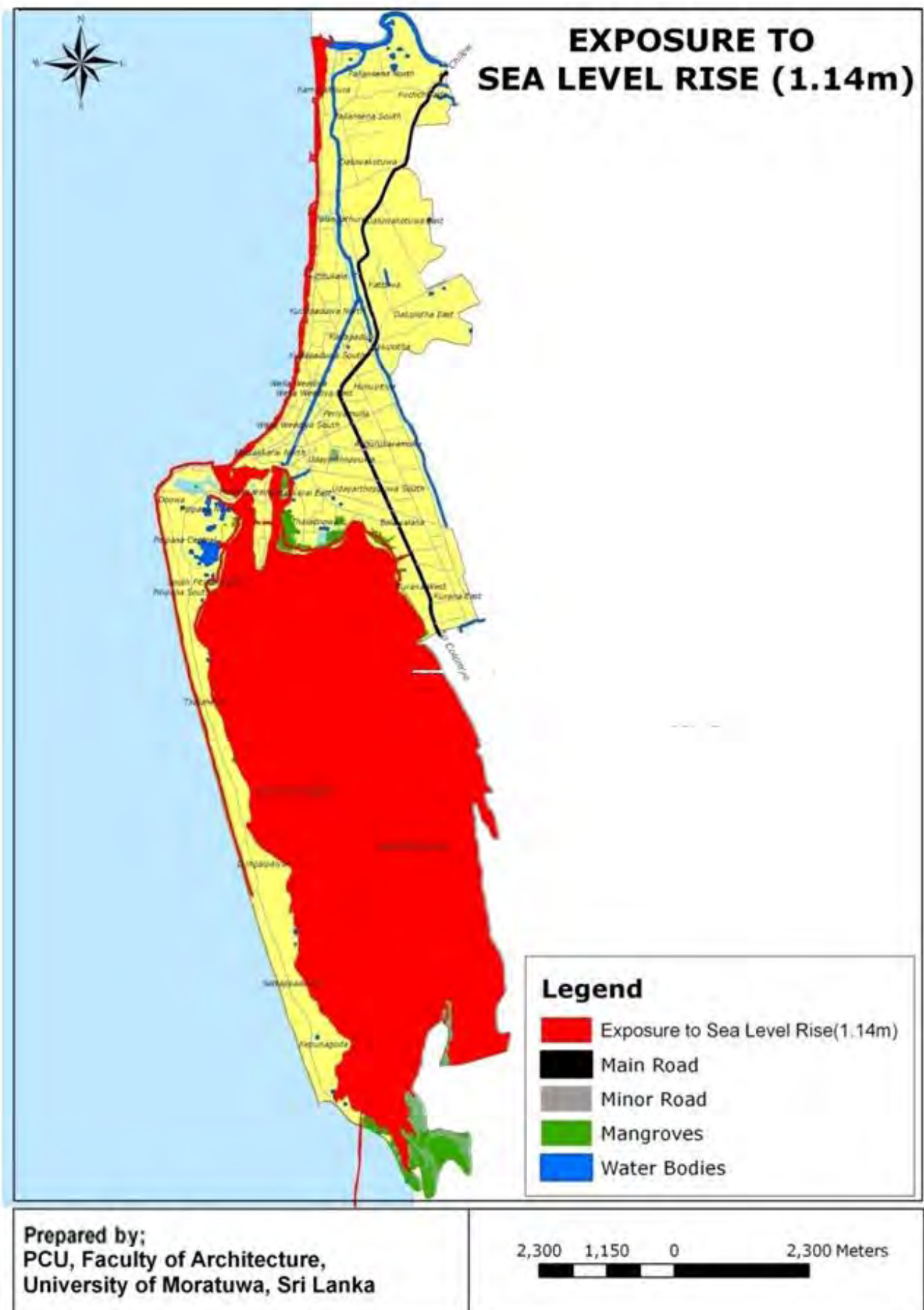
Elements		Exposure to sea-level rise	
		Amount	**As % of Total**
Areas (Ha)	People	People who live in affected areas & fishery community (6,752, 15% of total population) will be directly exposed to sea-level rise	15%
	Houses	Duwa; 50-60 Munnakkare; 50-60 Siriwardana Pedesa; 50-60 Porutota ; 30-40 Kammaltera ; 20-30 Wella Weediya ; 10-20	2%
	Residential Areas	Above Residential Areas	
	Built up areas		
	Forest/Scrubs	N/A	N/A
	Mangrove areas	26 Ha	25
	Agriculture areas	N/A	N/A
	Lagoon	Entire Lagoon	100%
	Beach	15m length belt & 24Ha (Beach From Kammalthota to Maha Lellama & Doowa area)	75%
	Historical /Archaeological Places	Fort	
Activities	Trade & Commercial Activities	Fishery market sales hall at Maha Lellama & 5 re-selling markets	80%
	Lagoon Fishery	Fishermen : 2,239 Entire Lagoon fish production & 3 boat anchorage locations	100%
	Coastal Fishery	Fishermen : 13,285 15 boat anchorage locations & fishery harbour	100%
	Tourism	Entire coastal tourism area (15m Beach 24Ha, 75% of total beach area) 10 Beach-side tourist hotels	80%
	Agriculture	N/A	N/A
Infrastructure Systems	Roads :	N/A	N/A
	Transportation	3 Bridges	5-10%
	Electricity Supply	N/A	N/A
	Water Supply Network	N/A	N/A
	Domestic Water Sources	N/A	N/A
	Drainage	N/A	N/A
	Sanitary Facilities Domestic Toilets	N/A	N/A
	Hospitals/Medical Centers	N/A	N/A
	Schools/Educational Institutions	1 (at Wella Weediya)	5%

EXPOSURE TO BEACH EROSION

Prepared by;
PCU, Faculty of Architecture,
University of Moratuwa, Sri Lanka

Source : Environmental Officers
DSD Negombo & NMC
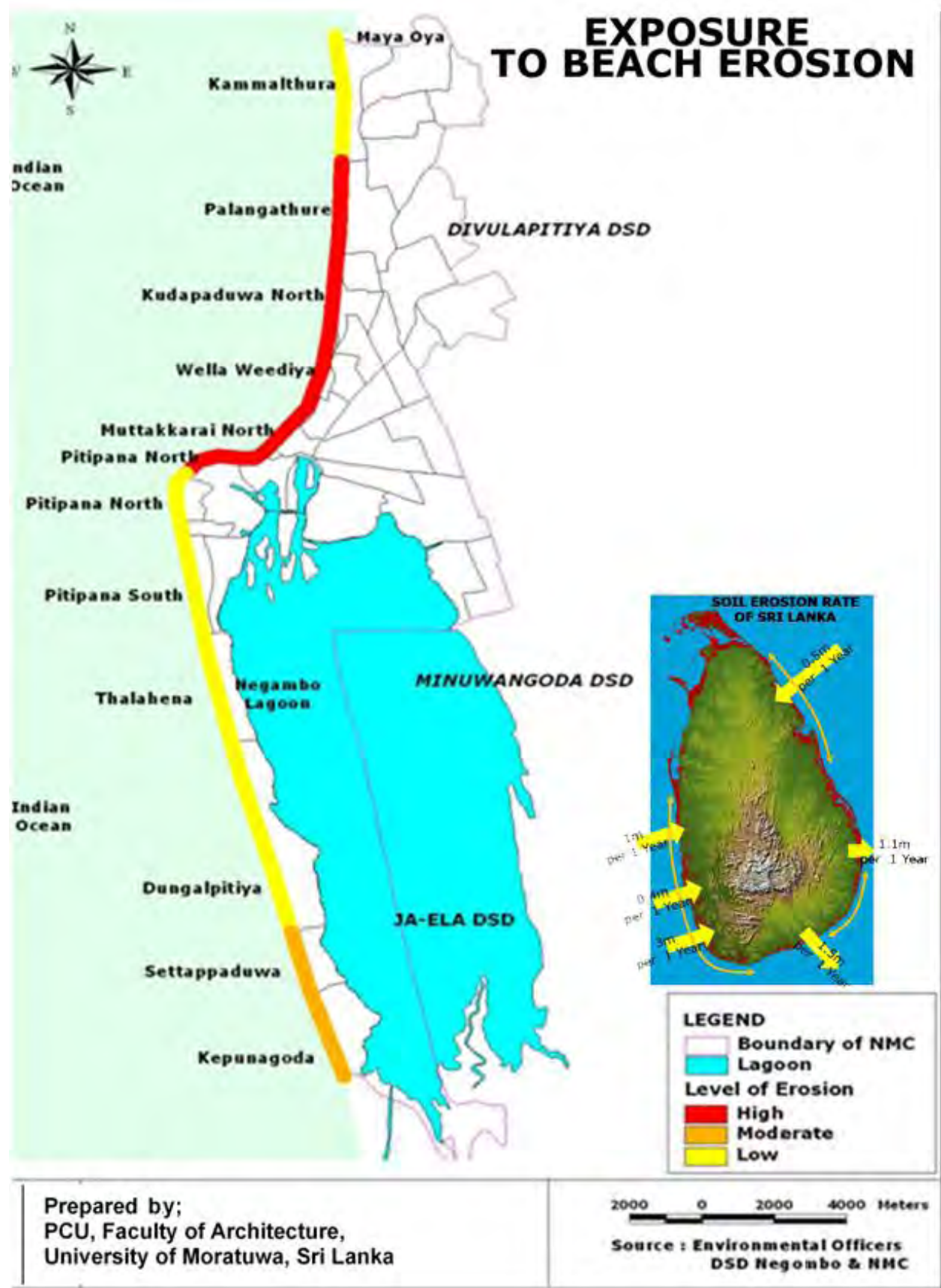
	Elements	Exposure to Coastal Erosion	
		Amount	**As % of Total**
Areas (Ha)	People	N/A	N/A
	Houses	N/A	N/A
	Residential Areas	N/A	N/A
	Built up areas	N/A	N/A
	Forest/Scrubs	N/A	N/A
	Mangrove areas	N/A	N/A
	Agriculture areas	N/A	N/A
	Lagoon	N/A	N/A
	Beach	20m entire beach (0.9 m per annum)	100%
	Historical /Archaeological Places	N/A	N/A
Activities	Trading & Commercial Activities	N/A	N/A
	Lagoon Fishery	N/A	N/A
	Coastal Fishery	Fishermen : 13285 15 boat anchorage locations & fishery harbour	100%
	Tourism	20m belt of beach area	50%
	Agriculture	N/A	N/A

Infrastructure Systems	Roads
	    Main Road :
	    Minor Road :
	    Local Road :
		N/A	N/A

	Transportation	N/A	N/A
	Electricity Supply	N/A	N/A
	Water Supply Network	N/A	N/A
	Domestic Water Sources	N/A	N/A
	Drainage	N/A	N/A
	Sanitary Facilities Domestic Toilets	N/A	N/A
	Hospitals/Medical Centers	N/A	N/A
	Schools/Educational Institutions	N/A	N/A

EXPOSURE TO SALINISATION

Legend

- ■ Exposure to Salt Water Intrusion
- ■ Main Road
- ■ Minor Road
- ■ Mangroves
- ☐ Water Bodies

Prepared by;
PCU, Faculty of Architecture,
University of Moratuwa, Sri Lanka

2,300   1,150   0   2,300 Meters

	Elements	Exposure to Salinisation	
		Amount	**As % of Total**
Areas (Ha)	People	People living in the following areas may be exposed to the effects of salinisation in NMC area Kammalthura, Palangthure, Ettukala, Kudapaduwa North, Wella Weediya, Well Weediya East, Periyamulla, Wella Weediya South, Muttakari North, Udayarthoppura, Udayarthoppwa South, Muttakari East, Thaladoowa, Doowa, Pitipana North, Pitipana Central Pitipana East, Pitipan South, Thalahena, Siriwardana Pedesa, Dungalpitiya, Settapaduwa, Ke[unagoda	80
	Houses	N/A	N/A
	Residential Areas	N/A	N/A
	Built up areas	N/A	N/A
	Forest/Scrubs	N/A	N/A
	Mangrove areas	100 Ha (Entire Area)	100%
	Agriculture areas	Paddy Land 6.7 Ha	100%
	Lagoon	Entire Area	100%
	Beach	N/A	N/A
	Historical/ Archaeological Places	N/A	N/A
Activities	Trading & Commercial Activities	N/A	N/A
	Lagoon Fishery	Fishermen : 2,239 & entire fishery activity	60%
	Coastal Fishery	N/A	N/A
	Tourism	N/A	N/A
	Agriculture	Paddy land 6.7 Ha	100%
Infrastructure Systems	Roads	N/A	N/A
	Transportation	N/A	N/A
	Electricity Supply	N/A	N/A
	Water Supply Network	Water source at Kochchkade (Maha Oya)	100%
	Domestic Water Sources	People who live in the following areas & use well water for drinking may be exposed to the effects of salinisation in NMC area Kammalthura, Palangthure, Ettukala, Kudapaduwa North, Wella Weediya, Well Weediya East, Periyamulla, Wella Weediya South, Muttakari North, Udayarthoppura, Udayarthoppwa South, Muttakari East, Thaladoowa, Doowa, Pitipana North, Pitipana Central Pitipana East, Pitipan South, Thalahena, Siriwardana Pedesa, Dungalpitiya, Settapaduwa, Kelunagoda	60%
	Drainage	N/A	N/A
	Sanitary Facilities	N/A	N/A
	Hospitals/Medical Centers	N/A	N/A
	Schools/Educational Institutions	3	15%

4.3. Step: 11 Define Sensitivity

This activity is designed to help reach an agreement on the quantitative and qualitative assessments of how the different impacts of climate change affect socio-economic and other development factors of the city. This was a relatively simple exercise for stakeholders because:

- Past trends of climate scenarios had already been downscaled to the city-level
- Areas exposed to extreme events had already been mapped out
- Elements-at-risk within the exposed areas had already been listed

This information was used during the decision-making exercise to define sensitivity. In adition to this, global and national climate change scenarios were used in the discussions to predict future scenarios and relevant affected locations. Trendline projections made for temperature and rainfall scenarios were provided as a preliminary approach to prediction.

This activity was conducted as a brainstorming session among the members of the assessment team with the participation of core stakeholders. By this stage, the stakeholderswere familiar with the concepts of climate change and expected outcomes. Therefore, the findings of the previous exercises were discussed, along with the results of the participatory mapping exercise. The key items that needed to be detailed for the next stages were now prioritised. The list of key changes in means, extremes and exposure is given below.

Climate change scenario	Possible Impact on Urban Areas
Changes in Means	Temperature
	Precipitation
	Sea-level rise
Changes in Extremes	Extreme rainfall
	Tropical cyclone thunder storms/lightning
Changes in Exposure	Population movements
	Biological changes

Thereafter, all element-at-risk maps, exposed area maps and land use maps of the NMC area were pinned up on a board so all stakeholders could see them. Based on these maps, stakeholder were then asked to list out the possible impacts of each predicted change on the urban environment of NMC.

Next, the team gave stakeholders a five scale ranking (Insignificant, Low, Moderate, High, Severe) to mark against the current level of each impact on the city. The team marked the possible future scenarios for 10 years, 25 and 50 years horizons, based on the current situation. The final assessment list is given below.

4.3.1. Impact Identification

Change in Climate		Possible Impact on Urban Areas*	Level of Sensitivity			
			2010 (Existing)	2020 (10 year)	2035 (25 year)	2060 (50 year)
Changes in Means	Temperature	Increased energy demand for air conditioning	Moderate Consequences	High Consequences	Severe Consequences	Severe Consequences
		Heat stress - Exaggerated by urban heat island effect	Insignificant	Low Consequences	Moderate Consequences	High Consequences
		- Deaths from cardio-respiratory diseases	Insignificant	Insignificant	Low Consequences	Moderate Consequences
		- Heat related sickness	Moderate Consequences	High Consequences	Severe Consequences	Severe Consequences
		- Air pollution related mortality & morbidity (The weather affects air pollution concentration & distribution, seasonality & production of aeroallergens)	Moderate Consequences	High Consequence	Severe Consequences	Severe Consequences
	Precipitation	Increased risk of flooding	High Consequences	Severe Consequences	Severe Consequences	Severe Consequences
	Sea-level rise	Coastal flooding - Coastal settlements - Coastal wetland	Moderate Consequences	High Consequences	Severe Consequences	Severe Consequences
		Coastal erosion	High Consequences	Severe Consequences	Severe Consequences	Severe Consequences
		Damage to fishery harbours & anchorages	Low Consequences	Moderate Consequences	High Consequences	Severe Consequences
		Damage to sea defence structures and breakwaters	Moderate Consequences	High Consequences	Severe Consequences	Severe Consequences
		Damage to near shore infrastructure	Moderate Consequences	High Consequences	Severe Consequences	Severe Consequences

Change in Climate		Possible Impact on Urban Areas*	Level of Sensitivity			
			2010 (Existing)	2020 (10 year)	2035 (25 year)	2060 (50 year)
Changes in Means	Sea-level rise	Inundation of important historical, cultural & religious sites	Low Consequences	Moderate Consequences	High Consequences	Severe Consequences
		Drop in income from tourism & agriculture	Low Consequences	Moderate Consequences	High Consequences	Severe Consequences
		Salt water intrusion - Low-lying agriculture - Water source	High Consequences	Severe Consequences	Severe Consequences	Severe Consequences
Changes in Extremes	Extreme rainfall & Tropical cyclone	More intense flooding	High Consequences	Severe Consequences	Severe Consequences	Severe Consequences
		Land degradation	Low Consequences	Moderate Consequences	High Consequences	Severe Consequences
		Disturbance to livelihoods & city economy	Moderate Consequences	High Consequences	Severe Consequences	Severe Consequences
		Damage to home & business	Moderate Consequences	High Consequences	Severe Consequences	Severe Consequences
		Damage to infrastructure (esp. transport infrastructure)	Moderate Consequences	High Consequences	Severe Consequences	Severe Consequences
		Injuries, Deaths & Long term physiological morbidities	Moderate Consequences	High Consequences	Severe Consequences	Severe Consequences
	Thunder storms/ Lightning	Damage to infrastructure (esp. power, telecommunication & other industrial installations)	Low Consequences	Moderate Consequences	High Consequences	Severe Consequences

Change in Climate		Possible Impact on Urban Areas*	Level of Sensitivity			
			2010 (Existing)	2020 (10 year)	2035 (25 year)	2060 (50 year)
Changes in Exposure	Population Movements	Movement away from coastal habitats under stress	Insignificant	Low Consequences	Moderate Consequences	High Consequences
	Biological Changes	Extended vector habitats with impact on health - More favourable breeding grounds for pathogens - The spread of epidemic diseases, mosquito-borne diseases, tick-borne diseases, food-borne diseases, and water-borne diseases	Moderate Consequences	High Consequences	Severe Consequences	Severe Consequences
		Extended vector habitats with impact on agriculture - Crop yield - Threats of pest	High Consequences	Severe Consequences	Severe Consequences	Severe Consequences
		Extended vector habitats with impact on fishery	Moderate Consequences	High Consequences	Severe Consequences	Severe Consequences
		Loss of bio-diversity	Moderate Consequences	High Consequences	Severe Consequences	Severe Consequences

*Source: Initial National Communication in the UNFCCC Sri Lanka (2000), Wilbanks T et al (2007), Kovats & Akhtar (2008)

As a next step, the stakeholder team agreed on common risk ratings to describe how critical the risks of climate change effects are, and the likelihood of such events occurring. The discussion was based on the results from previous steps.

As per the toolkit, each indicator in matrix 'A' and matrix 'B' was discussed. That said, given the results of matrix 'A', many impacts were seen as insignificant at the present moment. Furthermore, many of these impacts are interrelated which results in an overlapping of future impacts. Hence, stakeholders proposed to select the most severe impacts and to identify risks of the selected projected impacts. The project team accommodated their request, and accordingly a rating was introduced for the above impacts as follows: '*Insignificant = 1, Low Consequences = 2, Moderated Consequences = 3, High Consequences = 4 and Severe Consequences = 5*'.

From this analysis, the most severe events that might happen were listed by the stakeholders as follows:

1. Increase in rainfall and occurrence of floods
2. Increase in the occurrence of storm surges/cyclones
3. Sea-level rise and inundation of coastal areas

The team re-wrote the effects/impacts of climate change as identified in matrix 'A' in front of each selected CC Indicator.

A new column was inserted to the left, to list the critical socio-economic factors/elements of the city or municipality which may bear the impacts or effects of climate change. It was suggested to focus on People, Places, and Activity Sectors rather than all the factors/elements. It was considered a good suggestion to highlight the exposure to women, children, and old age groups as high risk. The available demographic database, however, was not complete enough to conduct a separate study. Therefore, this was incorporated under the general item of 'population'. Element-at-risk maps and assessment sheets and land use maps were used by the working team to carry out this exercise.

For the next exercise, copies of '*Matrix B: City Exposure and Sensitivity Analysis (Who/what are at risk to CC Effects)*' from the toolkit were distributed as a template**.** The assessment team was requested to identify probability or likelihood of impact/s and possible adverse

consequence/s for current and future time horizons. To determine the risk value of each climate indicator, ratings were provided for the exposure and sensitivity of each risk effect. The set of matrices prepared under this exercise is given below.

Increase in rainfall and occurrence of floods

Elements	Exposure (Probability or Likelihood of Impact)				Sensitivity (Possible Adverse Consequence/s)				Risk Rating (Total score over count of risk effects)
	2010 (Existing)	2020 (10 year)	2035 (25 year)	2060 (50 year)	2010 (Existing)	2020 (10 year)	2035 (25 year)	2060 (50 year)	
People									
Population	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Places									
Built up areas	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Forest/Scrubs	0.25	0.50	0.75	1.00	0.25	0.50	0.75	1.00	0.47
Mangrove areas	0.50	0.75	1.00	1.00	0.50	0.75	1.00	1.00	0.70
Agriculture areas	0.50	0.75	1.00	1.00	0.50	0.75	1.00	1.00	0.70
Lagoon	0.50	0.75	1.00	1.00	0.50	0.75	1.00	1.00	0.70
Beach	0.50	0.75	1.00	1.00	0.50	0.75	1.00	1.00	0.70
Historical /Archaeological Places	0.25	0.50	0.75	1.00	0.50	0.75	1.00	1.00	0.56
Activities									
Trading & Commercial Activities	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fishery	0.75	1.00	1.00	1.00	0.75	1.00	1.00	1.00	0.89
Tourism	0.75	1.00	1.00	1.00	0.75	1.00	1.00	1.00	0.89
Agriculture	0.50	0.75	1.00	1.00	0.50	0.75	1.00	1.00	0.70
Roads	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Transportation	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Electricity Supply	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Water Supply	0.75	1.00	1.00	1.00	0.75	1.00	1.00	1.00	0.89
Sanitary Facilities	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Hospitals/Medical Centers	0.75	1.00	1.00	1.00	0.75	1.00	1.00	1.00	0.89
Schools/Educational Institutions	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
								Total	**0.85**

Increase in occurrence of storm surges/cyclones

Elements	Exposure (Probability or Likelihood of Impact)				Sensitivity (Possible Adverse Consequence/s)				Risk Rating (Total score over count of risk effects)
	2010 (Existing)	2020 (10 year)	2035 (25 year)	2060 (50 year)	2010 (Existing)	2020 (10 year)	2035 (25 year)	2060 (50 year)	
People									
Population	0.50	0.75	1.00	1.00	0.50	0.75	1.00	1.00	0.70
Places									
Built up areas	0.50	0.75	1.00	1.00	0.50	0.75	1.00	1.00	0.70
Forest/Scrubs	0.50	0.75	1.00	1.00	0.50	0.75	1.00	1.00	0.70
Mangrove areas	0.50	0.75	1.00	1.00	0.50	0.75	1.00	1.00	0.70
Agriculture areas	0.50	0.75	1.00	1.00	0.50	0.75	1.00	1.00	0.70
Lagoon	0.50	0.75	1.00	1.00	0.50	0.75	1.00	1.00	0.70
Beach	0.50	0.75	1.00	1.00	0.50	0.75	1.00	1.00	0.70
Historical /Archaeological Places	0.50	0.75	1.00	1.00	0.50	0.75	1.00	1.00	0.70
Activities									
Trading & Commercial Activities	0.50	0.75	1.00	1.00	0.50	0.75	1.00	1.00	0.70
Fishery	0.50	0.75	1.00	1.00	0.50	0.75	1.00	1.00	0.70
Tourism	0.50	0.75	1.00	1.00	0.50	0.75	1.00	1.00	0.70
Agriculture	0.50	0.75	1.00	1.00	0.50	0.75	1.00	1.00	0.70
Roads	0.50	0.75	1.00	1.00	0.50	0.75	1.00	1.00	0.70
Transportation	0.50	0.75	1.00	1.00	0.50	0.75	1.00	1.00	0.70
Electricity Supply	0.75	1.00	1.00	1.00	0.75	1.00	1.00	1.00	0.89
Water Supply	0.50	0.75	1.00	1.00	0.50	0.75	1.00	1.00	0.70
Sanitary Facilities	0.25	0.50	0.75	1.00	0.25	0.50	0.75	1.00	0.47
Hospitals/Medical Centers	0.50	0.75	1.00	1.00	0.50	0.75	1.00	1.00	0.70
Schools/Educational Institutions	0.50	0.75	1.00	1.00	0.50	0.75	1.00	1.00	0.70
								Total	**0.70**

Sea-level rise and inundation of coastal areas

Elements	Exposure (Probability or Likelihood of Impact)				Sensitivity (Possible Adverse Consequence/s)				Risk Rating (Total score over count of risk effects)
	2010 (Existing)	2020 (10 year)	2035 (25 year)	2060 (50 year)	2010 (Existing)	2020 (10 year)	2035 (25 year)	2060 (50 year)	
People									
Population	0.00	0.25	0.50	0.75	0.00	0.25	0.50	0.75	0.22
Places									
Built up areas	0.00	0.25	0.50	0.75	0.00	0.25	0.50	0.75	0.22
Forest/Scrubs	0.00	0.25	0.50	0.50	0.00	0.25	0.50	0.50	0.14
Mangrove areas	0.00	0.25	0.50	0.50	0.00	0.25	0.50	0.50	0.14
Agriculture areas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lagoon	0.25	0.50	0.75	1.00	0.25	0.50	0.75	1.00	0.47
Beach	0.25	0.75	1.00	1.00	0.25	0.75	1.00	1.00	0.66
Historical /Archaeological Places	0.00	0.00	0.25	0.50	0.00	0.00	0.25	0.50	0.08
Activities									
Trading & Commercial Activities	0.00	0.00	0.25	0.50	0.00	0.00	0.25	0.50	0.08
Fishery	0.00	0.25	0.75	1.00	0.00	0.25	0.75	1.00	0.41
Tourism	0.00	0.50	0.75	1.00	0.00	0.50	0.75	1.00	0.45
Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Roads	0.00	0.25	0.50	0.75	0.00	0.25	0.50	0.75	0.22
Transportation	0.00	0.25	0.50	0.75	0.00	0.25	0.50	0.75	0.22
Electricity Supply	0.00	0.25	0.50	0.75	0.00	0.25	0.50	0.75	0.22
Water Supply	0.25	0.50	0.75	1.00	0.25	0.50	0.75	1.00	0.47
Sanitary Facilities	0.00	0.00	0.25	5.00	0.00	0.00	0.25	5.00	6.27
Hospitals/Medical Centers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Schools/Educational Institutions	0.00	0.25	0.50	0.50	0.00	0.25	0.50	0.50	0.14
								Total	**0.55**

The risk rating was generalized to present a rating for combined climate risks. Accordingly, the risk ratings of *Increase in rainfall/floods* (0.85) and *Cyclones & storm surges* (0.70) were identified as the most significant impacts with the highest probability of occurrence.

Floods were identified to be the most devastating event for people/life losses. Sea-level rise (0.55) was also seen to have a considerable impact on the local population. The coastal belt and the Negombo Lagoon were identified as the most vulnerable places for many predicted future climate change impacts. Tourism and fisheries sectors were rated as the most at risk activities under threat from future climate change events. It was highlighted that floods/increase in precipitation could have a significant impact on a range of socio-economically important sectors such as: urban life; roads & transportation; utility supply networks (water, electricity, telecommunications); health; and sanitation.

4.4. Step: 12 Identify Adaptive Capacity

Adaptive capacity is measured according to the level of resources, awareness and knowledge, technical know-how and other capabilities of each particular population group to adapt to climate change scenarios. Higher adaptive capacities can reduce the impact of climate change risks and offset the negative effects of climate change on sensitive socio-economic factors of a given system or area.

The Sorsogon city V&AA assessment based toolkit introduces both qualitative and quantitative methodologies to assess adaptive capacity.

Quantitative analysis could be done through desk assessment using available data from municipal/city profiles. The results of quantitative assessment would be useful for rating and comparing with the values derived from the exposure/sensitivity assessment.

*However, further characterization is needed through **qualitative assessment** in order to expand understanding of the coping range of the system/area and provide other critical information crucial in developing local climate change action plans. Qualitative assessments also provide wider opportunities for other stakeholders especially the communities themselves to participate in the V&A process.*

Sorsogon city V& AA

This first method was selected for this assessment, given the availability of a comprehensive set of secondary data for the assessment and the stakeholder's capability in the interpretation of this data.

4.4.1. Quantitative Analysis of CC Adaptive Capacity

From this exercise, the assessment team expected to identify relevant indicators that would enable the city to adjust its practices, processes, or structures to offset or reduce potential damage from negative impacts of climate change. To a certain extent, this exercise requires public participation as well as opinions of experts in analyzing, development planning and other relevant multi-disciplinary approaches. Similarly, secondary data collected at the data collection stage of this process was useful to assess the magnitude of each factor.

The same template, given in the toolkit was used for a Quantitative Assessment of Adaptive Capacity. The four dimensions identified in Sorsogon city are: Wealth, Technology, Infrastructure, and Information. Each is selected as equally important in the context of Negombo urban area. In addition to that, stakeholders suggested including Institutional Capacity, Frameworks, Policies, will and commitment as a key dimension to determine the adaptive capacity.

Indicators used to assess many of these dimensions were not applicable in the context of Sri Lankan cities. Therefore, all indicators were modified through a focus group discussion with core stakeholders. Assigning a suitable weight to each dimension and parameter was determined through expert opinion taking into account, the local situation. Accordingly, the most critical dimensions were assigned the highest values, whilst the least critical dimensions were assigned the lowest value. Weights were assigned based on the judgment of the assessment team as to the degree of importance of dimensions and indicators in off-setting negative climate change impacts. The most important factors were highlighted for each dimension and are summarised below.

Wealth	Unemployment rate 6.12% Households receiving Samurdhi benefit 14% 80% of people living in permanent housing
Technology	87% of housing units having access to electricity 100% service coverage for telecommunication, TV & radio connections
Infrastructure	Road 9% of total land use Road density 2.5 km per sqkm 20% of housing units have semi-permanent and improvised structures 20% of housing units do not have access to safe (water seal) sanitation

	67% of housing units have access to pipe borne water supply 87% of housing units have access to electricity supply General Hospital (bed capacity 341, doctors 80, operation theatre, blood bank, X ray)
Information	Literacy rate 90.7% More than 34% of the population has an education level higher than GCE O/L
Institutional	More than 13 active NGOs work in the NMC area 44 women organizations 42 youth organizations 26 fishery organizations

Note: there are some autonomous adaptation strategies that have been implemented by individuals as a response to climate change. They are well recognized as coping mechanisms but are not counted as a separate parameter due to the difficulties in identifying, consolidating, and quantifying these activities.

The following table depicts the quantitative assessment of NMC's adaptive capacity. All values were assigned a figure between 0-1. The results reveal that that NMC has strong technical capacities and moderate level adaptation capacity in terms of infrastructure and information to adapt to climate change impacts but there are key constraints in terms of the wealth of the city.

Dimensions / Indicators	Rating	Score	Wtd Score	Total Score
Wealth		**0.30**		0.16
Poverty Incidence	0.25		0.80	0.20	
Employment	0.25		0.80	0.20	
Informality (Land Tenure)	0.20		0.70	0.14	
				0.54	
Technology		**0.25**		0.21
Access to Information & Telecommunications	0.40		1.00	0.40	
Access to Electricity	0.30		0.87	0.26	
Technical Know-how	0.30		0.60	0.18	
				0.84	
Infrastructure		**0.25**		
HH with safe water access	0.25		0.67	0.17	0.18
Housing-Permanent structure	0.25		0.80	0.20	
Sea Wall	0.10		0.40	0.04	
Paved / Tar Road	0.20		0.80	0.16	
Availability of Health Facility	0.20		0.80	0.16	
				0.72	
Information		**0.20**		0.12
Education Level	0.20		0.80	0.16	
Literacy Rate	0.10		0.90	0.09	
Access to Information & Telecommunications	0.40		0.90	0.36	
				0.61	

Total		1.00			0.67

It can be concluded that from the highest possible value of 1, the city's adaptive capacity is found to be higher than the mid-point as it registers with a 0.7 rating due its strengths in information and technological capabilities.

4.5.   Step: 13 Identification of Hotspots

1. Kochchi kade

2. Ettukala

3. Periyamulla

4. Pitipana North

5. Pitipana South

6. Kapundgoda

Source : Land Use Map of NMC, UDA
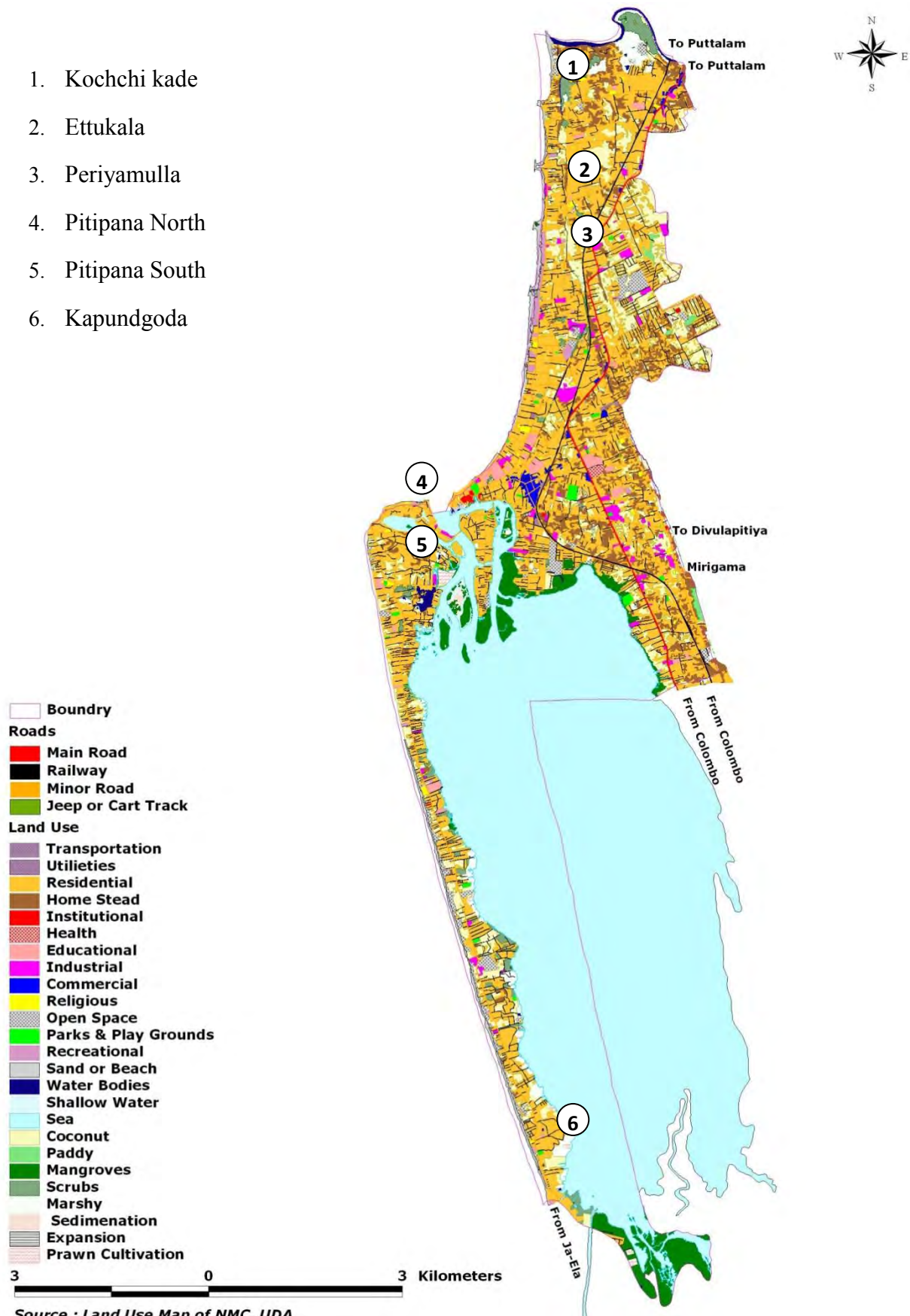
Climate change 'hotspots' were identified by overlaying all climate-related hazard maps covering sea-level rise, tropical cyclone and flood occurrences, salt water intrusion etc. This section explains the case studies conducted at each hotspot and public comments on the vulnerability and local adaptations to climate change scenarios.

1. Kochchikade

Most of the houses are located along the coastal belt. Many of them are permanent structures made of durable materials. Houses have tiles for roofs instead of sheets to protect homes from strong winds. The main livelihood is fishing. In addition to this, many families keep goats and poultry.

Temperature change

A significant increase in humidity has been experienced by residents in Kochchikade, especially during February, March and April. It is difficult to stay inside the house because of intense heat but it is inconvenient to stay outside in the afternoon due to the warm weather and humid breeze.

Rainfall change

Alteration in rainfall patterns have been experienced by people during December and January. Heavy rains have been experienced during the dry seasons. After the 2004 Indian Ocean Tsunami, high tide waves were lower than in previous years.

Wind patterns

Sudden variations of wind patterns have become a common experience during recent years. Such situations directly affect the livelihood activities of fishing communities.

Sea-level rise

Coastal erosion is evident along the Kochchikade coastal belt, which indicates a rise in sea levels. Inhabitants have experienced difficulty in taking their boats to the sea due to rapid and hard sand dune formation at beach.

2. Ettukala

Around 20-30 houses are located along the canal. There is no proper access to the houses apart from a footpath. Most of the houses are built from non durable materials. Many of them use tube wells for drinking, and the area has a pipe-borne water supply line. This community has been here for last 30-40 years. The main livelihood is labour. Each year, people are affected by floods.

Temperature change

Temperatures have increased recently and humidity levels continue to rise. People experience a very uncomfortable hot environment until 4.00pm-5.00pm in the evening. They feel it difficult to bear and prefer to stay outside the house.

Rainfall change

Ettukala is a flood-prone area. The most recent floods occurred in 2007. The frequency of floods has increased during the last decade.

Wind patterns

As a result of frequent high winds reported in the last few years, houses have had their roofs damaged several times.

Diseases

Vector-borne diseases such as dengue are reported to a certain extent.

Water quality

The residents in Ettukala use groundwater for drinking. Groundwater is extracted from a tube well that runs 50ft below the surface. The surface water has been very poor in quality over the past four to five years. White clothes cannot be washed here due to the yellowish colour of the water.

3. Periyamulla

People have settled along the canal reservation. There are around 20 families here. Most of the houses are built from non durable materials such as wood and coconut leaves. They don't have electricity supply. Canal water is used for cleaning and cooking activities. Now it is polluted and emits a bad odour.

Temperature change

The community has recently experienced a significant increase in both temperature and humidity levels.

Rainfall change

Rainfall patterns have varied significantly with a high frequency of extreme events. The highest flood level flood was reported in May 2011, the highest in 25 years. People in Periyamulla experience dry weather during Easter, but there used to be heavy rains in the past.

Diseases

The spread of dengue has become a common occurrence over the past four to five years. Dengue cases are reported during the rainy seasons of the year.

Water quality

The residents in Periyamulla use tube wells (20-25m in depth) for drinking water. The turbidity and salinity of the water has increased noticeably. The canal was in good condition

30 years ago, and was used for washing, bathing and other household activities although it is polluted and abandoned today.

4. Pitipana North

The main livelihood here is fishing. Residents have permanent houses made of durable materials. The area was affected by the 2004 Indian Ocean Tsunami.

Temperature change

Residents in Pitipana North have experienced a drastic increase in humidity levels. There is intense heat during both day and night and residents use fans and other methods of air cooling throughout the day.

Rainfall change

There has been a significant change in rainfall patterns after the 2004 Indian Ocean Tsunami, especially the frequency of flooding. Recently, there has been a high tendency for heavy rains followed by thunder and lightning when compared to the past.

Wind patterns

Pitipana North is getting a stronger breeze than in the past. Wind direction has become irregular after the 2004 Indian Ocean Tsunami. Presently winds originate from different directions at different times of the day.

Sea-level rise

Sea levels have increased and the beach was eroded by the 2004 Indian Ocean Tsunami. Sea levels seem to have risen by 5-6 ft during the last five years. At high tide, waves almost reach home gardens.

Diseases

Blistering on the skin due to intense heat has been reported. Apart from this, there have been some dengue cases nearby.

5. Pitipana South

Most of the houses are built with permanent materials. There are houses along the coastal belt and the coastal area is eroded. Drinking water is an issue for people here because of its salinity. There are a few tube wells in the area.

Temperature change

High humidity levels have been experienced by people living in Pitipana South. It is hard to stay at home even with fans. Just in very recent times, it has become unbearably hot during both day and night times.

Rainfall change

Rainfall patterns have changed lately, so it has become difficult to predict the weather. The distinct identification of dry and rainy seasons is gradually fading with a high frequency of sudden extremes.

Wind patterns

Strong winds have been experienced recently compared to the past.

Sea- level rise

A rise in sea levels has led to the erosion of nearly 10m of the coast during the last decade or so.

Water quality

Well water cannot be used for drinking purposes as it is too hard. The turbidity is relatively high in the water. Residents use tube wells as a source of water and no significant change in

the quality of groundwater has been noticed. The hardness of groundwater here was the only issue reported, and it has been this way for some time.

6. Kapungoda

The main livelihood is fishing. Residents live in permanent shelters made of cement (for floors) and bricks (for roofs). The Negombo Lagoon is one of the boundaries of the area. The area is endowed with rich bio-diversity.

Temperature change
Recently, there has been an increase in temperature during the months of March and April.

Rainfall change
Unexpected rains were reported especially during the months of May and June. The traditional rainfall pattern does not exist anymore and it is difficult to predict seasonal variations.

Water quality
There is evidence of a gradual degradation in water quality. High turbidity of water was reported and local residents say that the water tastes bad compared to the quality of water a decade ago.

Sea-level rise
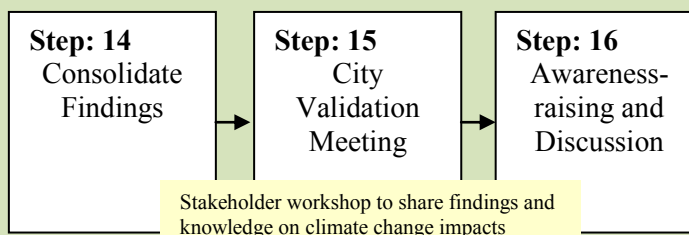High tides increased recently, thus reducing the stretch of beach with erosion.

Diseases
High humidity and strong winds (carrying sand particles) have led to a rise in eye infections being reported by residents living along the coast. Viral infections are also commonly experienced by communities during the rainy seasons.

5. PHASE FOUR – VALIDATION & PRESENTATION

This is the fourth and last stage of the city vulnerability assessment. This includes three steps: consolidating findings; conducting a city validation meeting; and awareness-raising and discussion.

Phase Four – Validation and Presentation

Step: 14 Consolidate Findings	Step: 15 City Validation Meeting	Step: 16 Awareness-raising and Discussion

Stakeholder workshop to share findings and knowledge on climate change impacts

5.1. Step: 14 Consolidate Findings

This report is the consolidated findings of a vulnerability assessment prepared for Negombo Municipality. The report consists of steps followed and findings reached at each step.

The report defines the vulnerability as a function of exposure, sensitivity, and adaptive capacity. Based on this, the assessment developed a vulnerability rating/score relative to an index. The exposure and sensitivity scores have been transposed into one quantitative value which is the risk rating in assessment matrix 'B' for selected socio-economic dimensions as 0.7 on a 0-1 scale rating. This can be considered as a higher value to mean rating which indicates a higher sensitivity and higher exposure to the impacts of climate change. The city has a relatively high adaptive capacity revealed as 0.67 in the same rating.

Event	Exposure X Sensitivity	Adaptive Capacity	Vulnerability = Exposure X Sensitivity /Adaptive Capacity
Floods	0.85	0.67	127%
Cyclones	0.70	0.67	104%
Sea level rise	0.55	0.67	82%
Average City Level			104%

However the positive difference (104%) indicates that the city does not have sufficient adaptive capacity to offset its vulnerability. This emphasizes the need to introduce and reinforce the adaptive capacity of the city to cope with expected climate change scenarios.

5.2. Step: 15 City Validation Meeting

This vulnerability assessment was validated through a stakeholder meeting before its finalization. This ensures that inputs from all relevant stakeholders, especially those who

were not able to participate in the assessment workshop, are considered in the final report. The primary objective of the city stakeholder validation process is to present the consolidated findings of the assessment and to gather more inputs from stakeholders. The second objective of the activity is to build agreement on priority areas for adaptation, based on the results. Accordingly, prior to the finalization of this report, the vulnerability assessment of Negombo Municipality was validated through a broad-based consultation at a City Validation Meeting.

Presentation of the findings of Vulnerability Assessment by Prof. PKS Mahanama (Dean, Faculty of Architecture, University of Moratuwa) and the team of University of Moratuwa

The main activities of the process are:

- To present the key findings of the City Vulnerability Assessment and its implications
- To explain the relevance of climate-related risks to city development based on the exposure and sensitivity assessment

Draft copies of the vulnerability assessment were distributed to the participants for their reference.

As an approach to the process, the overview of the UN-Habitat CCCI programme for conducting Vulnerability and Assessments was explained to the participants.

A presentation of the results of the Vulnerability Assessment was given to stakeholders including: the degree of current and future climatic risks; the location of vulnerable groups in the city; and the city-level adaptive capacity.

5.3. Step: 16 Awareness and discussion

There was an open forum conducted at the end of this session to allow for comments and to discuss the findings of the vulnerability assessment. The main objective of this discussion was to develop a mutual agreement on the way forward.

Participants were actively engaged in discussions. Many stakeholders suggested developing a list of possible actions to reduce the city's vulnerability to climate change. At the end of this session, the next session started on:

- What local governance facilitative actions (practices, process, system, etc) are crucial to minimize local vulnerability
- Strengths and weakness of the city and local stakeholders in managing the risks brought about by climate change, based on the adaptive capacity assessment
- What key adaptation options both at the city and hotspots levels have been identified to increase the city's adaptive capacity and to manage sensitivity (adverse consequences) to climate-change exposure.

The Honorable Mayor addressing the Stakeholders about the importance of the Vulnerability Assessment

Stakeholders review the Vulnerability Assessment report prepared by the PCU of the University of Moratuwa

Presentation on the role of UN-HABITAT in response to Climate Change by Dr. Fahmy Ismail (National Technical Adviser, UN-HABITAT)

Presentation on "National Policy & Action Plans on Climate Change Initiatives – Sri Lanka" by the Ministry of Environment & Natural Resources

This opens a path for discussions towards a city-level climate change adaptation plan.

The Report on Climate Change Vulnerability in Negombo Municipal Council, Sri Lanka provides an overview of the research, analysis, findings and recommendations of work carried out in 2010 and 2011. It is part of a series of climate change vulnerability assessment reports conducted by UN-Habitat's Cities and Climate Change Initiative. These reports constitute the first step towards climate resilient human settlements. Support for this report was granted by the Government of Norway and the United Nations Development Account.

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