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In cooperation with:

Managing Climate Change in Bangladesh: Foundations for Policymakers

Training Manual: NAP and NDC Support Programme

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Acronyms

2D	Two-Dimensional
3D	Three-Dimensional
ADB	Asian Development Bank
ADP	Annual Development Programme
AE	Accredited Entities
AFOLU	Agriculture, Forestry, and Other Land Use
AFB	Adaptation Fund Board
AGN	African Group of Negotiators
AILAC	Independent Association of Latin America and the Caribbean
ALBA	Bolivarian Alliance for the Peoples of Our America
AML	Anti-Money Laundering
AOSIS	Alliance of Small Island States
API	Application Programming Interface
AR	Assessment Report
BASIC	Brazil, South Africa, India, and China
BAU	Business as Usual
BBB	Build Back Better
BCCRF	Bangladesh Climate Change Resilience Fund
BCCSAP	Bangladesh Climate Change Strategy and Action Plan
BCCTF	Bangladesh Climate Change Trust Fund
BDT	Bangladeshi Taka
BMD	Bangladesh Meteorological Department
BORI	Bangladesh Oceanographic Research Institute
BUET	Bangladesh University of Engineering and Technology
BUR	Biennial Update Report
BWDB	Bangladesh Water Development Board
BWCSRP	Bangladesh Weather and Climate Services Regional Project
CBA	Community-Based Adaptation
CBDR	Common but Differentiated Responsibility
CCA	Climate Change Adaptation
CDD	Consecutive Dry Days
CER	Certified Emission Reductions
CDM	Clean Development Mechanism
CEGIS	Center for Environmental and Geographic Information Services
CF	Climate Finance
CFT	Countering the Financing of Terrorism
CH4	Methane
CID	Climatic Impact-Driver
CIP	Country Investment Plan
CMA	Conference of the Parties serving as the meeting of the Parties to the Paris Agreement
CMIP	Coupled Model Intercomparison Project
CMP	Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol
CO2	Carbon Dioxide
COP	Conference of the Parties
CORDEX	Coordinated Regional Climate Downscaling Experiment
CRA	Climate Risk Assessment
CRM	Climate Risk Management
CRS	Climate Risk Screening
CRVA	Climate Risk and Vulnerability Assessment
CSA	Climate Smart Agriculture
CVF	Climate Vulnerable Forum

CVI	Climate Vulnerability Index
CWD	Consecutive Wet Days
DAE	Department of Agricultural Extension
DFO	Divisional Forest officer
DMCs	Developing Member Countries
DoE	Department of Environment
DMA	Division of Adaptation and Mitigation
DRIP	Digital Risk Information Platform
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
EbA	Ecosystem-Based Adaptation
ECP	Extended Concentration Pathway
ECCP	Extended Community Climate Change Project
ECVs	Essential Climate Variables
EFCC	Environment, Forestry, and Climate Change
EIG	Environmental Integrity Group
Eof	Empirical Orthogonal Function
Esri	Environmental Systems Research Institute
ESS	Earth System Sensitivity
EU	European Union
FAA	Funded Activity Agreement
FAO	Food and Agriculture Organization of the United Nations
FPC	Forest Protection Committee
FP	Funding Proposal
FTP	File Transfer Protocol
FY	Financial Year
GAAP	Generally Accepted Accounting Principles
G20	Group of 20
G77	Group of 77
GBM	Ganges-Brahmaputra-Meghna
GCCA	Global Climate Change Alliance
GCF	Green Climate Fund
GCM	Global Circulation Model
GCS	Geographic Coordinate System
GDP	Gross Domestic Product
GEB	Global Environmental Benefit
GED	General Economics Division
GEF	Global Environment Facility
GEO	Group on Earth Observations
GEOSS	Global Earth Observation System of Systems
GHG	Greenhouse Gas
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
GoB	Government of the People's Republic of Bangladesh
GP L&D	GIZ Global Programme on Risk Assessment and Management for Adaptation to Climate Change (Loss and Damage)
GPS	Global Positioning System
GrADS	Grid Analysis and Display System
GRIB	General Regularly Distributed Information in Binary Form
GRULAC	Group of Latin American and Caribbean Countries
GSB	Geological Survey of Bangladesh
GtC	Gigatonne of Carbon
GtCO2	Gigatonne of Carbon Dioxide
GWP	Global Warming Potential
ha	Hectare
HCFC	Hydrochlorofluorocarbon
HELIX	High-End Climate Impacts and Extremes
HFA	Hyogo Framework for Action
HFC	Hydrofluorocarbon
HH	Household
HYCOS	Hydrological Cycle Observing System
ICCCAD	International Centre for Climate Change and Development

IDCOL	The Infrastructure Development Company Limited
IF	Investment Framework
INC	Initial National Communication
SNC	Second National Communication
INDC	Intended Nationally Determined Contribution
INRM	Integrated Natural Resources Management
IP	Impact Programme
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Other Product Use
IUB	Independent University, Bangladesh
IWM	Institute of Water Modelling
km	Kilometre
L&D	Loss and Damage
LDCs	Least Developed Countries
LDCF	Least Developed Countries Fund
LEED	Leadership in Energy and Environmental Design
LLA	Locally Led Adaptation
LST	Land Surface Temperature
LULUCF	Land Use, Land-Use Change, and Forestry
M&E	Monitoring and Evaluation
MCDA	Multiple Criteria Decision Analysis
MCDM	Multiple Criteria Decision-Making
MDTF	Multi-Donor Trust Fund
MoDMR	Ministry of Disaster Management and Relief (Bangladesh)
MoEF	Ministry of Environment and Forest (Bangladesh)
Moefcc	Ministry of Environment, Forest and Climate Change (Bangladesh)
MOR	Meteorological Optical Range
MRV	Monitoring, Reporting, and Verification
MTCO2e	Tonnes of Carbon Dioxide Equivalent
N2O	Nitrous Oxide
NAP	National Adaptation Plan
NAPA	National Adaptation Programme of Action
NASA	National Aeronautics and Space Administration
NCL	NCAR Command Language
NDA	National Designated Authority
NDC	Nationally Determined Contribution
Netcdf	Network Common Data Form
NGO	Non-Government Organization
NGI	Non-Grant Instruments
NMHS	National Meteorological and Hydrological Services
NMS	Network Management System
NOAA	National Oceanic and Atmospheric Administration
NPDM	National Plan for Disaster Management
NRM	Natural Resource Management
NSDS	National Sustainable Development Strategy
NWS	National Weather Service
ODA	official Development Assistance
OECD	Organization for Economic Co-Operation and Development
OPEC	Organization of the Petroleum Exporting Countries
PaaS	Platform-as-a-Service
PDA	Personal Digital Assistant
PES	Payments for Environmental Services
PFC	Perfluorocarbons
PMF	Performance Measurement Framework

PPCR	Pilot Program for Climate Resilience
PPF	Project Preparation Facility
PSF	Private Sector Facility
Ppmv	Parts Per Million Volume
PRECIS	Providing Regional Climates for Impacts Studies
PVCs	Particularly Vulnerable Countries
QGIS	Quantum GIS
RBM	Results-Based Management
RCM	Regional Climate Model
RCP	Representative Concentration Pathways
REDD+	Reducing Emissions From Deforestation and Forest Degradation
RMF	Results Management Framework
RMG	Readymade Garment
SAARC	South Asian Association for Regional Cooperation
SaaS	Software-as-a-Service
SAGA	System for Automated Geoscientific Analyses
SCCF	Special Climate Change Fund
SDGs	Sustainable Development Goals
SF6	Sulfur Hexafluoride
SIDS	Small Island Developing States
SLR	Sea Level Rise
SLSTR	Sea and Land Surface Temperature Radiomete
SPARRSO	Bangladesh Space Research and Remote Sensing Organization
SREX	Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation
SSP	Shared Socio-Economic Pathway
TAMD	Tracking Adaptation and Measuring Development
TAP	Technical Advisory Panel
TCR	Transient Climate Response
TCRE	Transient Climate Response to Cumulative CO2 Emissions
TNC	Third National Communication
UNDP	United Nations Development Programme
UNDRR	United Nations office for Disaster Risk Reduction
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations International Strategy for Disaster Reduction
UNREDD	United Nations Programme on Reducing Emissions from Deforestation and Forest Degradation
USAID	United States Agency for International Development
USD	United States Dollar
WGS84	World Geodetic System 1984
WHYCOS	World Hydrological Cycle Observing System
WIGOS	WMO Integrated Global Observing System
WMO	World Meteorological Organization

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Key terminologies

Accredited Entities: Accredited Entities partner with GCF to implement projects. Guided by our investment framework and the priorities of developing country governments, Accredited Entities convert concepts into action. They work alongside countries to come up with project ideas, and submit funding proposals for the GCF Board to approve.

Adaptation: Adaptation is an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous, and planned adaptation.

Adaptive capacity: 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 consequences. The extent to which human health is affected depends on: (i) the exposures of populations to climate change and its environmental consequences, (ii) the sensitivity of the population to the exposure, and (iii) the ability of affected systems and populations to adapt. We therefore need to understand how decisions are made about adaptation, including the roles of individuals, communities, nations, institutions and private sector.

Agents of Change: The individual or group that undertakes the task of initiating and managing change in a community is known as a change agent.

Bali Road Map: Agreed at the Bali COP13 in 2007, this was countries' first effort to lay the foundations for a new global deal to replace the Kyoto protocol, which was to be expired in 2012. The road map contained the Bali Action Plan, which outlined options for progress on climate mitigation, adaptation, technology and finance.

Baseline: A baseline will establish how a target group/area is prior to the implementation of the project. It is important to work from a good baseline as this is what you will compare to your project results to show the change your project has made. "Bad" baseline affects the quality and validity of the project M&E.

Cancun Agreements: After the disappointment of Copenhagen, negotiators expectations for 2010's meeting in Cancun were much lower. That meeting's conclusions were captured in the Cancun Agreements, which were mainly notable for formally committing countries to preventing temperatures rising by more than two degrees above pre-industrial levels, more than three decades after the limit was first proposed.

Copenhagen Accord: The much-hyped United Nations Climate Change Conference in 2009 were meant to deliver a new legally binding, global deal to replace the Kyoto Protocol. Instead, they resulted in a "political agreement" called the Copenhagen Accord. The accord "recognised" the need for countries to tackle climate change, and set the deadline to review existing agreements by the end of 2015.

Climate: Climate in a narrow sense is usually defined as the 'average weather', or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. These quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system. The classical period of time is 30 years, as defined by the World Meteorological Organization.

Climate Projection: Climate projections are simulations of earth's climate in future decades (typically until 2100) based on assumed 'scenarios' for the concentrations of greenhouse gases, aerosols, and other atmospheric constituents that affect the planet's radiative balance. Climate projections are obtained by running numerical models of Earth's climate, which may cover either the entire globe or a specific region e.g. Europe. These models are referred to as Global Climate Models (GCMs) – also known as General Circulation Models – or Regional Climate Models (RCMs), respectively.

Climate related Risks and Extreme Events: Climate related risks are created by a range of hazards. Some are slow in their onset (such as changes in temperature and precipitation leading to droughts, or agricultural losses), while others happen more suddenly (such as tropical storms and floods). It is now widely recognized that climate-related impacts are not just a future threat. Furthermore, past and current experiences in dealing with climate variability and extreme events, irrespective of attribution to climate change, hold valuable lessons for reducing vulnerability and enhancing resilience for future climate-related adverse impacts.

Climate Vulnerability: Climate Change Vulnerability is defined by the IPCC as the susceptibility of a species, system or resource to the negative effects of climate change and other stressors, and includes three components: exposure, sensitivity, and adaptive capacity.

Climatic data: This refers to a measured parameter which helps to specify the climate of a specific location or region.

Community based adaptation: Community-based adaptation (CBA) is a form of adaptation that aims to reduce the risks of climate change to the world's poorest people by involving them in the practices and planning of adaptation.

Carbon neutrality: There are two ways the world could become carbon neutral. It could stop emitting carbon dioxide through processes like burning fossil fuels for power or running petrol cars. Or, perhaps more likely, it could keep doing a bit of this while also capturing carbon dioxide and locking it away using carbon capture and storage technology. This means the world would have net zero emissions, even if countries continue to emit some greenhouse gas. Almost all of the scenarios the IPCC suggest where temperatures rise by less than two degrees rely on carbon capture and storage.

Common but differentiated responsibility: Developing countries often talk about ensuring any new global deal respects the principle of common but differentiated responsibility. This basically means designing a deal where those with the greatest historical responsibility for climate change and the means to implement low carbon policies take the biggest and earliest steps to cut emissions. This principle was enshrined in the UNFCCC, which separated countries into three groups: Annex I, Annex II, and non-Annex I.

Direct Access Entity: Direct Access Entities are sub-national, national or regional organizations that need to be nominated by developing country National Designated Authorities (NDAs) or focal points. Organizations nominated to become Direct Access Entities may be eligible to receive GCF readiness support.

Durban Platform: At COP17 in Durban in 2011, countries agreed the Durban Platform for Enhanced Action. It extended the Kyoto protocol until at least 2017 and committed countries to agreeing a new global deal by the end of 2015.

Exposure: The presence of people, livelihoods, species or ecosystems, environmental services and resources, infrastructure, or economic, social, or cultural assets in places that could be adversely affected by a hazard.

Externality: An externality is a cost or benefit caused by a producer that is not financially incurred or received by that producer. An externality can be both positive or negative and can stem from either the production or consumption of a good or service.

Evaporation: This refers to the quantity of water evaporated from an open water surface or from the ground.

Global Warming: Global warming occurs when carbon dioxide (CO2) and other air pollutants collect in the atmosphere and absorb sunlight and solar radiation that have bounced off the earth's surface. Normally this radiation would escape into space, but these pollutants, which can last for years to centuries in the atmosphere, trap the heat and cause the planet to get hotter. These heat-trapping pollutants—specifically carbon dioxide, methane, nitrous oxide, water vapor, and synthetic fluorinated gases—are known as greenhouse gases, and their impact is called the greenhouse effect.

Goal: This is the ultimate reason for undertaking a project or program. The goal is the 'higher-order objective' to which an intervention/initiative is intended to contribute.

Green Climate Fund (GCF): The GCF was established at the Copenhagen climate summit in 2009 with the aim of channeling money to help developing countries implement climate adaptation policies. When the fund is fully operational, nation states will contribute USD 100 billion a year. Countries have so far pledged a little over USD 10 billion to the fund for its first four years

Hazard: A physical process or event (hydro-meteorological or oceanographic variables or phenomena) that can harm human health, livelihoods, or natural resources. A hazard is not simply the potential for adverse effects.

Impact: The positive and negative, desirable and undesirable, primary and secondary long-term effects produced by an intervention which can be direct or indirect, intended or unintended. Such broader effects of a project/program's activities, outputs and outcomes exceed a project/program's immediate sphere of responsibility.

Indicator: An indicator is a pre-defined variable which helps to identify (in)direct differences in quality and/or quantity within a defined period of time. As a "unit of measure" it allows to judge if an intervention was successful or not. With the aid of indicators, complex problems are simplified and reduced to an observable dimension.

Input: Any resource that is put into a project or program to carry out an activity can be considered an input. Input can be units of time, staff, money, equipment, know-how, ideas, etc. available to be expended in order for an organization to produce the outputs and consequently outcomes identified as part of a planned program or project.

Intended Nationally Determined Contributions (INDCs): In 2013, countries agreed that governments would submit their own targets to cut emissions by the end of March 2015, known as INDCs. These submissions will then be reviewed, with countries negotiating over whether they need to be more or less ambitious. The INDC approach represents a move away from a centralized target setting system established by the Kyoto Protocol, where the UNFCCC – with the COP's assent – decided countries' goals based on their historical emissions and ability to implement climate policies. After ratification of the PA by a country, INDC becomes NDC.

Legally binding: One of the main points of contention in the negotiations is whether countries should be legally obligated to cut emissions under any new deal. The EU is in favour of legally binding emissions reductions targets for all countries. The US is determined that any new deal should not be legally binding as it would then have to get the assent of the US Congress, which is unlikely. Many countries, such as India, support legally binding targets for developed economies but would reject a deal that applied them to developing nations.

Loss and damage (L&D): This phrase refers to the impacts of climate change that countries won't be able to adapt to, and which will result in economic losses. Some countries are calling for a mechanism to be introduced where developed nations, that are historically responsible for the bulk of greenhouse gas emissions, compensate those most vulnerable to the impacts of climate change.

Market mechanisms: One approach to cutting emissions is to use the power of the market to discourage polluting activities and encourage low carbon investment. Market mechanisms supposedly allow countries to meet their emissions reduction targets in a flexible way. Perhaps the UNFCCC's best known market mechanism is the Clean Development Mechanism. This allows developed countries to fund low carbon projects in developing countries, such as building a new wind farm, and count any emissions reductions that ensue against their own goals. The Kyoto protocol also created an international emissions trading system. Under the scheme, countries are allocated permits to emit greenhouse gases. Those that emit less than their allowance can then sell the permits to countries wanting to emit more. Under Article 6.4 of the PA, this mechanism is called Sustainable Development Mechanism.

Market failure: Market failure is the economic situation defined by an inefficient distribution of goods and services in the free market. A market failure occurs whenever the individuals in a group end up worse off than if they had not acted in perfectly rational self-interest. Such a group either incurs too many costs or receives too few benefits.

Measurement: This refers to a set of operations having the objective of determining the value of a quantity.

METRIC: Metrics are used to quantify the contributions to climate change of emissions of different substances.

National Adaptation Plans (NAPs): At the 2010 Cancun meeting, countries agreed the Cancun Adaptation Framework. As part of the framework, countries agreed to develop National Adaptation Plans to identify strategies and policies to protect them from the impacts of climate change. The least developed countries also formulate National Adaptation Programs of Action (NAPAs), focusing on policies to reduce future risks by making countries more resilient to climate change now.

Net Present Value: Net present value (NPV) is the difference between the present value of cash inflows and the present value of cash outflows over a period of time. NPV is used in capital budgeting and investment planning to analyze the profitability of a projected investment or project.

Non-economic Loss and Damage: The concept of non-economic loss and damage captures the impacts of climate change that are hard to quantify and often go unnoticed by the outside world, such as the loss of traditional ways of living, cultural heritage and biodiversity.

Objectives: Objectives describe the planned areas of activity by which a project or program is to achieve its aims. Objectives directly translate into a list of activities. Objectives are usually endeavored to be reached in finite time by setting deadlines.

Outcome/Development Outcome: Outcomes are changes, benefits, learning or other effects that happen as a result of services and activities provided by an organization. Outcomes can be positive or negative, expected or unexpected. Outcomes can be relevant for individuals, families, whole communities, organizations, or other fields such as policy, law or natural environment. Outcomes relate to specific aims/purpose. Outcomes are all the changes that may actually occur when you carry out activities to achieve a specific aim. They may not always be the same as the outcomes you planned. Outcomes can be a direct and/or indirect result of outputs.

Paradigm Shift: A paradigm shift is defined as "an important change that happens when the usual way of thinking about or doing something is replaced by a new and different way.

Performance-based Management Framework: The performance framework is, in effect, a summary of the key internal processes and components through which the Council sets, delivers, monitors and reports on its priorities; as such it encompasses elements of strategy, finance, performance, people and risk management, and reporting and accountability.

Precipitation: This refers to the liquid or solid products of the condensation of water vapour falling from clouds or deposited from air onto the ground. It includes rain, hail, snow, dew, rime, hoar frost and fog precipitation.

Prioritization: The act of putting tasks, problems, etc. in order of importance, so that you can deal with the most important first.

Participatory Development: Participatory development is an important approach for people-oriented development that emphasizes raising the quality of participation in local societies as a step toward the realization of self-reliant sustainable development and social justice.

Pseudo-participation: Pseudo-participation is an approach to management in which managers cultivate an impression of openness but are careful to retain decision-making in their own hands.

REDD+: REDD+ is a climate change mitigation solution being developed by Parties to the United Nations Framework Convention on Climate Change (UNFCCC).

Result-based Management Framework: This is a management strategy by which all actors, contributing directly or indirectly to achieving a set of results, ensure that their processes, products and services contribute to the achievement of desired results (outputs, outcomes and higher-level goals or impact).

Risk: The potential for consequences where something of human value (including humans themselves) is at stake and where the outcome is uncertain.1 This tool defines climate risk as a combination of hazard exposure, sensitivity to impact, and adaptive capacity. It does not define risk as the product of the probability of hazardous events and the consequences of those events, as is frequently used.

Standard: This refers to various instruments, methods and scales used to establish the uncertainty of measurements.

Social dimension of Sustainable Development: The three substantive social dimensions of sustainable development - poverty reduction, social investment, and safe and caring communities - are not new social goals. Nations and communities have long sought to achieve these goals.

Sunshine: This is associated with the brightness of the solar disc exceeding the background of diffuse sky light, or as is better observed by the human eye, with the appearance of shadows behind illuminated objects. The term is related more to visual radiation than to energy radiated at other wavelengths, although both aspects are inseparable.

Stakeholder: Agencies, organizations, institutions, entities, groups and individuals who influence or who are directly or indirectly influenced/affected by a project or program can be defined as stakeholders. Stakeholders have a significant interest in the success or failure of a project or program. The involvement of the largest possible number of stakeholders into the management of project cycle (planning, implementation, evaluation, reporting) will promote understanding, enlarge ownership, and foster sustainability of the project's /program's sustainability.

Temperature: This refers to a physical quantity characterizing the mean random motion of molecules in a physical body.

Top-down and bottom-up Approach: The top-down approach to management is when company-wide decisions are made solely by leadership at the top, while the bottom-up approach gives all teams a voice in these types of decisions.

Uncertainty (in relation to accuracy): This refers to the numerical expression of accuracy. Accuracy is a qualitative term. The common and less precise use of accuracy as in 'an accuracy of ±x', which reads 'an uncertainty of x'.

Vulnerability: Vulnerability to climate change is the degree to which a system is susceptible to, and 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 change and variation to which a system is exposed, it's sensitivity and its adaptive capacity.

Warsaw International Mechanism for Loss and Damage: The Warsaw climate conference in 2013 was perhaps most notable for being hosted by Poland, a country committed to promoting the coal industry. The meeting also established the Warsaw International Mechanism for Loss and Damage, giving policymakers a formal structure within which to discuss compensating countries for the damage caused by climate change could sit.

Weather: Weather refers to the behavior of the atmosphere on a day-to-day basis in a relatively smaller area. Weather parameters are daily temperature, relative humidity, sunshine, wind and rainfall. Describing these parameters for a location defines the weather for that locality. The weather of a day during the monsoon season may be described as rainy and windy; hot during summer; and cold during winter.

Message from GIZ Bangladesh

In this year 2022, Bangladesh and Germany celebrate 50 years of successful cooperation. The global challenge of climate change is among the various areas in which the two countries have cooperated over the past decades. The need to find solutions is well known worldwide, as is the need to manage the negative impacts of climate change through mitigation and adaptation measures.

In Bangladesh, the impacts of climate change are severe, especially affecting geographical hotspots and vulnerable groups, especially women, children, people with disabilities and marginalised communities living in poverty, who carry the biggest weight of losses and damages. The country has therefore made climate change a top political priority. Bangladesh is playing a very important role in international climate diplomacy. It has committed to drastically reduce its own emissions in the frame of the Nationally Determined Contributions (NDC) and has published an ambitious National Adaptation Plan (NAP) that shall provide guidance on climate resilience while promoting sustainable urban and rural development as well as conserving ecosystems.

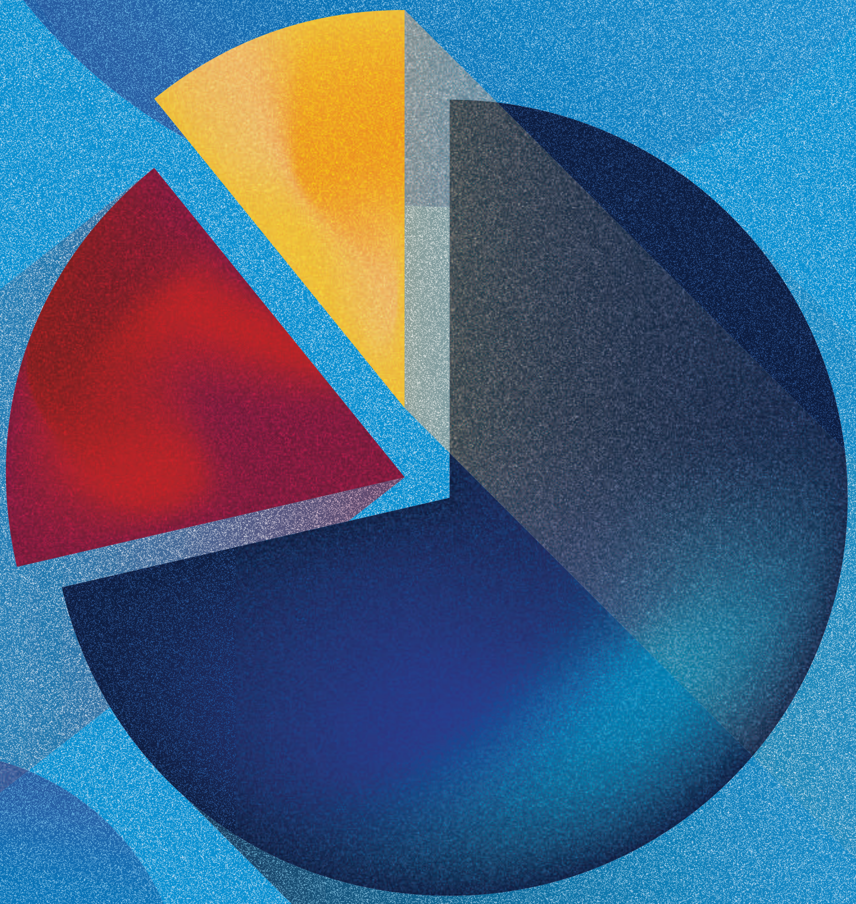
The "NAP and NDC Support Programme", commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ), has been working closely with the Ministry of Environment, Forest and Climate Change (MoEFCC) and the Department of Agricultural Extension (DAE) under the Ministry of Agriculture (MoA) to lay the groundwork for a successful implementation of the NAP and the NDC. The project is being carried out by the *Deutsche Gesellschaft für Internationale Zusammenarbeit* (GIZ) since 2019 with the aim of making Bangladesh more climate resilient through improved capacities, enhanced institutional processes, and access to climate data. These enable experts in government institutions on national and local levels to plan and revise projects that address climate risk related vulnerabilities in different areas.

The project has supported the development of a "Climate, Gender and Vulnerability Pre-Assessment" (CGVPA) tool. It consists of two customised checklists and guidelines to be used in the Department of Environment (DoE) of the MoEFCC and the DAE. The tool can also be adapted for use in other institutions. It allows its users to ensure that the projects they design are climate-sensitive and consider the needs of vulnerable populations. To support finding and accessing reliable data for climate-sensitive action planning at national as well as local levels, the project developed a brochure titled "Inventory of Available Climate Data and Climate Information of Bangladesh", and a browsable tool. This inventory contains orientation on 55 climate data sources from the Government of Bangladesh and international institutions.

Finally, twelve tailored training modules on understanding climate change and responding to its impacts were designed. More than 160 key government officials participated at these trainings implemented by the *International Centre for Climate Change and Development* (ICCCAD).

I hope this training manual "Managing Climate Change in Bangladesh - Foundations for Policymakers" serves as a valuable source of information and capacity development for climate-risk sensitive analysis and decision-making.

Dr. Dana de la Fontaine
Programme Coordinator, Adaptation of Urban Areas to Climate Change
GIZ Bangladesh



MODULE 01

Climate change and Bangladesh: science and impacts

Overview of the training module

1.1 Brief introduction to the module

Subject

Climate change and Bangladesh – science and impacts

Learning outcomes

This module aims to provide participants with a comprehensive overview of the issues related to climate change and disaster risk reduction (DRR). It also intends to stimulate further discussion on methodological and technical issues in order to promote a better understanding and application of a common approach to analyzing the adverse impacts of climate change and identifying measures to deal with them.

Topics

- Climate change trends in Bangladesh, with a focus on Bangladesh's vulnerable communities
- Climate-change-induced hazards and their impacts on Bangladesh (its vulnerable regions and most impacted sectors)
- Impacts of climate change on systems and livelihoods in Bangladesh
- Gender-disaggregated information on vulnerabilities

1.2 Understanding climate change: the basics

1.2.1 What is climate change?

The Earth's climate is not static and has changed many times in response to a variety of natural causes such as interactions between the ocean and atmosphere, changes in the Earth's orbit, sun energy, and volcanic eruptions. "Climate change" refers to a change in climate conditions that can be identified (e.g., using statistical tests) by changes in the mean and/or variability of the climate's properties and that persist for an extended period, typically decades or longer. Climate change is therefore evident in the long-term statistics of climate elements where changes (such as in temperature, precipitation, and wind pressure) are sustained over several decades or an even longer period.

1.2.2 What are the causes of climate change?

Climate change may be due to forces internal or external to Earth's climate system. Internal climate forcing processes include the effects of oceans, continental drift, atmospheric processes, the water cycle, clouds, ice and snow, land surfaces, volcanic eruptions, and human processes (mainly industrial and agricultural). When it comes to external influences, some processes like changes in solar radiation occurs naturally and contribute to the total natural variability of the climate system. Others, however, such as the change in the composition of the atmosphere that began with the industrial revolution, are the result of human activity. Recent changes in the climate are widespread, rapid, intensifying, and unprecedented in thousands of years (IPCC, 2021).

Box 1.1 Causes of climate change

Natural causes: The Earth's climate varies naturally as a result of interactions between the ocean and the atmosphere, changes in the Earth's orbit, fluctuations in the energy received from the sun, and volcanic eruptions.

Anthropogenic/human-induced causes: The main human influence on the global climate is likely to be emissions of greenhouse gases (GHGs) such as carbon dioxide (CO2), nitrous oxide (N2O) and methane (CH4). Anthropogenic environmental change is caused or influenced by people, either directly or indirectly.

1.2.3 Global warming

Since the Industrial Revolution, the global annual temperature has increased in total by a little over 1ºC, or about 2ºF. Between 1880 – the year in which accurate recordkeeping began – and 1980 it rose on average by 0.07ºC (0.13ºF) every 10 years. Since 1981, however, this rate of increase has more than doubled: For the last 40 years we have seen the global annual temperature rise by 0.18ºC, or 0.32ºF, per decade (MacMillan and Turrentine, 2021).

In addition, nine of the ten warmest years since 1880 have occurred since 2005, and the five warmest years on record have all occurred since 2015. Climate change deniers have argued that there has been a "pause" or a "slowdown" in rising global temperatures. However, numerous studies, including a 2018 paper published in the journal *Environmental Research Letters*, have disproved this claim. The impacts of global warming are already harming people around the world (Risbey et al., 2021).

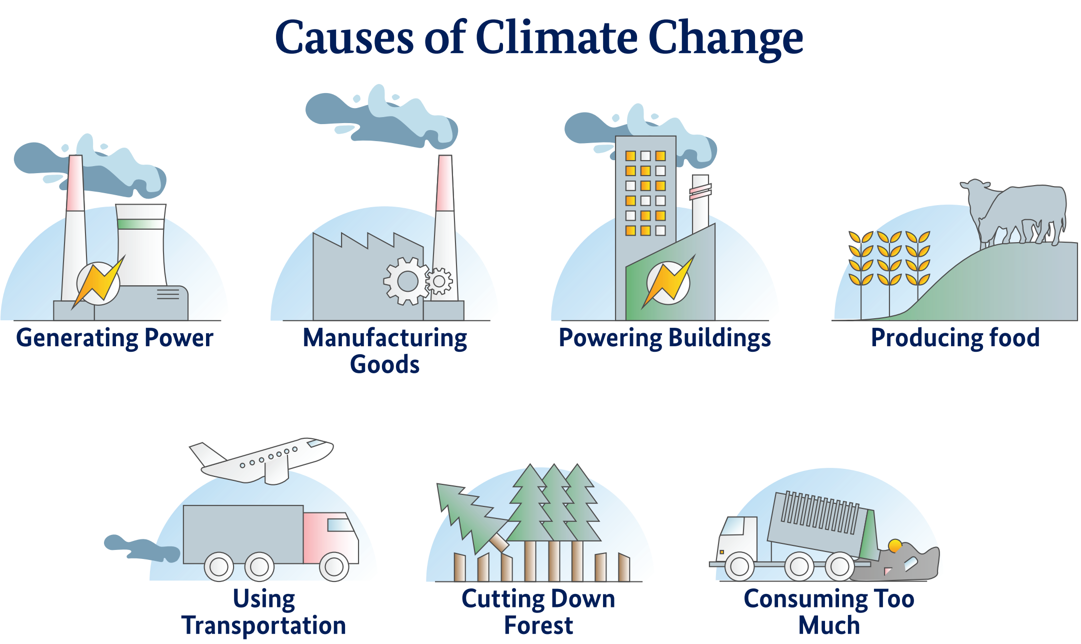


Figure 1.1: Causes of Climate Change (Source: Dreamstime, 2022)

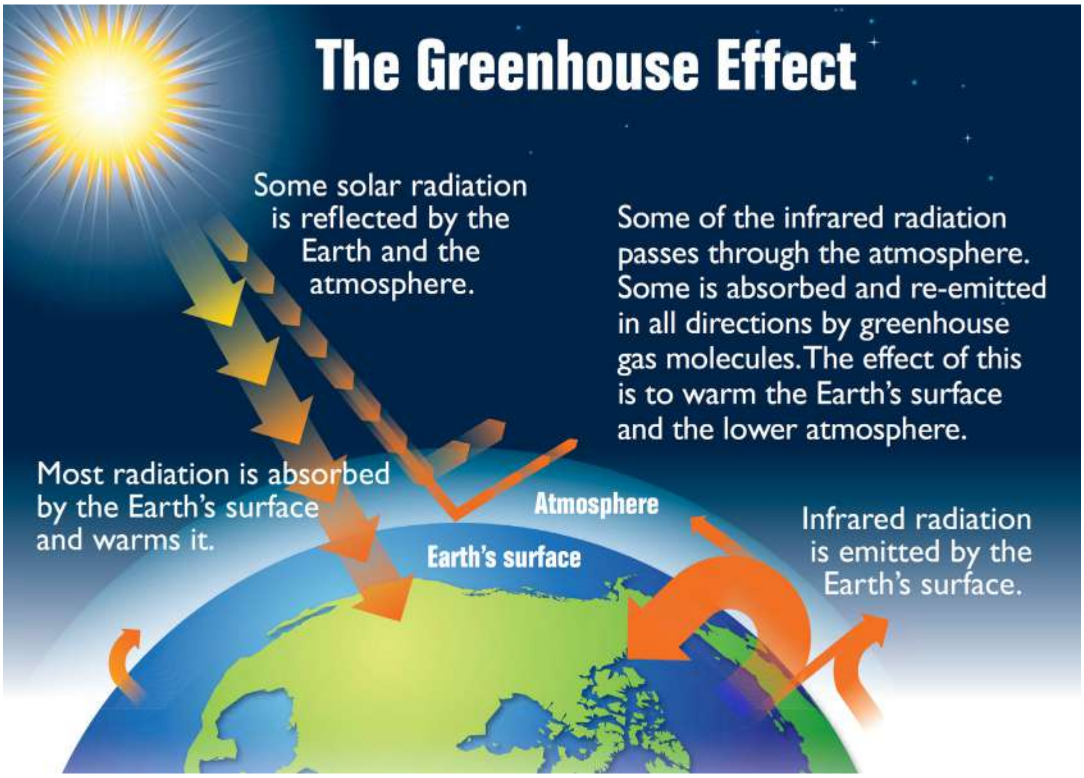


Figure 1.2: Schematic diagram of the greenhouse effect (source: Energy Education, 2021)

It is unequivocal that human influence has warmed the atmosphere, ocean, and land. Widespread and rapid changes in the atmosphere, ocean, cryosphere, and biosphere have occurred (IPCC, 2022). In 2019, atmospheric CO2 concentrations were higher than at any time in at least two million years (high confidence), and concentrations of CH4 and N2O were higher than at any time in at least 800,000 years (very high confidence). Compared to the natural multi-millennial changes occurring between glacial and interglacial periods over at least the past 800,000 years, the increases occurring since 1750 in the concentration of N2O (23%) are similar to these natural changes whereas those in the concentrations of CO2 (47%) and CH4 (156%) have far exceeded them (IPCC, 2021).

1.2.4 Greenhouse gases and global warming potential

GHGs occur naturally and are part of our atmosphere's makeup. For that reason, the Earth is sometimes called the 'Goldilocks planet' – its conditions are not too hot and not too cold but are just right to allow life (including us) to flourish. Part of what makes Earth so amenable is its natural greenhouse effect, which keeps the planet at a friendly 15°C (59°F) on average (NASA, 2022). However, in the last century or so, humans have been interfering with the planet's energy balance, mainly through the burning of fossil fuels that add carbon dioxide to the air. The level of carbon dioxide in Earth's atmosphere has been rising consistently for decades, trapping extra heat near Earth's surface and causing temperatures to rise.

Greenhouse Gases	Formula	Radioactive Forcing (W/m^2)	Global Warming Potential
Carbon dioxide	(CO_2)	1.46	1
Methane	(CH_4)	0.48	24
Nitrous Oxide	(N_2O)	0.15	310
Hydrofluorocarbons	(HFCs)	0.003	1300-11,700
Perfluorocarbons	(PFCs)	0.001	6500-9200
Sulfur hexafluoride	(SF_6)	0.002	23900

Table 1.1: List of GHGs with their Radioactive Forcing and GWP (Source: Wikipedia, 2022)

Global warming potential (GWP) is a measure of the radiative effect of each unit of gas over a specific period of time, expressed as a multiple of the radiative effect of CO2. An amount of gas with high GWP will warm the earth more than the same amount of CO2. Table 1.1 above shows the values for the radiative forcing and GWP of several GHGs. The GWPs are estimates of radiative properties for each gas.

Figure 1.3: GHGs are being emitted into the atmosphere with dire consequences – here, we see an example of the industrial emission of these gases (image: Tatiana Grozetskaya, Shutterstock.com) Source: LIVESCIENCE (2021)

1.2.5 Global emissions and their sources

Carbon dioxide has increased in the atmosphere due to fossil fuel use in transportation, building heating and cooling, and the manufacture of cement and other goods. Deforestation releases CO2 and reduces its uptake by plants. Carbon dioxide is also released in natural processes such as the decomposition of plant matter.

Over the last century, Methane concentrations have increased as a result of human activities related to agriculture, natural gas distribution, and landfills. Methane is also produced by natural processes such as those occurring in wetlands, for example. Methane concentrations are not, however, currently increasing in the atmosphere; indeed, the growth rates in methane concentrations have been decreasing over the last two decades.

Nitrous oxide is also emitted by human activities, such as fertilizer use and the burning of fossil fuels, as well as through natural processes in the soil and oceans.

While increases in halocarbon gas concentrations are primarily due to human activities, natural processes are also a minor source of these gases.

Carbon dioxide emissions, primarily from the combustion of fossil fuels, have risen dramatically since the start of the Industrial Revolution. Most of the world's GHG emissions come from a relatively small number of countries. China, the United States, and the European Union nations collectively are the three largest emitters on an absolute basis. Per-capita GHG emissions are highest in the United States and Russia. Carbon dioxide emissions have risen rapidly for the past 70 years. However, they are projected to remain steady, albeit at a very high level, over the coming decades. Emission reductions in developed economies are expected to offset carbon dioxide emission growth in developing countries.

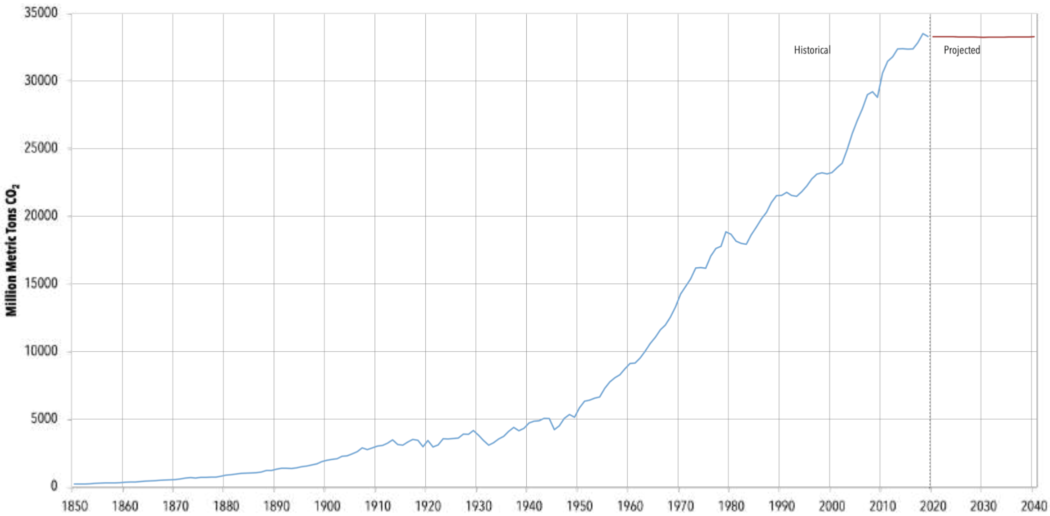


Figure 1.4: Global carbon dioxide emissions, 1850–2040 (C2ES, 2022)

1.2.6 Climate change scenarios

Globally, five major consequences of climate change have been observed:

a. Temperature rise
   1. Land surface temperature rise
   2. Sea surface temperature rise
b. Variation in precipitation (rainfall, snow, sleet, hail, etc.)
c. Ice melt
d. Antarctic ice sheet mass loss
e. Sea level rise

We will now look at each of these in turn.

(a) Temperature rise

Among the major challenges in understanding the climate system is quantifying the Earth's heat balance. Global warming is the increase in the average temperature of the Earth's near-surface air and oceans since the mid-20th century and the projected continuation of this increase.

i. Land surface temperature rise

Land Surface Temperature (LST) is the radiative skin temperature of the land derived from infrared radiation. In the SLSTR project, "skin" temperature refers to the temperature of the top surface when in bare soil conditions, and to the effective emitting temperature of vegetation "canopies" as determined from a view of the top of a canopy.

A simplified definition would be how hot the "surface" of the Earth would feel to the touch in a particular location. From a satellite's point of view, the "surface" is whatever it sees when it looks through the atmosphere to the ground. It could be snow and ice, the grass on a lawn, the roof of a building or the leaves in the canopy of a forest. LST is not the same as the air temperature that is included in the daily weather report.

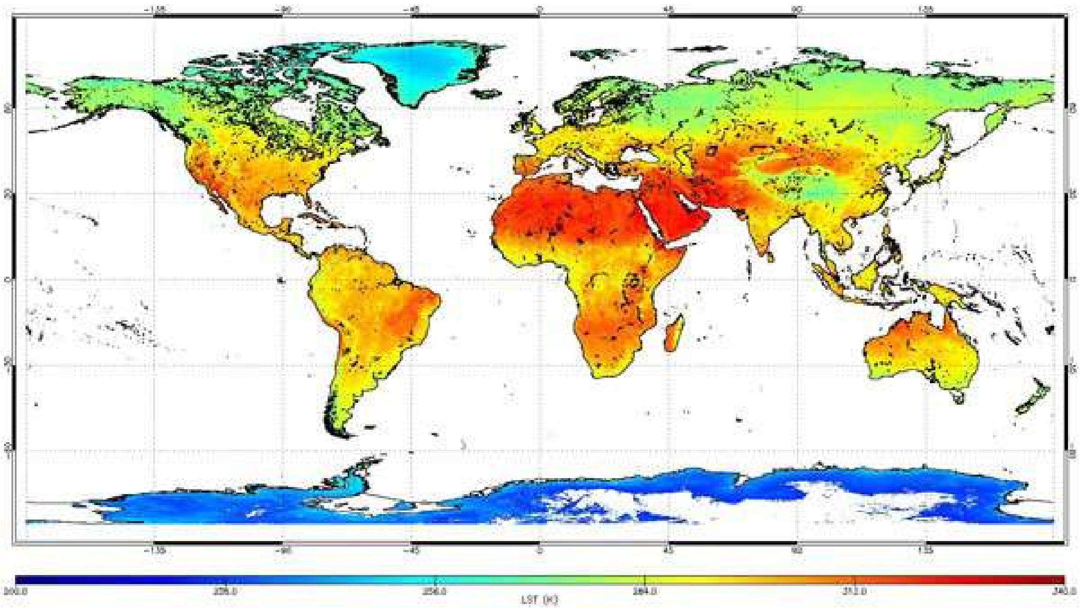


Figure 1.5: Global LST map (September 2016) derived from Sentinel-3A/SLSTR daytime data. (Credit: University of Leicester) Source: Sentinel Online (2022)

According to the Intergovernmental Panel on Climate Change (IPCC, 2021), the likely range of the human-caused increase in total global surface temperature from 1850–1900 to 2010–2019 is 0.8°C to 1.3°C, with a best estimate of 1.07°C. In this period, it is likely that well-mixed GHGs contributed a warming of 1.0°C to 2.0°C, other human drivers (principally aerosols) contributed a cooling of 0.0°C to 0.8°C, natural drivers changed global surface temperature by -0.1°C to +0.1°C, and internal variability changed it by 0.2°C to +0.2°C. It is very likely that well-mixed GHGs have been the main driver of tropospheric warming since 1979 and extremely likely that human-caused stratospheric ozone depletion was the main driver of cooling in the lower stratosphere between 1979 and the mid 1990s.

ii. Sea surface temperature rise

Sea surface temperature – the temperature of the water at the ocean surface – is an important physical attribute of the world's oceans. The surface temperature of the world's oceans varies mainly with latitude, with the warmest waters generally near the equator and the coldest waters in the Arctic and Antarctic regions. As the oceans absorb more heat, sea surface temperature increases, and the ocean circulation patterns that transport warm and cold water around the globe change.

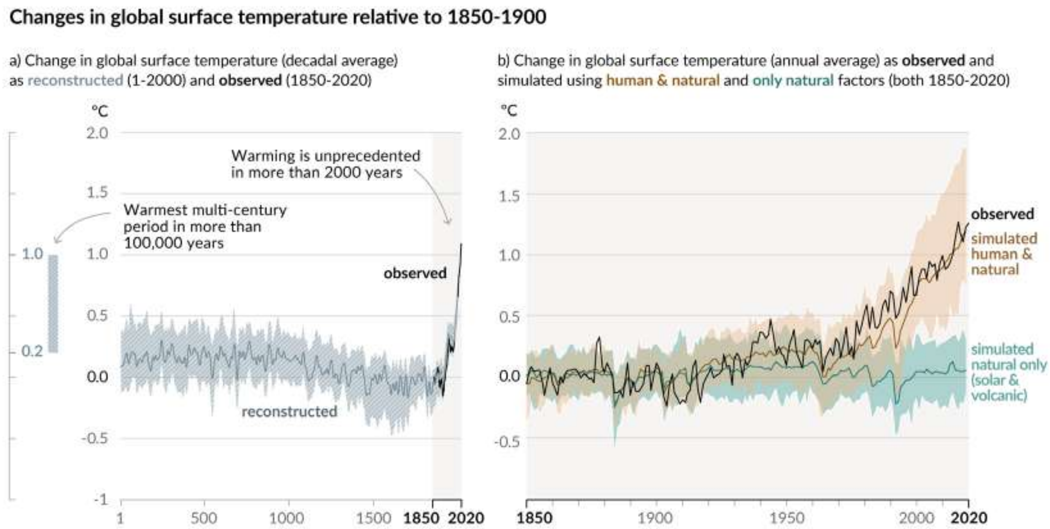


Figure 1.6: Changes in global surface temperature relative to 1850–2020 (IPCC, 2021)

Changes in sea surface temperature can alter marine ecosystems in several ways. For example, variations in ocean temperature can affect what species of plants, animals, and microbes are present in a location, and they can alter migration and breeding patterns, threaten sensitive ocean life such as corals, and change the frequency and intensity of harmful algal blooms such as the "red tide" phenomenon. Over the long term, increases in sea surface temperature could also reduce the circulation patterns that bring nutrients from the deep sea to surface waters. Changes in reef habitat and nutrient supply could dramatically alter ocean ecosystems and lead to declines in fish populations, which in turn could affect people who depend on fishing for food or jobs.

Because the oceans continuously interact with the atmosphere, sea surface temperature can also have profound effects on global climate. Increases in the sea surface temperature have led to an increase in the amount of atmospheric water vapor over the oceans. This water vapor feeds weather systems that produce precipitation, increasing the risk of heavy rain and snow. Changes in sea surface temperature can also shift storm tracks, potentially contributing to droughts in some areas. Increases in sea surface temperature are also expected to lengthen the growth season for certain bacteria that can contaminate seafood and cause foodborne illnesses, thereby increasing the risk of health effects (EPA, 2021).

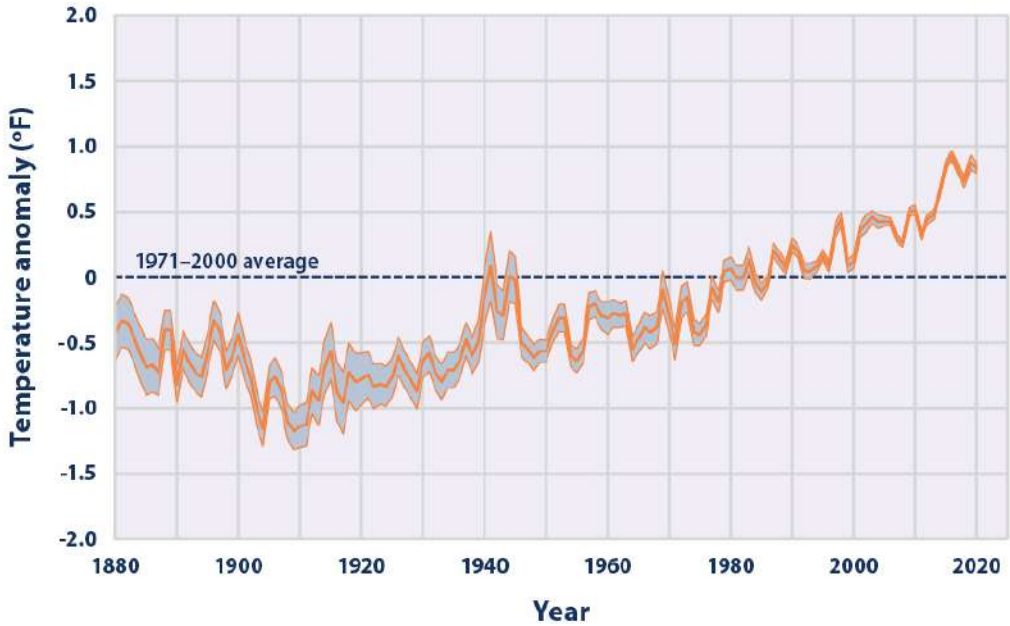


Figure 1.7: Average global sea surface temperature in ºF, 1880–2020 (source: NOAA, 2021 as cited in EPA, 2021)

Figure 1.7 shows how the average surface temperature of the world's oceans has changed since 1880. This graph uses the 1971–2000 average as a baseline for depicting change. Choosing a different baseline period would not change the shape of the data over time. The shaded band shows the range of uncertainty in the data, based on the number of measurements collected and the precision of the methods used.

(b) Variation in precipitation (rainfall, snow, sleet, hail, etc.)

Climate change is having an adverse impact on the patterns of global precipitation, which includes not just rainfall but also snowfall, sleet, hail, etc. As variations in rainfall have the potential to cause natural hazards like flood, landslide, drought, and so on, the rest of this section focuses specifically on that form of precipitation.

The increasing global temperature will cause changes in the amount and pattern of precipitation. Analysis of data from 1900 to 2005 has revealed long-term trends in precipitation amounts for many large regions, with significantly increased precipitation observed in northern Europe, northern and Central Asia, and the eastern parts of North and South America. Drought has been observed in the Sahel, the Mediterranean, southern Africa, and parts of southern Asia. Precipitation is highly variable spatially and temporally, and the data for some regions are limited.

Globally averaged precipitation over land has likely increased since 1950, with a faster rate of increase since the 1980s (medium confidence). It is likely that human influence contributed to the pattern of observed precipitation changes since the mid 20th century and extremely likely that human influence contributed to the pattern of observed changes in near-surface ocean salinity. Mid-latitude storm tracks have likely shifted poleward in both hemispheres since the 1980s, with marked seasonality in trends (medium confidence). For the southern hemisphere, human influence very likely contributed to the poleward shift of the closely related extratropical jet in austral summer.

(c) Ice melt

The amount of ice on Earth is decreasing. There has been a widespread retreat of mountain glaciers since the end of the 19th century. The extent of northern hemisphere snow cover has declined. Seasonal river and lake ice duration has decreased over the last 150 years. Since 1978, annual mean Arctic Sea ice extent has been declining and summer minimum Arctic ice extent has decreased. During the 1990s the Antarctic Peninsula and Amundsen Shelf saw their ice thinning and the acceleration of tributary glaciers, and in 2002 the Larsen B Ice Shelf disintegrated into the ocean.

Human influence is very likely the main driver of the global retreat of glaciers since the 1990s and the decrease in Arctic Sea ice area between 1979–1988 and 2010–2019 (decreases of about 40% in September and about 10% in March). No significant trend has been observed in the Antarctic sea ice area from 1979 to 2020 due to regionally opposing trends and large internal variability. Human influence has very likely contributed to the decrease in Northern Hemisphere spring snow cover since 1950. It is very likely that human influence has contributed to the observed surface melting of the Greenland Ice Sheet over the past two decades, but there is only limited evidence, with medium agreement, of human influence on the Antarctic Ice Sheet mass loss (IPCC, 2014). Based on model simulations of the Coupled Model Intercomparison Project 6 (CMIP6), the September Arctic sea ice area is 106 km2. Under the mid and high GHG emissions scenarios, it is projected that the Arctic will be practically ice-free near the middle of this century (IPCC, 2021).

(d) Ice sheet mass loss in Asia

According to the Asia regional fact sheet in the IPCC's Sixth Assessment Report (2022), glaciers are declining and permafrost is thawing. Seasonal snow duration, glacial mass, and permafrost area will decline further by the mid 21st century (high confidence). Glacier runoff in the Asian high mountains will increase up to the middle of the 21st century but may decrease thereafter due to the loss of glacier storage.

(e) Sea level rise

The global average sea level rose at an average rate of 1.8 (1.3 to 2.3) mm/year over the 1961 to 2003 period. This rate was higher in the 1993 to 2003 period at about 3.1 (2.4 to 3.8) mm/year. Whether the higher rate for 1993–2003 reflects decadal variability or an increase in the longer-term trend is unclear. The total 20th-century rise is estimated to be 0.17 (0.12 to 0.22) mm/year (IPCC, 2021).

The global mean sea level increased by 0.20 m (0.15 to 0.25 m) between 1901 and 2018. The average rate of sea level rise was 1.3 (0.6 to 2.1) mm/year between 1901 and 1971, increasing to 1.9 (0.8 to 2.9) mm/year between 1971 and 2006, and further increasing to 3.7 (3.2 to 4.2) mm/year between 2006 and 2018 (high confidence). Human influence has very likely been the main driver of these increases since at least 1971 (IPCC, 2021).

Changes in the land biosphere since 1970 are consistent with global warming: climate zones have shifted poleward in both hemispheres, and the growing season has on average lengthened by up to two days per decade since the 1950s in the extratropical northern hemisphere (high confidence) (IPCC, 2021).

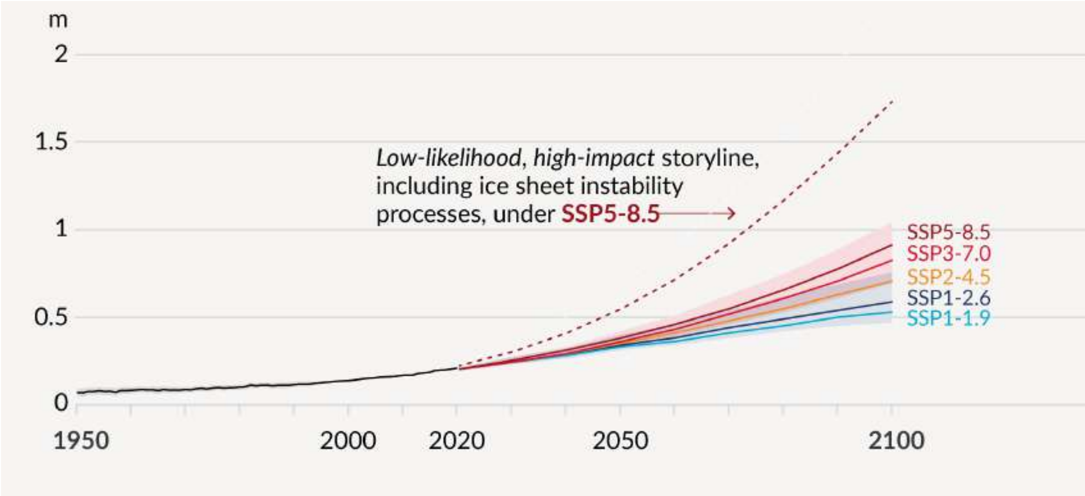


Figure 1.8: Average global sea surface temperature in ºF, 1880–2020 (source: NOAA, 2021 as cited in EPA, 2021)

1.2.7 Climate change impacts

Human-induced climate change is already giving rise to many weather and climate extremes in every region across the globe. Since the IPCC's Fifth Assessment Report, there has been increasing evidence of observed changes in extremes such as heatwaves, heavy precipitation, droughts, and tropical cyclones that are, in particular, attributed to human influence.

Four types of climate change

H **Hazards: increasing in frequency and/or intensity**
- Changes in the spatial and seasonal extent of hazards – new groups exposed to hazards that may be new for them.
- Floods, droughts, storms, tropical cyclones, heatwaves, wildfires, cold waves, landslides.

T **Trends in precipitation and temperature**
- Substantial increase in the numbers of people in poverty as a result of their livelihoods, nutrition, and health being undermined.
- An increased level of population vulnerability.
- Appearance of new groups vulnerable to all types of hazards, not only climatic ones.

I **Increased variability**
- Uncertainty regarding seasonal change.
- Disruption of the El Niño-Southern Oscillation.

S **Slow-onset changes**
- Sea level rise, glacier melt, coral damage, biodiversity loss.

1.3 Introduction to Bangladesh

1.3.1 Geography, physical features, and hydrology

Bangladesh stretches latitudinally between 20°34’N and 26°38’N and longitudinally between 88°01’E and 92°41’E. The country is surrounded by the Himalayan foothills, the Garo Hills of Meghalaya and the Arakan Yoma range. The Bengal Basin has been filled by sediments washed down from these highlands located on three of its sides, particularly from the Himalayas, where the slopes are steeper and the rocks less consolidated. The greater part of this land-building process must have been due to the Ganges and Brahmaputra rivers. The hills to the east – mostly the outer ranges of the Arakan Yoma – date from the middle of the Miocene to the Pleistocene. By the latter period, much of the Bengal Basin was complete: large sections of the early deposits remain as the Barind Tract of the Northern Bengal region and Madhupur Tract of the Central Bengal region. There are other scattered remains such as the Tripura Hills piedmont. Much of the Pleistocene deposits have either been eroded away or have sunk below recent alluvial deposits, which cover three quarters of Bangladesh. Most of the deltaic southern part of the Bengal Basin is probably not more than 10,000 years old (Rashid, 1991).

Bangladesh covers an area of 147,570 km2 and the delta it largely contains is one of the biggest in the world, consisting of three big rivers: the Ganges, the Brahmaputra, and the Meghna. These rivers meet within the Chandpur District of Bangladesh and then, in the Bhola District, they flow into the Bay of Bengal. The delta proper begins with the distributaries that flow southwards down through the lower delta to the coastal zone on the Bay of Bengal.

Bangladesh has a unique natural resource base, about 80% of which consists of floodplains, wetlands and over 700 rivers in a riverine network that sustains rare wildlife, flora, and fauna. Given its geographical location beneath the eastern Himalayas and the three major rivers it holds, Bangladesh is highly prone to flooding. Its topography is flat, with the majority of the landmass lying 10 meters or less above the mean sea level. Due to rises in the average sea level, an increased area of the country may be extremely vulnerable to flooding (GED, 2015).

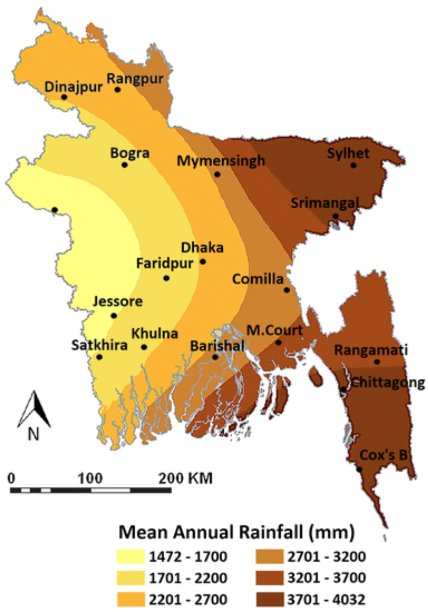


Figure 1.9: Figure 1.9. Spatial distribution of rainfall in Bangladesh (source: Mohsenipour et al., 2018)

Bangladesh receives enormous amounts of water every year from its vast catchment area, of which only 7% falls within its national territory. The remaining 93% falls within surrounding areas including parts of India, Nepal, and Tibet. This mass of water therefore originates in transboundary catchments, over which Bangladesh has little control, and follows its course down to the Bay of Bengal, debouching through the country’s river outlets. It is imperative to note that, in Bangladesh, there is a major seasonal variation in the amount of river flow and that this has serious consequences for the morphology of its rivers. During the summer rainy season, the combined effect of rainfall and mountain ice melt is much more intense than in the other seasons. As a result, the amount of water in the country’s river systems varies immensely depending on the season. This natural phenomenon, in addition to human activity and extreme weather events, contributes to silting up and raising the riverbed, and sometimes to drying up the rivers. At times of high flow, there can be flooding, riverbank erosion, and flash floods because the rivers are incapable of holding the whole water mass. Sometimes, local prolonged rainfall exacerbates the situation, with water stagnating in some locations due to inadequate drainage and the negative impacts of engineering constructions.

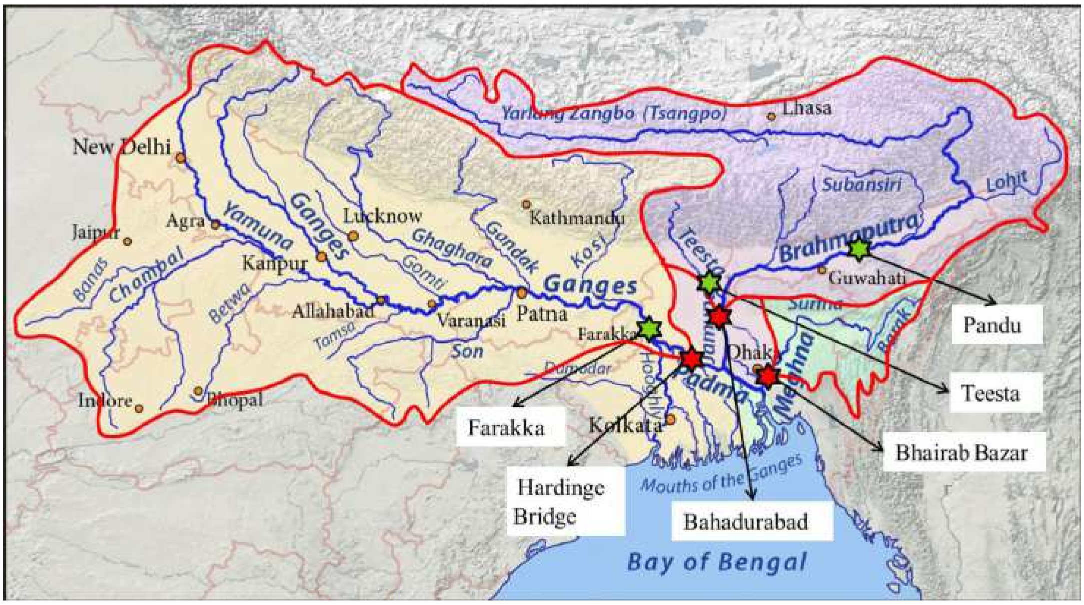


Figure 1.10: The boundary of the Ganges–Brahmaputra–Meghna (GBM) basin (thick red line), (source: Masood et al. 2015)

Bangladesh's deltaic form means the country lies just above the sea level, and its funnel-shaped estuary makes it susceptible to cyclonic hazards including strong winds, storm surges, and tidal surges. By raising the temperature, global warming will also raise sea levels through, among other things, the thermal expansion of sea water. This combination of a warmer atmosphere and higher sea levels will therefore contribute to intensifying the severity and frequency of weather events in country.

One of the most crowded countries in the world, Bangladesh is home to some 160 million people who live at extremely high densities of around 1,200 persons per square kilometer. The country also has a high unemployment rate. These factors exert tremendous pressure on the country's natural resources, which are at the same time also threatened by natural hazards such as recurring floods, river erosion, cyclones, etc. Bangladesh is one of the developing countries where the combination of the land resource base and the high density of population means it is threatened by natural hazards and anthropogenic mismanagement and over-exploitation (GED, 2014). Around 60% of the country's total land area is under cultivation, one of the highest such levels in Asia (ibid.).

1.3.2 Natural resources

Water plays a vital role in the environment and the economy. It is essential for food, fiber, and fuel production (crop growing, livestock rearing, forestry, fisheries) and is thus vital for ensuring a sustainable livelihood. The availability of fresh water in Bangladesh is highly seasonal and depends on monsoon rainfall both inside and outside of Bangladesh in the Ganges-Brahmaputra-Meghna (GBM) catchments. The monsoon accounts for 70–85% of annual rainfall and for around 92% of annual run-off, 8% of which is generated by rainfall within the country. The entire water ecosystem of Bangladesh, comprised of the GBM rivers, their tributaries and distributaries, and perennial and seasonal water bodies like haors, baors, and beels, is characterized by this seasonality of rain and its variability. All three of the GBM river systems originate outside Bangladesh. In total the country has 57 transboundary rivers, 54 of which come down from India and three from Myanmar, and Bangladesh is situated at these rivers' lowest points.

1.3.3 Climate of Bangladesh

Bangladesh's climate is characterized by high temperatures, heavy rainfall, often excessive humidity, and fairly marked seasonal variations. In recent years the weather pattern has been erratic, with the cool, dry season becoming shorter. This could be a temporary phenomenon, or it may be the beginning of the long-term changes due to global warming caused by GHGs (Rashid, 1991).

The mean annual temperature in the country is around 25°C. The mean monthly temperatures range between 18°C in January and 30°C in April and May. The highest temperatures throughout the year range between 38°C and 41°C. The average annual rainfall in the country is about 2,200 mm. About 80% of the total rainfall occurs from May to September (MoEFCC, 2018).

The broad features of the temperature regime are that (i) the highest temperatures are recorded in the months of March, April, and May; (ii) there is a period of equable temperature from June to September, June being the transitional period; (iii) then there is a steady fall in maximum and minimum temperatures from October to the end of December; and (iv) the coolest period is from the last week of December to the last week of January, with February a transitional month leading into the next three hot and dry months (Rashid, 1991).

Although Bangladesh is situated in the sub-tropical zone, it displays a tropical monsoon climate characterized by heavy summer rainfall and high summer temperatures. The reason for this is its location in South Asia where the Himalayas act as a barrier to moisture-laden monsoon winds in the summer season, causing the occurrence of heavy rainfall. The Himalayan Range also helps to protect the country from extremely cool winds blowing from the extreme north (i.e., the Siberian regions). In addition, the uplands in central India and the hilly terrain in the eastern parts of Bangladesh mean the latter receives huge amounts of water as surface run-off during the monsoon periods, which run from June to October (MoEFCC, 2018).

From the climatic point of view, four distinct seasons can be identified (although some experts recognize only three and, traditionally, Bangladeshis consider there to be six). These four seasons are (a) the cool, dry winter from December to February, (b) the hot pre-monsoon summer from March to May, (c) the hot, humid, and rainy season from June to September, and (d) the hot and humid but drier autumn from October to November when the south-west wind retreats (MoEFCC, 2018). We will now look at each of these seasons in more detail:

(a) The **cool winter dry season** (December to February) is characterized by an anti-cyclonic pressure system, very light northerly winds, mild temperatures, and dry weather with clear but occasionally cloudy skies. The winter begins first in the west-central part of Bangladesh in mid-December (lasting in this zone for around four months) and then advances towards the east and south. January is the coldest month, with the cold winter air moving into the country from the north-western part of India. Average temperatures in January vary from about 17°C in the north-western and north-eastern parts of the country to 20–21°C in its coastal areas. The minimum temperatures may drop to 4–7°C in the far north-western and north-eastern parts of the country. The average winter rainfall varies from 20 mm in the west and south to just over 40 mm in the north-east. Rainfall in this season accounts for only 2–4% of the total annual rainfall.

(b) The **pre-monsoon hot summer season** (March to May) begins as the winter anti-cyclonic pressure regimes start changing to summer heat from March onwards. The season is characterized by high temperatures and convective rainfall. April is the hottest month when the average temperature varies from 27°C in the north-east to 32°C in the west-central region and often reaches as high as 40°C. Seasonal rainfall varies from year to year and from place to place, and drought is not unusual.

The rainfall in this season accounts for around 15–20% of the annual total. Rainfall from the thunderstorms of this season (known as the "nor'westers", an important climatic event of the season) is copious, varying from 150–200 mm in the west-central zone to more than 800 mm in the north-east. This reflects the effect of the hill ranges in the north-eastern part of Bangladesh and the adjoining parts of India that trigger the uplift of air and the convectional overturning of the moist air from the Bay of Bengal. This season's rainfall has implications for two crops: the harvesting of the rabi crop and the planting of the kharif-1 crop. The season is marked by cyclonic storms formed in the Bay of Bengal, which have the potential to strike the Bangladesh coast with storm surges, often with devastating effects on the people living in the coastal region of Bangladesh.

(c) The **rainy or monsoon season** (June to September) coincides with the summer season when the country's weather is dominated by the south-westerly winds from the Bay of Bengal. The average temperature varies from 27–29°C, with a mean minimum temperature of 25°C and mean maximum of 31°C. The humidity is more than 80% with 80–90% cloud cover. This season accounts for about 70–85% of the total annual rainfall. Rainfall in this season is caused by the tropical depressions coming from the Bay of Bengal. Rainfall varies widely, from about 1,220 mm in Rajshahi and 1,490 mm in Narayanganj, to 3,380 mm in Cox's Bazar and as high as 5,000 mm in the northern part of Sylhet. The average rainy days vary from 60 days in the west-central region to 95 days in the south-east and over 100 days in the north-east. The timing of summer monsoon is very important from an agricultural point of view because it has implications for two crops: the harvesting of aus rice (kharif-1) and planting of aman rice (kharif-2). Moreover, severe flooding may occur in this season causing extensive damage to crops, livestock, human life, and infrastructure. Sometimes floods may reach calamitous proportions, as happened in 1987, 1988, and 1998. The summer monsoon has an enormous influence on the agriculture, hydrology, and drainage systems of Bangladesh and thus influences the economy of the country.

(d) The **post-monsoon or autumn** (October to November) is the transitional season from the summer monsoon to the winter. As the south-west monsoon begins to withdraw from the country in early October, the autumn season sets in gradually. From mid-October the monsoon rainfall then rapidly peters out. In the western half of the country and in central Bangladesh the rains are normally over by the last week of October, whereas in the east and south-east they may continue up to about the second week of November. Very little rain then falls until the middle of January. The cloud cover is around 25% in the northern and eastern region and about 40–50% in the southern and eastern regions. The rainfall varies from 2% to 10%. The winds are variable in October, but there is a definite strengthening of the northerly winds at the expense of the south-easterlies. The post-monsoon season is characterized by the occurrences of cyclonic storms, particularly between September and November. Some of these cyclonic storms form in the Bay of Bengal at about 100 N latitude or even near the equatorial belt. Initially they move north-west and, when they near 200 N latitude, they turn north-east and hit the Bangladesh coast. Near the eye of the cyclone, there is a heavy swell known as the storm surge, which can be devastating to lives and properties.

The major characteristics of the Bangladesh climate are as follows:

- Seasonality of temperature and rainfall: four seasons that are characteristically distinct.
- Variability of temperature and, in particular, of rainfall: there are variabilities in the arrival and departure of monsoon rainfall and in the amount of rainfall received during the pre- and post-monsoon periods.
- Regional variations: these are categorised into Seven climatic sub-regions within Bangladesh, with each sub-region having rainfall and temperature characteristics that are essentially different.

1.3.4 Climate change trends in Bangladesh

Bangladesh has a humid, warm climate influenced by pre-monsoon, monsoon and post-monsoon circulations and frequently experiences heavy precipitation and tropical cyclones. Bangladesh's historical climate has experienced average temperatures of around 26°C, but range between 15°C and 34°C throughout the year. The warmest months coincide with the rainy season (April-September), while the winter season (December-February) is colder and drier. Bangladesh is a very wet country, receiving on average about 2,200 millimeters (mm) of rainfall per year. Most regions receive at least 1,500 mm and others, such as in the northeastern border regions, receive as much as 5,000 mm of rainfall per year. Humidity remains high throughout the year, peaking during the monsoon season (June to October). Rainfall is driven by the Southwest monsoon, which originates over the Indian Ocean and carries warm, moist, and unstable air. Typically, a tropical cyclone (of strength classification Tropical Storm or above) will make landfall in Bangladesh once in every two to three years bringing heavy rainfall, very high wind speeds, and storm surges. Please see the following trend for 2030 and 2050 (Climate Change Knowledge Portal, 2021).

Year	Increase in temperature (°C)	Precipitation change (%) compared to 1990	Sea level rise (cm)
2030	+0.7 (rainy season)	+11 (rainy season)	30
	+1.3 (winter season)	-3 (winter season)	30
2050	+1.11 (rainy season)	+28 (rainy season)	30
	+1.18 (winter season)	-37 (winter season)	50

Table 1.2: Climate change trends

Climate-change-induced hazards and their impacts on Bangladesh

1.4 Existing Hazards and Impacts

1.4.1 Hazards in Bangladesh

(a) Flood

Flood is a state of high water levels along a river channel or on the coast that leads to the inundation of land, which is not usually submerged. Floods may happen gradually, may take hours or may even happen suddenly without any warning due to a breach in embankments, spill over, heavy rains, etc. Floods are annual phenomena, with the most severe ones occurring during the months of July and August. Regular river floods affect 20% of the country, increasing to 68% in extreme years. The floods of 1988, 1998, 2004, and 2007 were particularly catastrophic, resulting in large-scale destruction and loss of life.

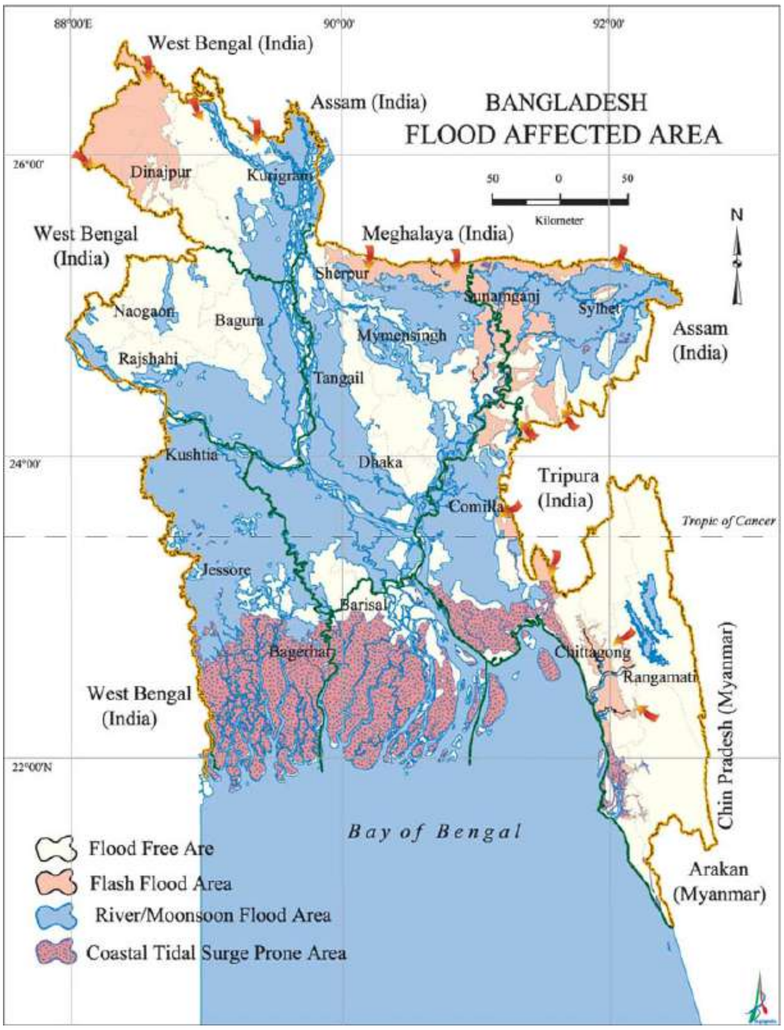


Figure 1.11: Flood-affected areas of Bangladesh (source: Banglapedia, 2022)

Four types of flooding occur in Bangladesh:

Box 1.2 Different types of flood

Flash floods most often happen in Bangladesh in April–May and September–November when the hilly rivers in the east and north of the country can overflow. When they occur at harvest time, these flash floods can impact on annual rice crops. An example of this is the crop decimation that occurred from 2004 to 2014 in the haor (backswamp) region. The areas of Sylhet and Sunamganj are also prone to flash flooding.

The sectors most impacted by flash flooding: agriculture (crops, livestock, fisheries), water (urban and industrial supply, and drinking water scarcity), infrastructure, human settlements, energy, and health.

Plain floods are caused by the combination of drainage congestion and heavy rains. These floods generally occur in the deltas of the country's south-west and are becoming more frequent in low-lying urban areas. In 1988, record floods inundated 250 km2 of the country's capital, Dhaka, for three weeks. Chattogram also experiences monsoon-related floods.

The sectors most impacted by plain flooding: agriculture (crops, livestock, fisheries), water (urban and industrial supply, and drinking water scarcity), infrastructure, human settlements, energy, and health.

River floods are the most common form of flooding in Bangladesh. During the monsoon, the riparian areas, and sometimes areas far beyond the riverbanks, become inundated. Extreme flooding occurs when the rivers flood at the same time or when the rivers flood during a heavy monsoon (June–September).

The sectors most impacted by river flooding: agriculture (crops, livestock, fisheries), water (urban and industrial supply, and drinking water scarcity), infrastructure, human settlements, energy, and health.

Coastal floods in Bangladesh tend to result from storm surges and tidal action on and around the country's 800 km of coastline, which runs along the northern rim of the Bay of Bengal. These coastal floods inundate areas with saline water, damaging their crops, vegetation, and fresh water sources.

The sectors most impacted by coastal flooding: agriculture (crops, livestock, fisheries), water (water logging, scarcity of drinking water), human settlements, energy, and health

While flood-related facilities have been decreasing, such as lack of early warning, poor insfrastructure etc., economic losses have over time been increasing. The Government of the People's Republic of Bangladesh has been working to develop and implement various measures to prevent or deal with floods in the country. Important initiatives include the flood action plan, flood hydrology study, flood management model study, national water management plan, national water policies, flood early-warning study, and the construction of flood embankments and flood shelters. Despite this, the potential for flood damage is increasing due to climate change, urbanization, the growth of settlements in flood-prone areas, and an overreliance on flood control works such as levees and reservoirs.

(b) Cyclone

The coastal regions of Bangladesh are subject to damaging cyclones almost every year. They generally occur in early summer (April-May) or late rainy season (October-November). Cyclones originate from low atmospheric pressures over the Bay of Bengal. Cyclones in the South Asian sub-continent are presently classified according to their intensity such as depression (winds upto 62 km/h), cyclonic storm (winds from 63-87 km/h), severe cyclonic storm (winds from 88-118 km/h) and severe cyclonic storms of cyclone intensity (winds above 118 km/h) (Hossain and Mullick, 2020).

At least 12 major tropical cyclones hit the country since 1965, leaving 479,490 people dead. According to the Ministry of Disaster Management and Relief, Bangladesh is one of the worst sufferers of cyclones in terms of casualties. Of the total 88 cyclones took place in the greater Bengal territory, most of them were in Cox's Bazar, Patuakhali, Noakhali, Chattogram, Teknaf, Sonadia coast and Kutubdia Island (42 cyclones) followed by the Sundarbans (18 cyclones) (ibid).

Severe tropical cyclones in Bangladesh since 1965 (Dhaka Tribune, 2020):

1. Bhola Cyclone (November 11, 1970)
2. The April 1991 Cyclone
3. Barisal Cyclone (May 11, 1965)
4. The December 1965 Cyclone
5. The October 1966 Cyclone
6. Urir Char Cyclone (May 25, 1985)
7. Cyclone 04B (November 30, 1988)
8. May 1997 Cyclone
9. Cyclone Sidr (November 15, 2007)
10. Cyclone Aila (May 25, 2009)
11. Cyclone Mahasen (May 16, 2013)
12. Cyclone Roanu (May 21, 2016)

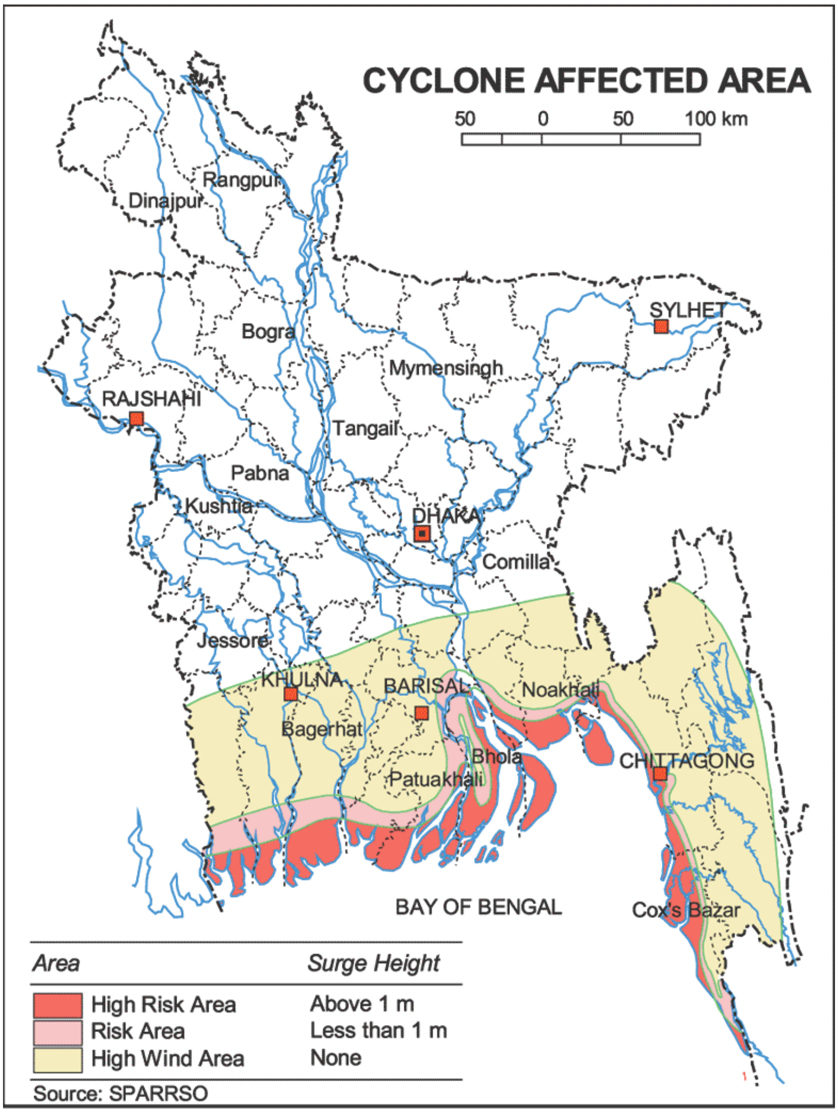


Figure 1.12: Cyclone Affected Area (source: Shamrat, 2017)

(c) Rising sea levels in Bangladesh

By the end of the century, sea levels are expected to rise along the Bangladesh coastline by up to 1.5m. This will be accompanied by more extreme seasonal fluctuations on sea levels. Disastrous storms and unusually high tides are currently once-a-decade occurrences, but can take place as regularly as 3 to 15 times annually by 2100.. As a result of this, rural Bangladeshis face a stark choice; change their way or life or seek employment and a home elsewhere (BBC, 2019)Increased climatic volatility has also resulted in increased frequencies of in-land migration. Where in the past we saw in-land migration occurring as a result of annual flooding or riverbank erosion, we see it occurring now due to saltwater intrusion which affects the environment in the long run. This makes it harder to grow crops because the land is permanently altered by the saline water. In the past, people could go to work in the city for a few months while the land was flooded and return when the flood had retreated. Now, that is no longer possible.

For some, the saltwater offers an opportunity. Where rice might have once grown, shrimp farms are taking over – the saltwater providing the right environment to switch to aquaculture. When we look at people converting from agricultural production, households seem to maintain their production well by switching to aquaculture, remaining resilient. These solutions, however, need to remain sustainable for their continued resilience.

How sustainable will aquaculture be? If enough people convert and there is too much saline intrusion that could create new problems and distort the economy in ways people cannot predict.

The BBC report also stressed that we see both types of migration going on in Bangladesh – that compelled by the wish to pursue improved opportunities, or that they can no longer make ends meet because of environmental changes.

As a low-lying country, Bangladesh has always been vulnerable to changing sea levels, so adapting and migrating are not unusual. Bangladeshis are currently on a good tangent for economic growth, but climate volatility renders the continuation of this growth uncertain.

(d) Coastal and riverbank erosion

Coastal erosion is an endemic and recurrent natural hazard in Bangladesh. As the sea surface temperature increases, the sea level rises, which increases the velocity of ocean currents in coastal areas. These faster-moving currents then promote erosion. When rivers enter their mature stage (as the three mighty rivers of the Ganges, Brahmaputra and Meghna do in Bangladesh) they become sluggish and meander or braid. These oscillations cause massive riverbank erosion. Every year, millions of people are affected by erosion that destroys standing crops, farmland, and homestead land. It is estimated that about 5% of the total floodplain of Bangladesh is directly affected by erosion (Rahman and Gain, 2020).

e) Salinity intrusion

Seawater intrusion is a pressing issue in coastal aquifers worldwide. Surface water resources, like rivers and canals, are severely affected by the intrusion of saline water (Werner et al., 2013). In the mega-delta coastal areas of Viet Nam, Bangladesh, and India, surface and near-surface drinking water are particularly susceptible to contamination by saline water intrusion, putting more than 25 million people at risk of drinking saline water. Climate change is intensifying this problem, which also has adverse health consequences, such as a greater prevalence of hypertension and cardiovascular diseases (Hoque et al., 2016). The cumulative effects of salinity, arsenic contamination, and drought pose threats to water quality and security, as well as to the health of coastal communities in Bangladesh (Abedin et al., 2014). The increasing salinity of water in the country occurs as a result of rising sea levels, cyclone and storm surges, and upstream withdrawal of freshwater.

(f) Drought conditions

Bangladesh is largely dependent on agriculture, and this sector is greatly influenced by climate, which is more propitious for agriculture in Bangladesh than it is in some other countries around the world. However, in recent years the adverse effects of rapid climate change on agriculture have become clearly visible in certain parts of the country, damaging crop cultivation and production. In the main, Bangladesh has three crop-growing seasons: the summer season (kharif-1), the rainy season (kharif-2), and the winter season. Of these three seasons, it is the summer and rainy (kharif) seasons that are most vulnerable to environmental hazards, such as drought, cyclones, and storm surges, that impact heavily on agricultural production. During

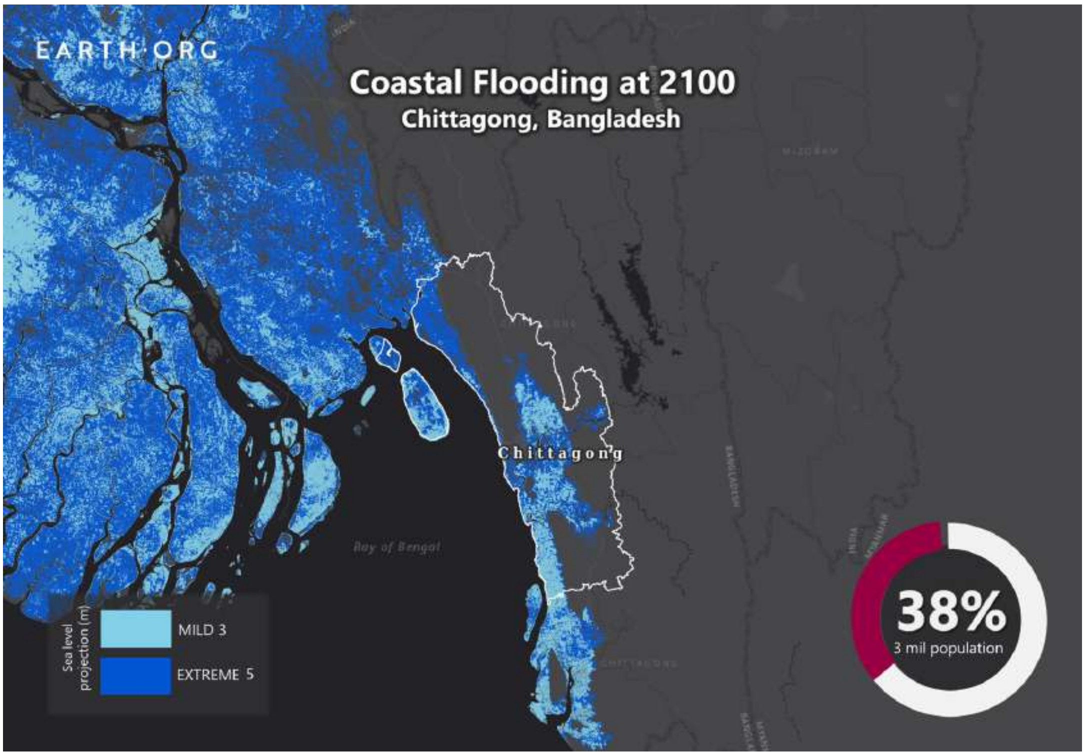


Figure 1.13: Satellite observations of sea level rise from 1993 to 2021 (source: Earth.org, 2020)

the rainy season, crop growing is dependent on natural rainwater. Sometimes heavy and continuous rainfall can cause physiological drought for crop plants where they are unable to absorb water despite it being freely available. Conversely, summer season crops receive less rainfall and can therefore suffer from regular drought due to the low moisture content of the soil. In this context, drought can be defined as the unavailability for a short or even a long period of the amount of water that plants require. Be they temporary or long term, droughts can severely damage crop growth and production depending on whether they occur at a critical condition in crop growth (Aziz et al., 2021).

1.4.2 Critically vulnerable areas and most impacted sectors

The following table presents the climate factors and events for climate-vulnerable regions and the vulnerabilities in these locations.

Climatic factors and events	Critical vulnerable locations	Vulnerabilities
Temperature rise and drought	North-west and central areas	Agriculture (crop growing, livestock rearing, fisheries), water, forest and energy resources, health
Sea level rise and salinity intrusion	Coastal areas and islands	Agriculture (crops, livestock, fisheries), water (waterlogging, scarcity of drinking water), human settlements, energy, health
Floods	Central region, north-east region, and char lands	Agriculture (crops, livestock, fisheries), water (urban and industrial supply, scarcity of drinking water), infrastructure, human settlements, disasters, energy, health
Cyclone and storm surge	Coastal and marine zone	Agriculture (crops, livestock, fisheries), marine fisheries, infrastructure, human settlements, life, property
Drainage congestion	Coastal areas, urban areas, and south-west	Water (navigation), agriculture (crop growing)

Table 1.3: Vulnerable regions of Bangladesh and their vulnerabilities. Source: MoEF (2009)

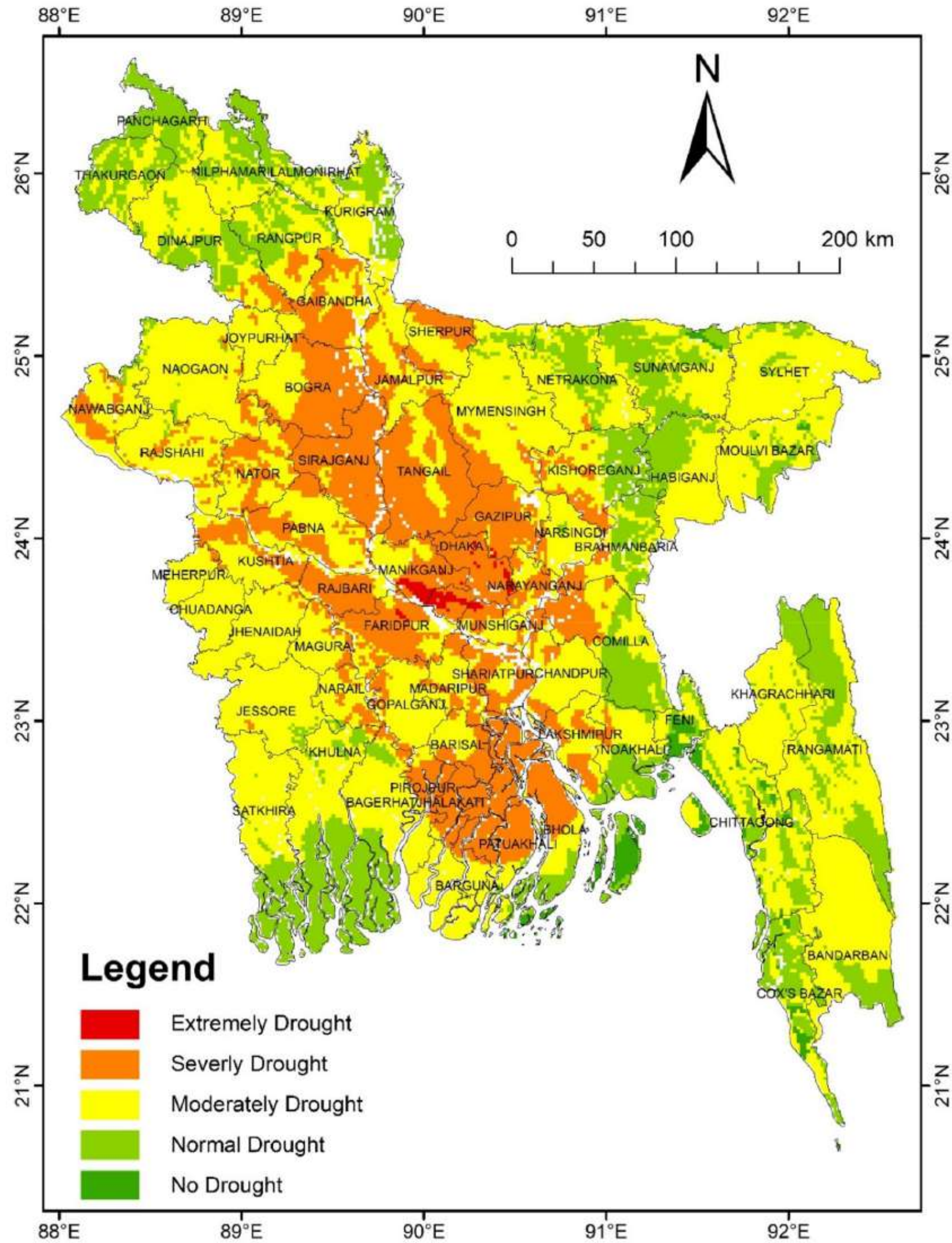


Figure 1.14: Kharif agricultural drought map of Bangladesh (source: Aziz et al., 2021)

1.4.3 Impacts of climate change on Bangladesh's coastal region

Several studies indicate that the vulnerability of Bangladesh's coastal zone would be acute due to the combined effects of climate change, sea level rise, subsidence, and changes in upstream river discharge, cyclone patterns, and coastal embankments. Four key types of primary physical effects have been identified as key vulnerabilities in Bangladesh's coastal area: saline water intrusion, drainage congestion, extreme events, and changes in coastal morphology.

Low river flow, sea level rise, and subsidence would enhance the effect of saline water intrusion in estuaries and into groundwater. The pressures of a growing population and rising demand due to economic development will further reduce the relative availability of fresh water supply in future. The adverse effects of saline water intrusion on coastal agriculture will be significant, and fresh water for public and industrial supply will become less and less available.

The combined effects of higher sea water levels, subsidence, siltation of estuary branches, higher riverbed levels, and reduced sedimentation in flood-protected areas will impede drainage and gradually increase waterlogging problems. This effect will be particularly strong in the coastal zone. Drainage problems will also be aggravated by the continuous development of infrastructure (e.g., roads), which will further reduce the delta's limited natural drainage capacity. Increased periods of inundation may hamper agricultural productivity and will also threaten human health by increasing the potential for waterborne disease.

The disturbance of coastal morphological processes will become a significant problem under a warmer and changing climate regime. Bangladesh's coastal morphological processes are extremely dynamic, partly because of the tidal and seasonal variations in river flows and run-off. Climate change is expected to increase these variations, mainly through two (related) processes including changes in sedimentation and flooding.

Box 1.3 Climate change and vulnerable groups

Impact of climate change on children

- Health: children are more vulnerable to vector-borne diseases than adults.
- Natural disasters: children are small in size and are relatively unable to care for themselves.
- Malnutrition: drought and crop failures undermine children's nutrition and chances of survival.

Impact of climate change on the elderly and people with disabilities

- Diminished ability to adapt: these people find it more difficult to regulate their body temperature and to adapt physiologically to heat.
- Resistance to seeking assistance: this group tends to experience more social isolation and fear.
- Detrimental physical impacts: this group is at greater risk of dehydration and malnutrition and of their existing health problems worsening.
- Loss of access to infrastructure: power cuts can affect life-support equipment and affect mobility (wheelchairs and ramps).

Impact of climate change on poor and indigenous people

- Living conditions: Bangladesh's indigenous peoples tend to live in the places that are worst hit, and their poverty and the discrimination they suffer exacerbates their vulnerability.
- Proximity to nature: the close relationship of many indigenous peoples to their environments means they are more sensitive to the impacts of climate change.
- Violation of human rights: impacts on these people's right to self-determination.
- Issues with biofuels: heralded as a solution to climate change, biofuel production in practice can involve human rights violations.

Climate change indicators	Vulnerabilities in coastal areas, islands, and the marine zone	Impacts
Increase in average temperature	Agriculture (crops, livestock, fisheries), water, energy, health	• Increase in disease, health risks, and pest attacks • Decrease in crop and vegetable production • Drying out of ponds, loss of soil moisture, decrease in fish production • Increased scarcity of water for domestic use
Increased rainfall	Agriculture (crops, livestock, fisheries), water, health	• Flooding and river erosion • Waterlogging affecting agricultural practices and crops • Flooded aquaculture ponds lose their fish stocks
Decreased rainfall	Agriculture (crops, livestock, fisheries), water, health	• Damaged or decreased crop yield/production • Drying out of aquaculture ponds, which affects fish production • Increase in diseases and pests
Sea level rise	Agriculture (crops, livestock, fisheries), water, human settlements, energy, health	• Inundation of lowlands by saline water • Decreased crop production due to the loss of cultivable land • Biodiversity loss • Extreme scarcity of drinking water • Migration
Salinity intrusions	Agriculture (crops, livestock, fisheries), water, human settlements, health	• Decreases in crop production • Soil degradation • Freshwater fish production is harmed • Increases in human diseases like diarrhea, dysentery, etc.
Extreme events (flood, cyclone, drought, river erosion)	Agriculture (crops, livestock, fisheries), land, infrastructure, human settlements, life, property	• Damage • Injury • Death

Table 1.4: Climate-change-related factors and their impacts in coastal areas, islands, and the marine zone

1.4.4 Impacts of climate change on different systems, sectors, and livelihoods in Bangladesh

(a) Land and soil

Two key factors affecting land and soil in Bangladesh are structural changes in land use and riverbank erosion, which is rampant along the river benches of the country's coastal and offshore areas. Of the 2.85 million hectares that make up Bangladesh's coastal and offshore area, some 1.2 million hectares comprise arable land affected by varying degrees of soil salinity (Habiba et al., 2014). Some key causes of this salinization of coastal land are (i) tidal flooding during the wet season, (ii) direct inundation by saline or brackish water, (iii) the upward or lateral movement of saline groundwater during the dry season, and (iv) inundation with brackish water for shrimp farming. Salinity problems have increased over time with the desiccation of the soil.

(b) Agriculture sector

From the climate change perspective, agriculture will be the most critical sector. All the consequences of climate change – such as temperature rise, rainfall variation, sea level rise, and the increasing intensity and frequency of extreme weather events – will adversely affect global agricultural practice and production.

Each year it is not unusual for Bangladesh to see 22% to 30% of its land area inundated in a flooding event. However, when a major flood event occurs, two-thirds or more of the country might be affected – for example, the 1998 floods inundated around 70% of the country. Prolonged periods of inundation will destroy crops, with losses depending on the timing of the flood event in the crop calendar and on its magnitude and duration. Following the 1998 floods, the water levels in various parts of the country remained over the official danger level for 67 days, which left crops significantly damaged.

Every year, droughts of different magnitudes affect three to four million hectares of cropland. A severe drought can, for example, devastate up to 70–90% of a T. Aman rice crop. Northwestern districts are severely affected by drought. Among them the Rajshahi and Nawabganj districts are well-known rice growing regions. The 1978–79 drought affected 42% of Bangladesh's cultivated land, resulting in crop losses estimated at two million tonnes in total. Crop losses from the 1997 drought amounted to one million tonnes, valued at USD 500 million (Selvaraju, 2006).

Cyclones and storm surges usually have a significant impact on crop agriculture, and it is predicted that crops will respond to climate change differently, in particular to the warming of the climate system. High and extremely low temperatures would be detrimental to growth. Both inundation due to sea level rise and salinity ingress threaten crop agriculture in Bangladesh's coastal districts. High temperatures and a reduction in precipitation could cause the onset of droughts with the potential to affect crop yields. In November 2007, Cyclone Sidr destroyed nearly ripe crops growing in 900,000 hectares of Bangladesh's south-west (Awal and Khan, 2020). Many households also lost their food stocks because their homes were damaged. Another a major risk from climate change is the projected crop losses due to increased salinity in coastal Bangladesh (Dasgupta et al., 2015). By increasing sea levels, tidal activity/inundation, irrigation use, cyclonic storm surges, and waterlogging, future climate change could increasingly intensify this salinization problem.

Box 1.4 Climate change and vulnerable groups

Cyclone Amphan, 2020

Cyclone Amphan formed over the Indian Ocean on May 16, 2020, and started moving north over the Bay of Bengal toward north-east India's coastal areas and the south of Bangladesh. On May 20, 2020 the Bangladesh Meteorological Department issued a Signal 10 ("great danger") warning for coastal districts and their offshore islands and chars. Following the Signal 10 warning and an evacuation order of the Bangladesh government, more than 2.4 million people were moved to 14,636 permanent and temporary shelters. Cyclone Amphan slammed into the coastal districts of West Bengal, India, and then entered Bangladesh on the evening of May 20th. With wind speeds of 150 km/h, it caused major destruction across 26 districts in the country. According to the Needs Assessment Working Group (NAWG) report of May 31st, approximately 2.6 million people were affected, 205,368 houses were damaged, and 55,767 houses were destroyed in the 26 affected districts. A total of 26 people lost their lives. In addition, 40,894 latrines, 18,235 water points, 32,037 hectares of crops and vegetables, 18,707 hectares of fish cultivation area, 440 km of road, and 76 km of embankments were damaged.

In August 2021, due to active monsoon conditions and the lack of sustainable embarkment repair, a strong tidal surge once again impacted cyclone-affected communities in Khulna and Satkhira. Around 50,000 people were severely affected in Koyra and Paikgachha upazilas (sub-districts) in the Khulna District. At least 250 shrimp enclosures were washed away and 15,000 people were exposed to serious land waterlogging issues. In Satkhira district, 151 ha of land were inundated, and 101 ha of farmlands and fish enclosures were flooded.

Early flash flooding in the haor region in 2017

In early April 2017 a flash flood in six haor districts devastated boro rice crops worth BDT 130 billion. Since then, millions of farmers have felt anguish every time they see a grey cloud in the northern sky in early April. According to news reports, during the first week of April of that year, rain and hailstorms destroyed vast tracts of paddy in the Kishoreganj and Moulvibazar districts.

In general, yearly floods occur in the haor region in late April and last for several months. Boro rice is harvested after Bengali New Year, so around mid-April. Any premature hailstorms and flash flooding in late March or early April can cause havoc for farmers. The flooding in 2017, in addition to damaging the boro crop, also devastated fisheries and poultry and livestock farms in Netrokona, Sunamganj, Sylhet, Moulvibazar, Habiganj, and Kishoreganj districts (The Daily Star, 2017). Flash floods in the latter part of March or early April, such as those that occurred in 2017 and 2019, are not a regular occurrence in the haor region.

(c) Water resources

Freshwater resources are highly sensitive to variations in weather and climate. The changes in global climate that are occurring as a result of the accumulation of GHGs in the atmosphere will affect patterns of freshwater availability and will alter the frequencies of floods and droughts.

Climate model simulations and other analyses suggest that total flows, probabilities of extreme high or low flow conditions, seasonal run-off regimes, groundwater–surface water interactions, and water-quality characteristics could all be significantly affected by climate change over the course of the coming decades. The additional effects of global climate change have important implications for water resources that include

- increased evaporation rates;
- a higher proportion of precipitation received as rain, rather than snow;
- earlier and shorter run-off seasons; and
- increased water temperatures and decreased water quality in both inland and coastal areas.

Bangladesh's National Adaptation Programme of Action (NAPA) highlights two types of problems existing in the coastal water bodies – namely, salinity in the estuarine areas and water pollution in the marine zone. The magnitude of these problems depends on seasonal freshwater flow from the rivers and on the operation of seaports. Generally, water scarcity is a dry-season phenomenon when supply is not sufficient to meet demand or when the quality of the water restricts its use. Dry-season water resources are comprised of run-off and transboundary river inflow, together with the water contained in surface water bodies and groundwater. Scarcity is also dependent on the amount of soil moisture available at the beginning of the season.

(d) Forest

The Sundarbans mangrove forest is being adversely affected by sea level rise and salinity intrusion. The sundari tree (Heritiera littoralis) is disappearing due to increased salinity in the soil and water. Homestead and roadside trees and plants are also declining due to salinity intrusion in coastal region of Bangladesh (MoEFCC, 2018).

(e) Infrastructure

High-value coastal infrastructure – e.g., houses, roads, bridges, culverts, educational institutions, industries, utilities such as water supply facilities, etc. – can be damaged within a very short space of time due to hazards like cyclones, flooding, and riverbank erosion.

(f) Economy and livelihoods

Climate change's impacts on livelihoods depend on the nature and severity of its physical impacts on agriculture, water availability and quality, and disaster-proneness, and on the hospitableness of the physical environment in the face of rising temperatures, changing water regimes, pathogenic activity, and coastal inundation. Given these physical changes include sea level rise, the livelihood impacts will be significant, as consequence reducing employment or employability, income, and consumption. These impacts will be felt by different socio-economic groups.

The economy of and livelihoods in the coastal region of Bangladesh will be impacted in the following ways:

- Damage to agriculture, fisheries including shrimp farms, salt farms, and other livelihood activities.
- Damage to businesses and trades (SMEs like poultry producers, agro-processing units).
- Reduced human potential for work.
- Reduced incomes and job losses.

(g) Health

Climate change is a significant and emerging threat to public health, and it changes the way we address issues on behalf of vulnerable population groups.

Projected climate-change-related exposures are likely to affect the health status of millions of people, particularly those with a low capacity for resilience, by increasing:

- malnutrition and its consequent disorders, with implications for child growth and development;
- the number of deaths, diseases, and injuries due to heatwaves, floods, storms, fires, and droughts;

- the burden of diarrheal disease; and
- the frequency of cardio-respiratory diseases due to higher concentrations of ground-level ozone related to climate change.

Box 1.5 Theory into Practice

Implementation of Learning

To make informed decisions, people need to have a basic awareness of the causes, likelihood, and severity of climate change impacts, as well as the range, cost, and efficacy of various options to limit or adapt to it. Participants taking this module should come away with a clear understanding of basic climate science and its overall impacts, which will help them to take decisions in their respective sectors. For example, participants working in the field-level offices of the Department of Agricultural Extension (DAE) will be made aware of the potential adverse impacts of climate change on crop production and will also be able to monitor the impacts of the weather and climate streams on crop production and take timely decisions. Eventually, this knowledge and skills will help them to promote sustainable and resilient agricultural production.

For further guidance, please read or watch the following:

Documents

Climate Change Profile Bangladesh 2018:
https://www.government.nl/binaries/government/documenten/publications/2019/02/05/climate-change-profiles/Bangladesh.pdf

Bangladesh – Climate Change Impacts and Vulnerability:
https://www.preventionweb.net/files/574_10370.pdf

Overview of linkages between gender and climate change:
https://www.undp.org/sites/g/files/zskgke326/files/publications/Gender_Climate_Change_Training%20Module%201%20Overview.pdf

Video

Climate Change Impacts in Bangladesh:
https://youtu.be/V3IL6Y1TDHo

How global climate change is already devastating Bangladesh:
https://www.youtube.com/watch?v=I9yJ7K_3n50

Working Group

Intergovernmental Panel on Climate Change:
https://www.ipcc.ch/

United Nations Framework Convention on Climate Change:
https://unfccc.int/

(h) Energy

An increased frequency and intensity of extreme storm events may damage electricity transmission infrastructure and services. Increased wind and lightning could also damage transmission lines and structures. Extreme rainfall events could flood power substations. Increasing storms would significantly drive up the costs of energy and infrastructure maintenance and would lead to longer and more frequent blackouts and service disruption. Extreme heatwave events are likely to be more frequent, increasing the demand for air conditioning.

(i) Settlement security

Poor communities can be especially vulnerable, particularly those located in high-risk areas. They tend to be more resilient, however, when they source climate-sensitive resources such as water and food supplies locally. The most vulnerable settlements and societies are generally those located in coastal and river floodplains, those whose economies are closely linked with climate-sensitive resources, and those in areas prone to extreme weather events, especially where rapid urbanization is occurring.

1.4.5 Gender-disaggregated information on vulnerabilities

The implications of gender on environmental change, and the different ways in which men and women respond to disasters, are vital to understand and need to be addressed. These differences, largely due to unequal social relations, determine men's and women's roles, behavior, and responsibilities in the household, workplace, and community. For instance, access to income and resources ensures better livelihood security, protection, and capability to recover. These differentiated levels of access to resources are key to understanding gender roles in, and as a consequence of, people's level of vulnerability, exposure to risk, and coping and resilience capacity. One example is the high mortality of women during the 1991 cyclone in Bangladesh. According to cultural norms, women were late in vacating their households, and most women do not know how to swim.

Considering gender roles in agriculture and fisheries, the informal sector, the household, and the community can assist us in pinpointing where vulnerability to ecological threats lies. Women's responsibility for fetching water and fuel can place them under increasing strain as they trek further in search of firewood and face diminishing plant resources and water shortages. Trekking long distances for water and fuel also affects the academic performance of young girls, who are often kept at home to help with household duties. Similarly, a disproportionately large number of women work in the informal sector, and informal sector jobs are often the worst hit and slowest to recover when disasters strike.

Changes in the climate have the potential to create widespread additional health problems. These are likely to increase women's workloads further, since women have traditionally carried the responsibility for caring for the sick and the elderly. Women's health may also suffer as a result of their existing lower level of access to health services, their reduced nutritional status, and the requirement placed on them to juggle multiple roles. Men's mental health may also suffer, as men are less likely to seek counseling for trauma, a possible outcome of experiencing disaster.

Box 1.6 Gender dimension of climate change

Overview of linkages between gender and climate change

Gender inequalities intersect with climate risks and vulnerabilities. Women's historic disadvantages – their limited access to resources, restricted rights, and muted voice in shaping decisions – make them highly vulnerable to climate change. The nature of that vulnerability varies widely, which cautions against generalization. But climate change is likely to magnify existing patterns of gender disadvantage.

Source: UNDP, 2007

Recommendations for integrating gender and climate change

- Involve women in vulnerability assessments to ensure that the evaluations do not focus solely on economic sectors dominated by men.
- Involve both men and women in the prioritization and design of climate change adaptation projects, and build on their indigenous knowledge.
- Reach men and women through industrial as well as household clean-energy interventions.
- Make information, training, and technologies for climate change adaptation and mitigation accessible and relevant for all stakeholders.
- Take advantage of women's skills and knowledge – such as natural resources management and social networks – in community-based adaptation.
- Incorporate gender considerations into national climate change strategies and regulations.
- Ensure that the burdens and opportunities created by climate change adaptation work are equitable.

Source: https://www.usaid.gov/tanzania/documents/documents/climate-change-fact-sheet

Exercise ······ Section 5

1.5 Group work

a. Your task is to identify:

- the impacts of climate change in the three climate hotspots,
- which regions are most at risk, and
- what national actors' contributions can be in those regions.

Climate region	Impacts of climate change	Name of national actors working in this region	National actors' interventions to address the adverse impacts of climate change
Cyclone prone area			
Riverine flood prone area			
Flash flood prone area			

b. Identify the degree of vulnerability to different climate factors of each of the sectors listed in the table below.

Degree of vulnerability for each of the following areas:

H = Serious consequences and a priority for action
M = Important and should be considered in the development plans for the city
L = Not important

Greenhouse Gases	Climate factors			
	Increase in temperature	Change in rainfall pattern	Sea level rise	Increase in extreme events
Built environment (H, M, or L)				
Cultural and religious heritage (H, M, or L)				
Local economy, industry, and business (H, M, or L)				
Urban agricultural production (H, M, or L)				
Social equity system (H, M, or L)				
Water supply/management (H, M, or L)				
Human lives and well-being (H, M, or L)				
Land use and availability (H, M, or L)				
Production and distribution of energy (H, M, or L)				

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Notes

MODULE 02

Climate change evidence, projection, vulnerability, and risks at the global, regional, and local scales

Overview of the training module

2.1 Brief introduction to the module

Subject

Climate change evidence, projection, vulnerability, and risks at the global, regional, and local scales

Learning outcomes

This module will help learners to gain an understanding of the vulnerabilities of climate change. Trainees will learn about different climate projection models and about the climate risks assessment technique for effective climate risk management.

Topics

- Climate change evidence
- How can we know about future climate change?
- Climate change projection for Bangladesh
- Assessment of climate change vulnerability and risks

2.2 Climate change evidence

2.2.1 How are humans changing the climate?

In the 11,000 years prior to the Industrial Revolution, the average temperature across the world was stable at around 14°C. The Industrial Revolution began in the mid-1800s when humans began to burn fossil fuels such as coal, oil, and gas for fuel. Burning fossil fuels produces energy but also releases greenhouse gases (GHGs) such as carbon dioxide, methane, and nitrous monoxide into the air (Met Office, 2022). Over time, large quantities of these gases have built up in the atmosphere. For example, the level of carbon dioxide in the atmosphere rose by 40% during the 20th and 21st centuries and is now over 400 parts per million (ppm). In 2019 the level of carbon dioxide in the atmosphere was higher than at any time in at least two million years (ibid.).

Once in the atmosphere, GHGs such as carbon dioxide form a "blanket" around the planet. This blanket traps the heat from the sun and causes the Earth to heat up. This effect was noticed as far back as the 1980s. Once in the atmosphere, GHGs such as carbon dioxide form a "blanket" around the planet. This blanket traps the heat from the sun and causes the Earth to heat up. This effect was noticed as far back as the 1980s, as evidenced in the IPCC's statement on anthropogenic climate change (see Box 2.1 below).

Box 2.1 IPCC's statement on anthropogenic climate change

In 1988 the IPCC was set up to provide governments with information to tackle climate change. Evidence has shown that the high levels of GHGs in the atmosphere are the leading cause of increasing global temperatures. Scientists have been able to rule out natural events as causes of climate change, such as volcanic activity, changes in solar activity, or natural sources of CO2. These may, however, have a very small effect, on top of human contributions. In their most recent report, the IPCC states that human activity is unequivocally the cause of climate change.

2.2.2 How fast is the temperature rising?

It is unequivocal that human influence has warmed the atmosphere, ocean, and land. Widespread and rapid changes in the atmosphere, ocean, cryosphere, and biosphere have occurred. Human influence has warmed the climate at a rate that is unprecedented in at least the last 2000 years. Since the Industrial Revolution, the average temperature of the planet has risen by around 1.1°C. This is a rapid change in terms of our global climate system. Previously, natural global changes are understood to have happened over much longer periods of time. It is also important to remember that the world is not warming evenly, so the temperature increase is higher than 1°C in some countries.

2.2.3 How 'shared socio-economic pathways' explore future climate change

Over the past few years, an international team of climate scientists, economists, and energy systems modelers have built a range of new "pathways" that examine how global society, demographics, and economics might change over the next century. They are collectively known as the "shared socio-economic pathways" (SSPs).

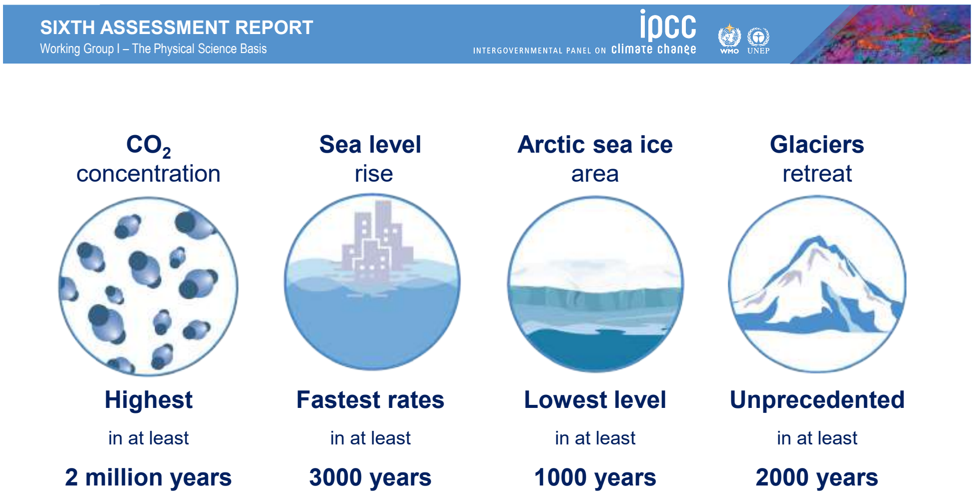

Figure 2.1: Some key climate change impacts in facts and figures (source: IPCC, 2021)

Figure 2.2: Recent changes observed in the climate and oceans (source: IPCC, 2021)

These SSPs are now being used as important inputs for the latest climate models, feeding into the IPCC's Sixth Assessment Report, which was published in three parts over 2021 and 2022. They are also being used to explore how societal choices will affect GHG emissions and, therefore, how the climate goals of the Paris Agreement could be met.

The new SSPs offer five pathways that the world could take. Compared to previous scenarios, these offer a broader view of a "business-as-usual" world without future climate policy, with global warming in 2100 ranging from a low of 3.1°C to a high of 5.1°C above pre-industrial levels (Carbon Brief, 2018). They show that it would be much easier to mitigate and adapt to climate change in some versions of the future than in others. They suggest, for example, that a future with "resurgent nationalism" and a fragmentation of the international order could make the "well below 2°C" Paris target impossible.

2.2.4 How much warming could we see?

GHGs can live in our atmosphere for tens or hundreds of years. The gases that are already in our atmosphere are effectively locked in and will contribute to increasing temperatures. Even if we stop all emissions today, we cannot avoid some level of warming. The amount of warming we will see, beyond what we have already caused, depends on the changes we make.

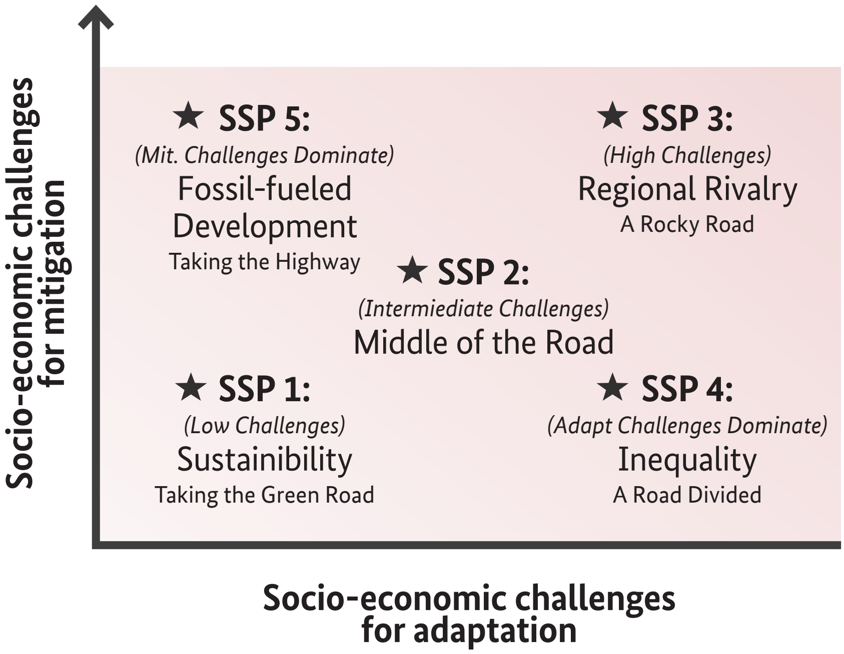

Figure 2.3: Overview of SSPs (UNFCCC, 2022)

2.2.5 The Paris Agreement and global temperature goals

In 2015, almost every country in the world signed a document promising to cut down on GHG emissions. The aim was to limit the average global temperature to 2°C above pre-industrial temperatures. If possible, countries pledged to aim for a 1.5°C limit. Since then, the IPCC has published a report explaining the different impacts between a 1.5°C or 2°C temperature rise. This report shows that there are many benefits for people

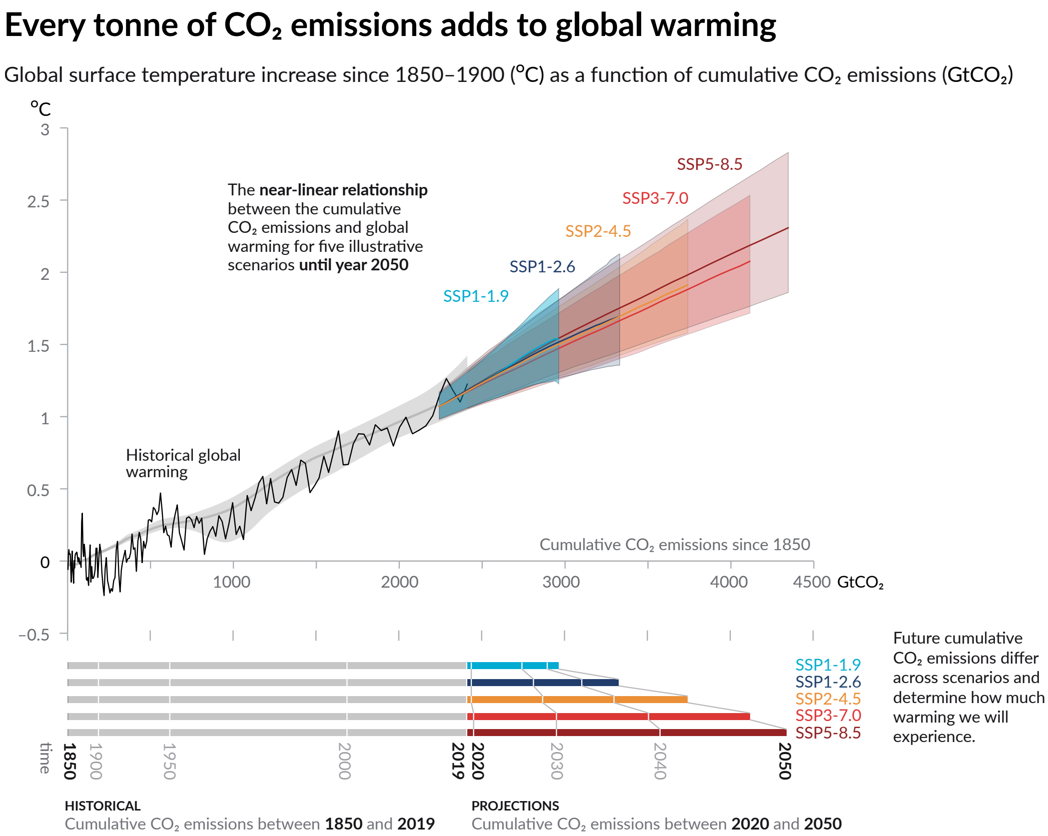

Figure 2.4: Global surface temperature increase since 1850 (°C) as a function of cumulative CO2 emissions (GtCO2) (source: IPCC, 2021)

all over the world in limiting temperatures to 1.5°C. Large and rapid reductions in global GHG emissions are needed to meet this goal. The below chart (Figure 2.6) from the IPCC shows possible futures for our climate. The blue line represents what could happen if we commit to cutting emissions, and the red line represents what could happen if we do not make any changes.

If we want to avoid significant increases in the average surface temperature, we must cut GHG emissions and switch to renewable energy sources. We must also use land more sustainably and may need to use techniques to remove carbon dioxide from the air. If we continue to burn fossil fuels and cut down forests at the same rate, the planet could warm by more than 4°C by 2100. This warming could fundamentally change life on earth, with potentially drastic consequences.

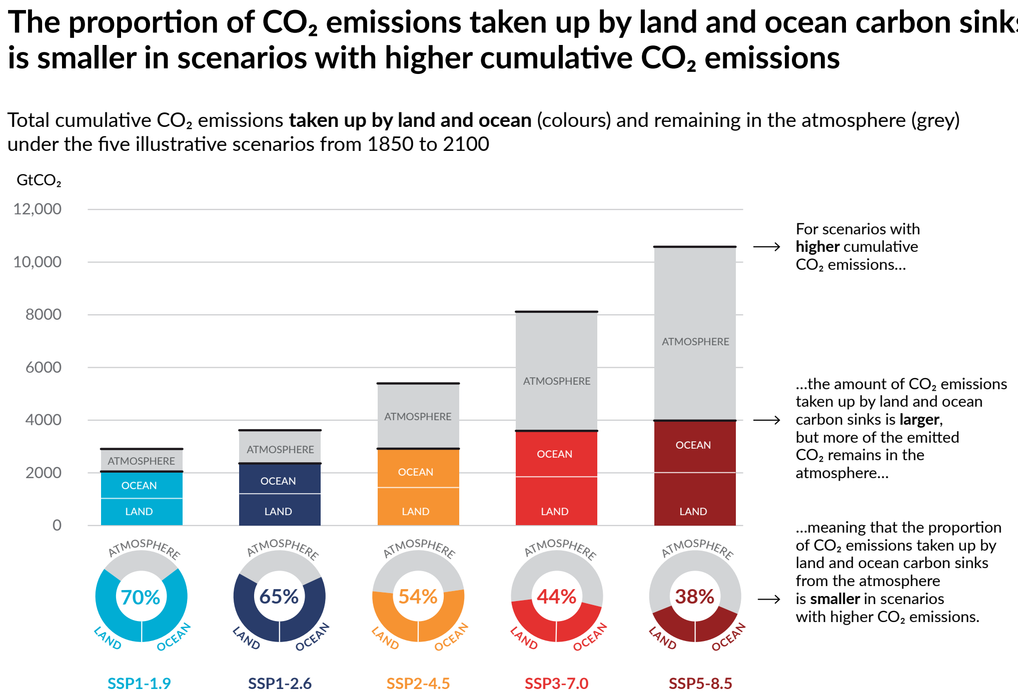

Figure 2.5: Total cumulative CO2 emissions taken up by land and oceans (colors) and remaining in the atmosphere (gray) under the five illustrative scenarios from 1850 to 2100 (IPCC, 2021)

Human activities affect all the major climate system components, with some responding over decades and others over centuries

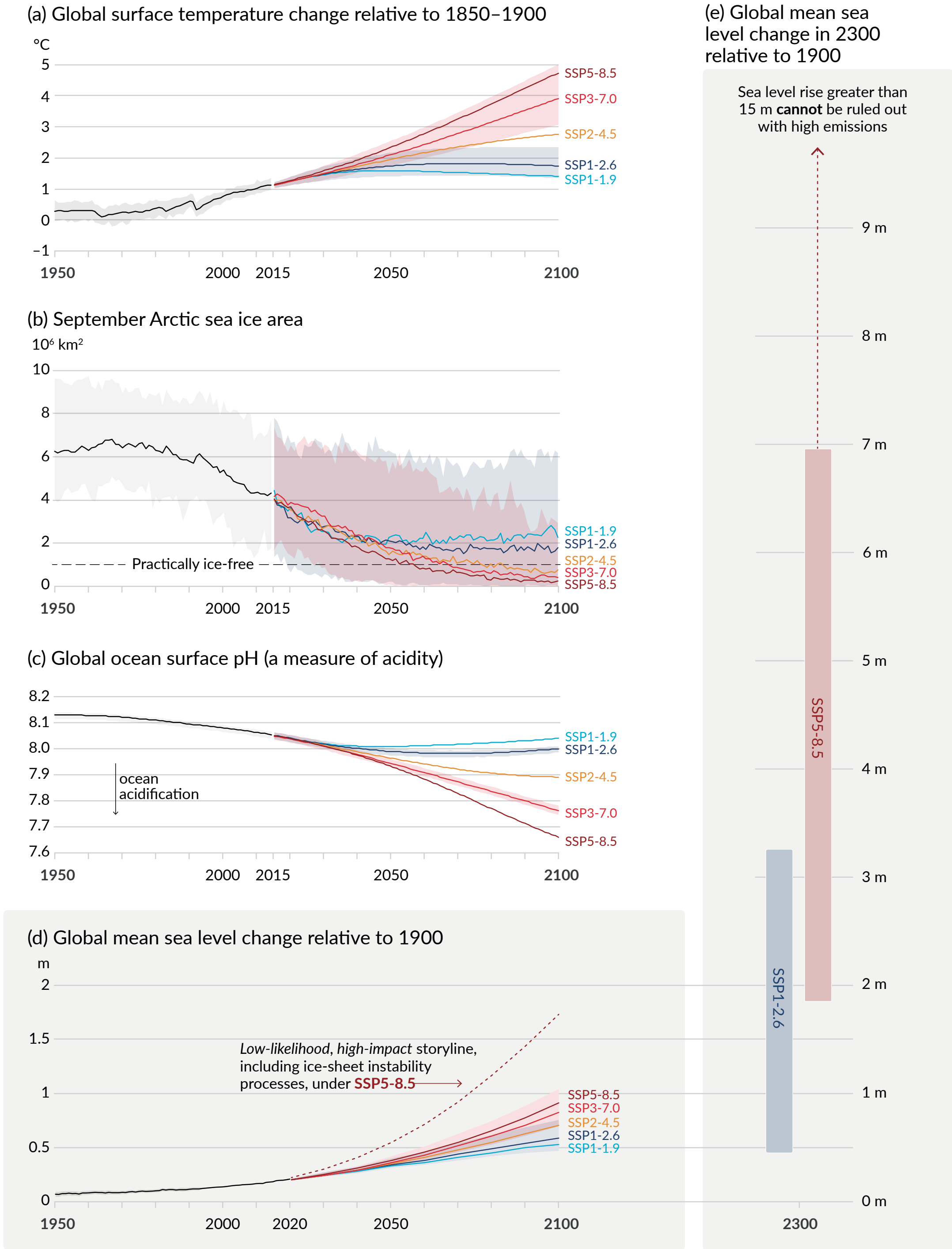

Figure 2.6: Possible futures for our climate (source: IPCC, 2021)

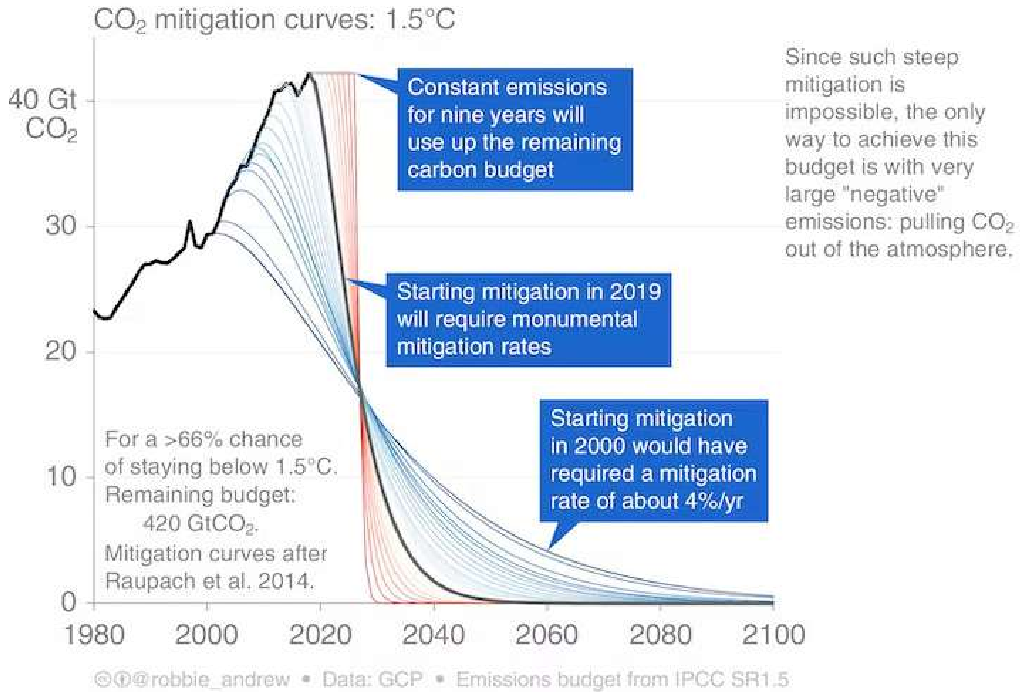

Figure 2.7: CO2 mitigation curves at 1.5°C (source: Ecorealities, 2018)

2.3 Knowledge about future climate change

2.3.1 Climate models

A climate model is a qualitative or quantitative representation of the climate system based on the physical, chemical, and biological properties of its components, their interactions and feedback processes, and accounting for some of its known properties. The climate system can be represented by models of varying complexity; that is, for any one component or combination of components, a spectrum or hierarchy of models can be identified, differing in such aspects as the number of spatial dimensions, the extent to which physical, chemical, or biological processes are explicitly represented, or the level at which empirical parametrizations are involved.

There is an evolution toward more complex models with interactive chemistry and biology. Climate models are applied as a research tool to study and simulate the climate and for operational purposes, including monthly, seasonal, and interannual climate predictions.

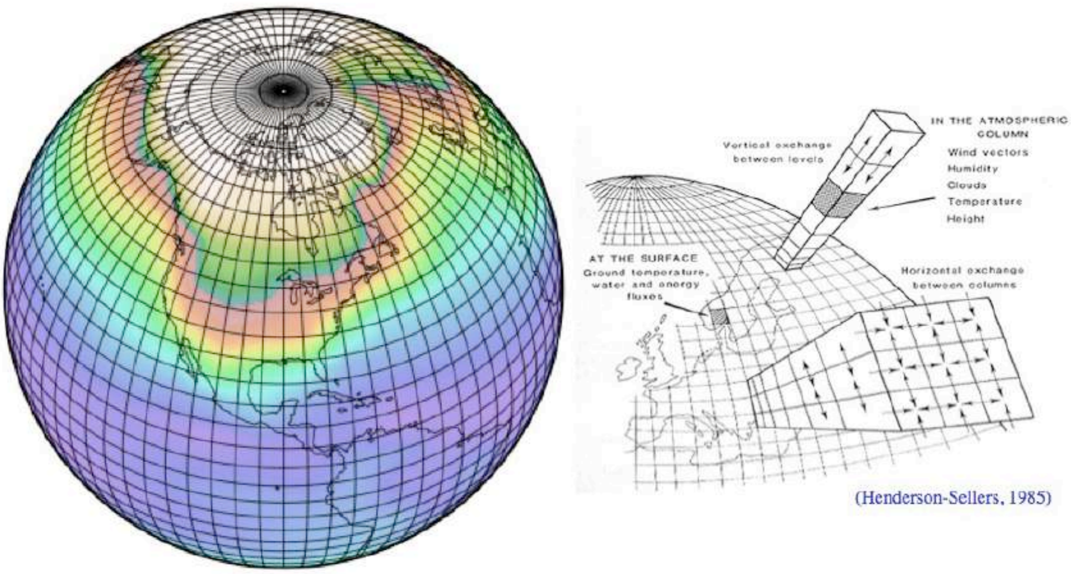

Figure 2.8: Three-dimensional general circulation model (GCM), and interactions and processes in each grid cell (Earth Exploration Toolbook, 2021)

2.3.2 Climate projection, climate prediction and weather forecast

Climate projections are the simulated responses of the climate system to a scenario of future emissions or concentrations of GHGs and aerosols and changes in land use, generally derived using climate models. Climate projections are distinguished from climate predictions by their dependence on the emission/concentration/radiative-forcing scenario used, which is in turn based on assumptions concerning, for example, future socio-economic and technological developments that may or may not be realized.

A climate prediction or climate forecast is the result of an attempt to produce (starting from a particular state of the climate system) an estimate of the actual evolution of the climate in the future – e.g., at seasonal, interannual, or decadal timescales. Because the future evolution of the climate system may be highly sensitive to initial conditions, has chaotic elements, and is subject to natural variability, such predictions are usually probabilistic in nature. While seasonal forecasts are routinely issued in some regions, climate predictions at longer timescales are still at an early research stage for example within the CMIP6 climate modeling community.

Basically, climate projections are distinguished from climate predictions in order to emphasize that climate projections depend on the emission/concentration/radiative-forcing scenario used and that they are based on assumptions which may or may not be realized and are therefore subject to substantial uncertainty not related to the climate system.

On the other hand, a weather forecast predicts the state of the atmosphere over a short period of time – for Europe usually up to about a week – and is dependent on the initial state of the atmosphere (and the upper ocean). This initial state is obtained by means of the global network of meteorological stations and observing systems.

2.3.3 Regional climate models

A regional climate model (RCM) is a climate model at higher resolution over a limited area. Such models are used in downscaling global climate results to specific regional domains. A regional climate scenario is a narrative used to describe how the future might unfold for a region. These are often used to understand impacts and guide adaptation efforts. They can include quantitative information that is based on scaled historical data or that is derived from internally consistent future climates based on a general circulation model (GCM).

An RCM is a tool for adding small-scale detailed information of future climate change to the large-scale projections of a GCM. RCMs are full climate models and, as such, are physically based and represent most or all of the processes, interactions, and feedbacks between the climate system components that are represented in GCMs. They take coarse resolution information from a GCM and then develop temporally and spatially fine-scale information, consistent with that from the GCM, using their higher resolution representation of the climate system. The typical resolution of an RCM is about 50 km in the horizontal, whereas GCMs are typically between 100 and 300 km.

Figure 2.9: **Right:** Providing Regional Climates for Impacts Studies (PRECIS) regional climate model; **left:** Coordinated Regional Climate Downscaling Experiment (CORDEX) modeling grid for the South Asia region (source: The Communication Initiative Network, 2012)

2.3.4 Climate scenario

A climate scenario is a plausible image of a future climate based on knowledge of the past climate and assumptions on future change (on increase of greenhouse gas (GHG) concentrations). They are constructed to estimate the impact of climate change. Usually they are constructed with the help of climate model information.

The terms "climate scenario" and "climate change scenario" are often used interchangeably. The term "climate change scenario" refers to a representation of the difference between the plausible future climate and the current or reference climate. A climate change scenario can be viewed as an interim step towards constructing a climate scenario. The scenarios should not be treated as predictions of what will happen in the future, since they are based on assumptions on increases in GHG concentrations (plausible does not mean that the scenario is probable).

Type of scenario	Description
Baseline scenario	A plausible representation of the future development of atmospheric concentrations of substances that are radiatively active (e.g., GHGs, aerosols, tropospheric ozone), plus human-induced land cover changes that can be radiatively active via albedo changes and that are often used as input to a climate model to compute climate projections.
Emissions scenario	A plausible representation of the future development of emissions of substances that are radiatively active (e.g., GHGs or aerosols), plus human-induced land cover changes that can be radiatively active via albedo changes, based on a coherent and internally consistent set of assumptions about driving forces (such as demographic and socio-economic development, technological change, and energy and land use) and their key relationships.

Table 2.1: Different types of climate scenario

2.3.5 Pathways

Pathways are the temporal evolution of natural and/or human systems toward a future state. Pathway concepts range from sets of quantitative and qualitative scenarios or narratives of potential futures to solution-oriented decision-making processes to achieve desirable societal goals. Pathway approaches typically focus on biophysical, techno-economic, and/or socio-behavioral trajectories and involve various dynamics, goals, and actors across different scales.

1.5°C pathway: A pathway of emissions of GHGs and other climate forcers that provides an approximately one-in-two to two-in-three chance, given current knowledge of the climate response, of global warming either remaining below 1.5°C or returning to 1.5°C by around 2100 following an overshoot.

2.3.6 Representative concentration pathways

Representative concentration pathways (RCPs) are scenarios that include time series of emissions and concentrations of the full suite of GHGs and aerosols and chemically active gases, as well as land use/land cover (Moss et al., 2010). The word "representative" signifies that each RCP provides only one of many possible scenarios that would lead to the specific radiative-forcing characteristics. The term "pathway" emphasizes that not only the long-term concentration levels are of interest, but also the trajectory taken over time to reach that outcome (Ibid.). RCPs usually refer to the portion of the concentration pathway extending up to 2100, for which integrated assessment models have produced corresponding emission scenarios. Extended concentration pathways describe extensions of the RCPs from 2100 to 2300 that have been calculated using simple rules generated by stakeholder consultations, and they do not represent fully consistent scenarios.

Four RCPs produced from integrated assessment models were selected from the published literature and are used in the IPCC's Fifth Assessment Report. Spanning a range from approximately below 2°C warming to high (>4°C) warming best-estimates by the end of the 21st century, these four (RCP2.6, RCP4.5, RCP6.0, RCP8.5) are presented in the following table for comparison.

RCP Type	Description
RCP2.6	A pathway where radiative forcing peaks at approximately 3 W m-2 and then declines to be limited at 2.6 W m-2 in 2100 (the corresponding Extended Concentration Pathway or ECP has constant emissions after 2100).
RCP4.5 and RCP6.0	Two intermediate stabilization pathways in which radiative forcing is limited at approximately 4.5 W m-2 and 6.0 W m-2 in 2100 (the corresponding ECPs have constant concentrations after 2150).
RCP8.5	A high pathway that leads to >8.5 W m-2 in 2100 (the corresponding ECP has constant emissions after 2100 until 2150 and constant concentrations after 2250).

Table 2.2: A brief overview of the four RCPs

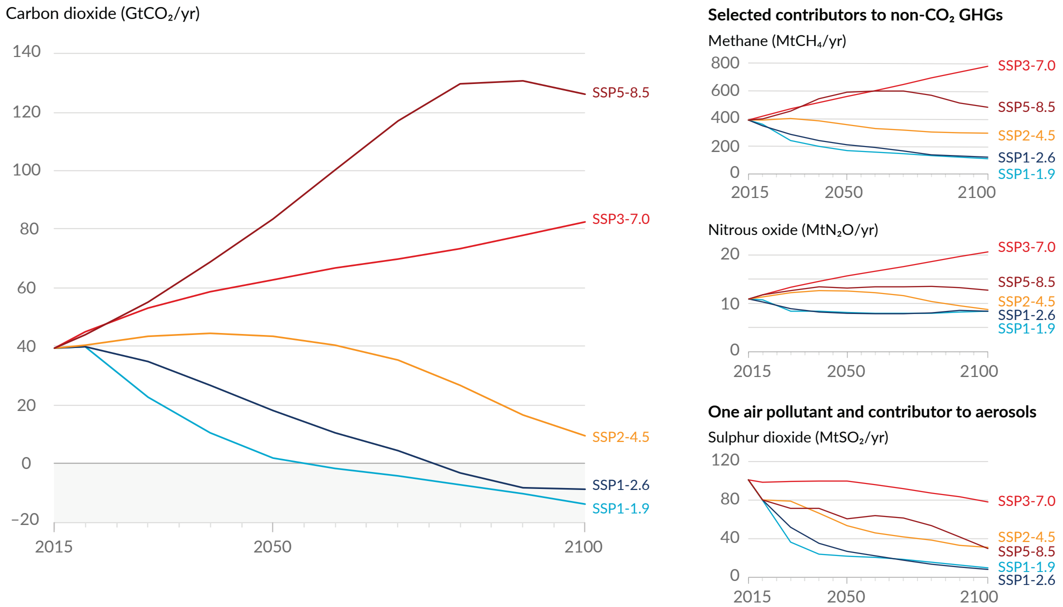

Figure 2.10: Future emissions of CO2 (left) and a subset of key non-CO2 drivers (right), across five illustrative scenarios (source: IPCC, 2021)

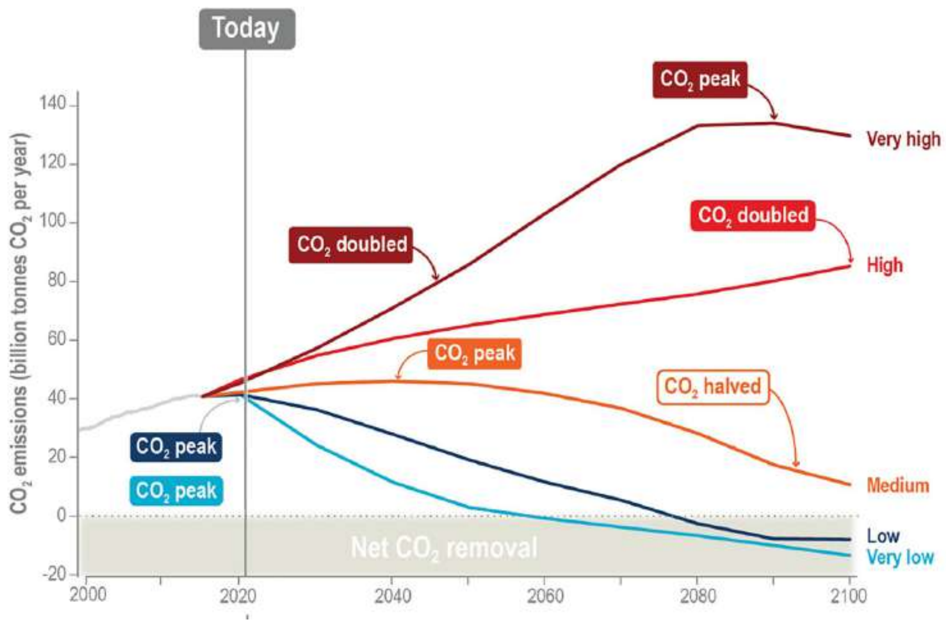

Figure 2.11: Future annual CO2 emissions (billion tonnes of CO2 per year) and their time to peak, doubling, or halving (source: IPCC, 2021)

2.3.7 Shared socio-economic pathways

Shared socio-economic pathways (SSPs) have been developed to complement the RCPs. By design, the RCP emission and concentration pathways were stripped of their association with a certain socio-economic development. Different levels of emissions and climate change along the dimension of the RCPs can hence be explored against the backdrop of different socio-economic development pathways (SSPs) on the other dimension in a matrix. This integrative SSP-RCP framework is now widely used in the climate impact and policy analysis literature (see, for example, http://iconics-ssp.org), where climate projections obtained under the RCP scenarios are analyzed against the backdrop of various SSPs.

As several emission updates were due, a new set of emission scenarios was developed in conjunction with the SSPs. Hence, the abbreviation SSP is now used for two things: On the one hand, SSP1, SSP2, SSP3, SSP4, and SSP5 are used to denote the five socio-economic scenario families. On the other hand, the abbreviations SSP1-1.9, SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5 are used to denote the newly developed emission scenarios that are the result of an SSP implementation within an integrated assessment model. These SSP scenarios are bare of climate policy assumption, but in combination with so-called shared policy assumptions, various approximate radiative-forcing levels of 1.9, 2.6, 4.5, 7.0, or 8.5 W m-2 are reached by the end of the century, respectively.

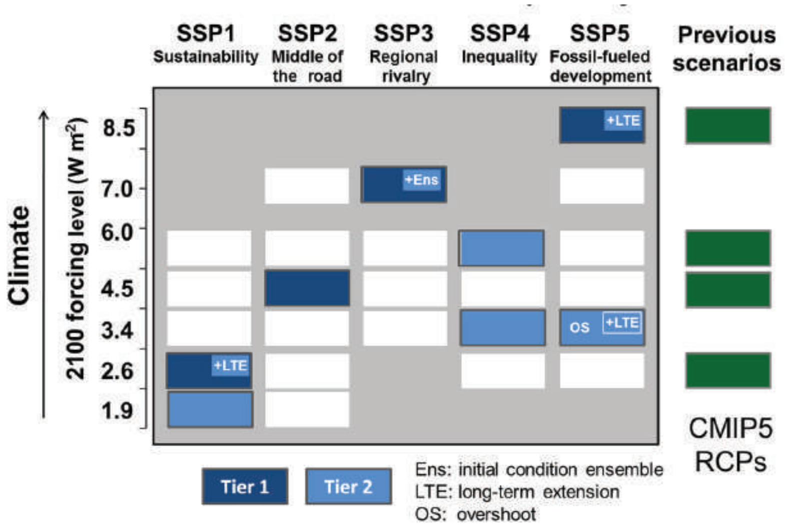

Figure 2.12: Shared socio-economic pathways (SSPs) and representative concentration pathways (RCPs) (source: O'Neill, 2016)

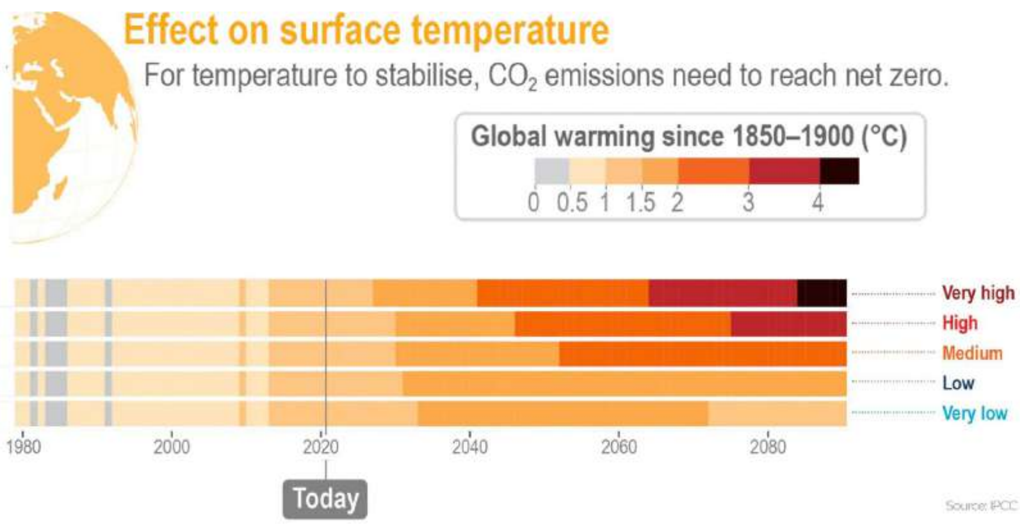

Figure 2.13: Effect on surface temperature of CO2 emissions since 1850 (source: IPCC, 2021)

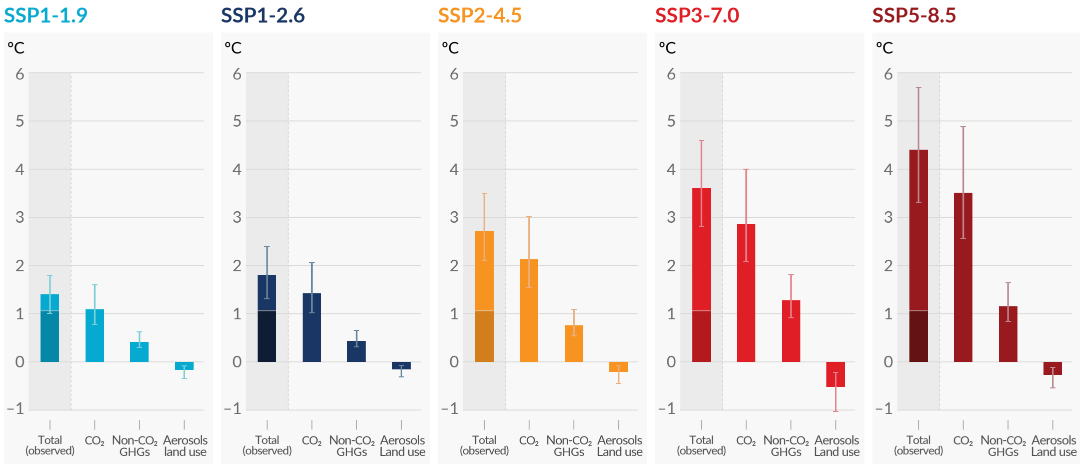

Figure 2.14: Change in global surface temperature in 2081–2100 relative to 1850–1900 (°C) (source: IPCC, 2021)

2.3.8 Radiative forcing

Radiative forcing is the change in the net, downward minus upward, radiative flux (expressed in W m-2) due to a change in an external driver of climate change, such as a change in the concentration of CO2, in the concentration of volcanic aerosols, or in the output of the sun. "Stratospherically adjusted radiative forcing" is computed with all tropospheric properties held fixed at their unperturbed values, and after allowing for stratospheric temperatures, if perturbed, to readjust to radiative-dynamical equilibrium. Radiative forcing is called "instantaneous" if no change in stratospheric temperature is accounted for. The radiative forcing once both stratospheric and tropospheric adjustments are accounted for is termed the "effective radiative forcing."

2.3.9 Climate sensitivity

Climate sensitivity refers to the amount of global surface warming that will occur in response to a doubling of atmospheric CO2 concentrations compared to pre-industrial levels. CO2 has increased from its pre-industrial level of 280 parts per million (ppm) to around 408 ppm today. Without actions to reduce emissions concentrations are likely to reach 560 ppm – double pre-industrial levels – around the year 2060. There are four main measures of climate sensitivity that scientists use which are described below

- Earth system sensitivity (ESS): The equilibrium surface temperature response of the coupled atmosphere-ocean-cryosphere-vegetation-carbon cycle system to a doubling of the atmospheric CO2 concentration. Because ESS allows ice sheets to adjust to the external perturbation, it may differ substantially from the equilibrium climate sensitivity derived from coupled atmosphere-ocean models.
- Equilibrium climate sensitivity: The equilibrium (steady-state) change in the surface temperature following a doubling of the atmospheric CO2 concentration from pre-industrial conditions.
- Transient climate response (TCR): The surface temperature response for the hypothetical scenario in which atmospheric CO2 increases at 1% yr-1 from pre-industrial conditions to the time of a doubling of atmospheric CO2 concentration (year 70).
- Transient climate response to cumulative CO2 emissions (TCRE): The transient surface temperature change per unit of cumulative CO2 emissions, usually 1,000 gigatonnes of carbon (GtC). TCRE combines information both on the airborne fraction of cumulative CO2 emissions (the fraction of the total CO2 emitted that remains in the atmosphere, which is determined by carbon cycle processes) and on the TCR. 2.3.10. Climate indicator, pattern, and velocity

2.3.10 Climate indicator, pattern, and velocity

Climate indicators are measures of the climate system including large-scale variables and climate proxies. Key indicators constitute a finite set of distinct variables that may collectively point to important overall changes in the climate system of broad societal relevance across the atmospheric, oceanic, cryospheric and biospheric domains, with land as an implicit cross-cutting theme. Taken together, these indicators would be expected to both have changed and continue to change in the future in a coherent and consistent manner.

Climate pattern is a set of spatially varying coefficients obtained by 'projection' (regression) of climate variables onto a climate index time series. When the climate index is a principal component, the climate pattern is an eigenvector of the covariance matrix, referred to as an empirical orthogonal function (EOF) in climate science.

Climate velocity The speed at which isolines of a specified climate variable travel across landscapes or seascapes due to changing climate. For example, climate velocity for temperature is the speed at which isotherms move due to changing climate (km yr−1) and is calculated as the temporal change in temperature (°C yr−1) divided by the current spatial gradient in temperature (°C km−1). It can be calculated using additional climate variables such as precipitation or can be based on the climatic niche of organisms.

2.3.11 Climate feedback

Climate feedback is an interaction in which a perturbation in one climate quantity causes a change in a second and the change in the second quantity ultimately leads to an additional change in the first. A negative feedback is one in which the initial perturbation is weakened by the changes it causes; a positive feedback is one in which the initial perturbation is enhanced. The initial perturbation can either be externally forced or arise as part of internal variability. See below a short description of different types of climate feedback.

albedo feedbackClimate–carbon cycle feedback: A climate feedback involving changes in the properties of land and ocean carbon cycles in response to climate change. In the ocean, changes in oceanic temperature and circulation could affect the atmosphere–ocean CO_2 flux. On the continents, climate change could affect plant photosynthesis and soil microbial respiration and hence the flux of CO_2 between the atmosphere and the land biosphere.

- Cloud feedback: A climate feedback involving changes in any of the properties of clouds as a response to a change in the local or global mean surface temperature. Understanding cloud feedbacks and determining their magnitude and sign require an understanding of how a change in climate may affect the spectrum of cloud types, the cloud fraction and height, the radiative properties of clouds and, finally, the Earth's radiation budget. At present, cloud feedbacks remain the largest source of uncertainty in climate sensitivity estimates.
- Ice-albedo feedback: A climate feedback involving changes in the Earth's surface albedo. Snow and ice have an albedo much higher (up to ~0.8) than the average planetary albedo (~0.3). With increasing temperatures, it is anticipated that snow and ice extent will decrease, thus the Earth's overall albedo will decrease and more solar radiation will be absorbed, warming the Earth.

Extreme weather events and climate impact factors

2.4 Climate extremes and climatic impact drivers

2.4.1 Climate extremes (extreme weather or climate events)

The occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable. By definition, the characteristics of what is called extreme weather may vary from place to place in an absolute sense. When a pattern of extreme weather persists for some time, such as a season, it may be classified as an extreme climate event, especially if it yields an average or total that is itself extreme (e.g., high temperature, drought, or heavy rainfall over a season). For simplicity, both extreme weather events and extreme climate events are referred to collectively as "climate extremes."

2.4.2 Climatic impact drivers

Climatic impact-drivers (CIDs) are physical climate system conditions (e.g., means, events, extremes) that affect an element of society or ecosystems. Depending on system tolerance, CIDs and their changes can be detrimental, beneficial, neutral, or a mixture of each across interacting system elements and regions.

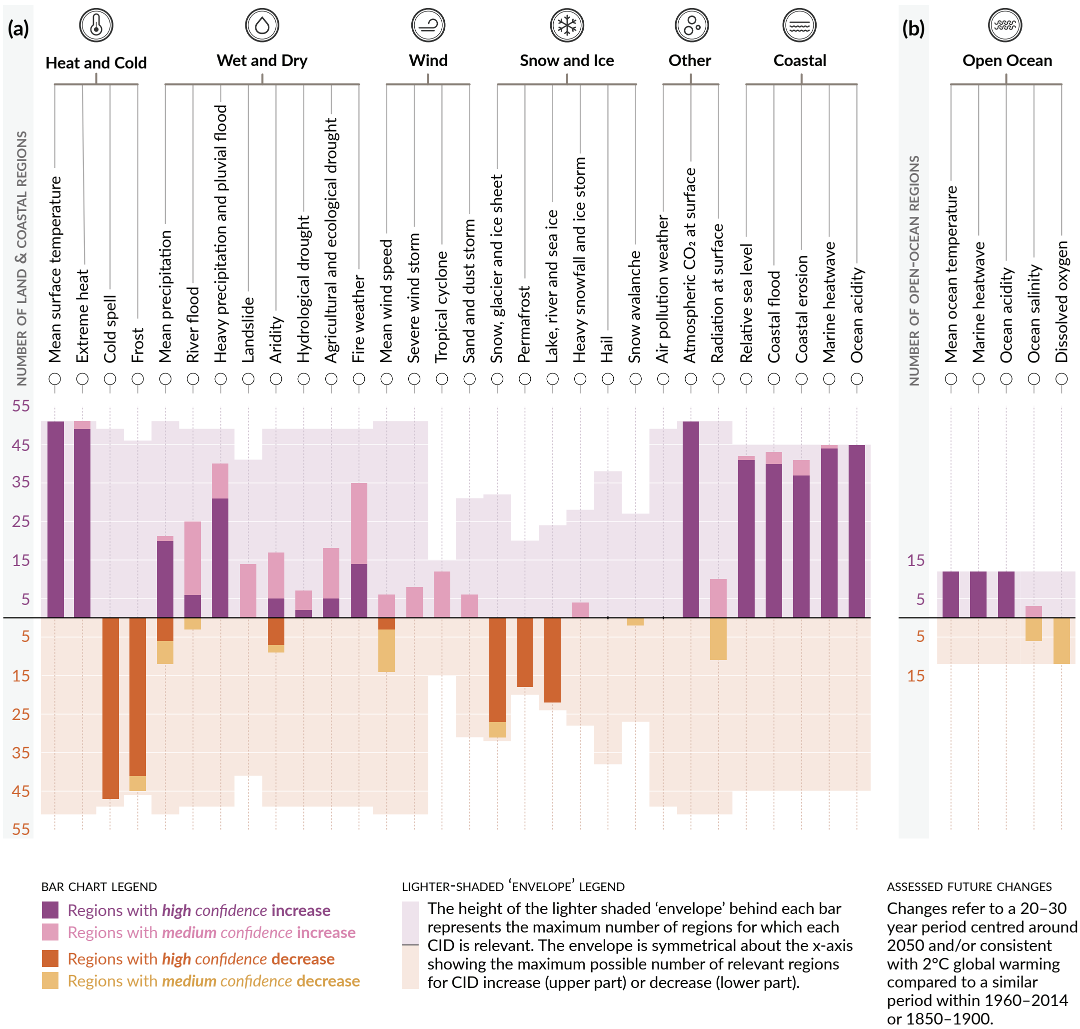

Figure 2.15: Changes in CIDs over a number of land and ocean regions (source: IPCC, 2021)

2.4.3. Drivers of climate change

We know that GHGs, aerosol emissions, and land use affect our climate. Overall, human activity is warming our planet. Climate change can affect our climate system in lots of different ways. Among other impacts, it gives rise to (i) changes in the hydrological cycle, (ii) warmer land and air, (iii) warming oceans and melting ice, (iv) rising sea levels, (v) ocean acidification, (vi) global greening (i.e., increased vegetation growth in recent decades, which has a strong cooling effect on the land due to the increased efficiency of heat and water vapor transfer to the atmosphere), (vii) changes in ocean currents, and (viii) more extreme weather.

Climate change can also affect people and ecosystems. For example, human activity –from releasing GHGs and aerosols into the atmosphere to changing land use – is the main driver of climate change. This has a range of impacts on the climate system, ecosystems, and people. Changes to the climate system include the following:

- Rising ocean levels: Rising temperatures are causing glaciers and ice sheets to melt, adding more water to the oceans and causing the ocean level to rise. Oceans absorb 90% of the extra heat from global warming: warmer water expands, and so our oceans are taking up more space.
- Ocean acidification: This occurs when the ocean absorbs carbon dioxide and becomes more acidic. It is often called the "evil twin" of climate change.
- Extreme weather events: Climate change is causing many extreme weather events to become more intense and frequent, such as heatwaves, droughts, and floods.
- Flooding of coastal regions: Coastal cities are at risk of flooding as sea levels continue to rise.
- Food insecurity: High temperatures, extreme weather events, flooding, and droughts can damage farmland. This makes it difficult for farmers to grow crops and means that their yield of crops each year is uncertain.
- Conflict and climate migrants: Climate change is a stress multiplier – it can take existing problems, such as lack of food or shelter, and make them worse. This can cause people to fight over resources (food, water, and shelter) or to migrate.
- Damage to marine ecosystems: Rising ocean temperatures, ocean acidification, and ocean anoxia (lack of oxygen) are damaging to marine life such as fish and coral reefs.

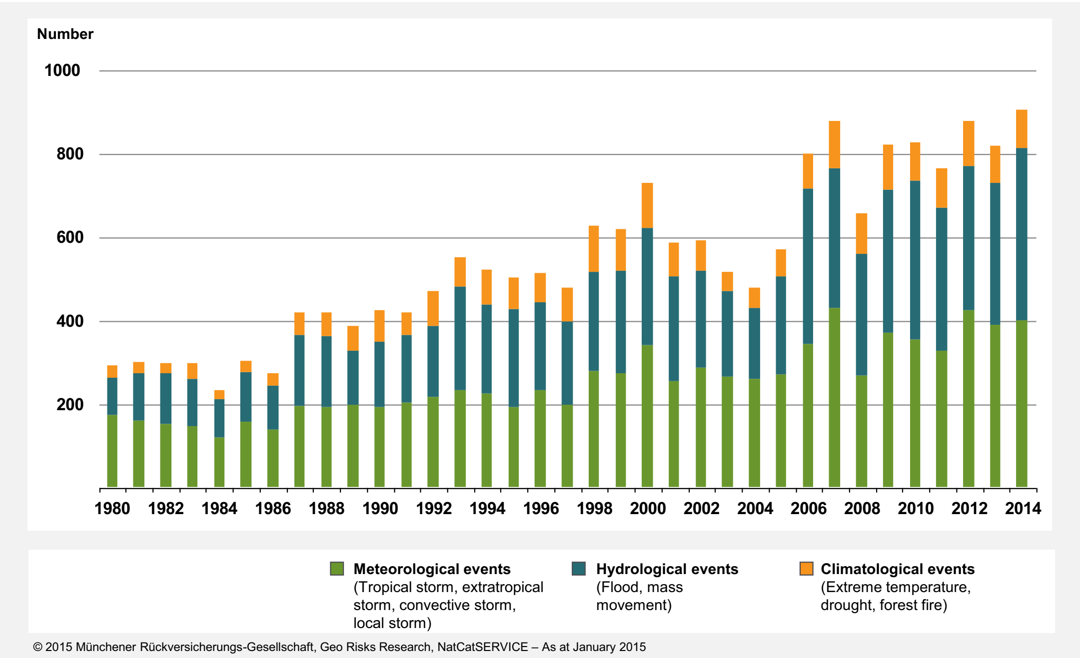

Figure 2.16: Number of loss events from 1980 to 2016 (source: Hoeppe, 2016)

Figure 2.17: Change in the frequency of extreme temperature, drought, heavy precipitation, snow cover, and proportion of tropical cyclones (source: IPCC, 2021)

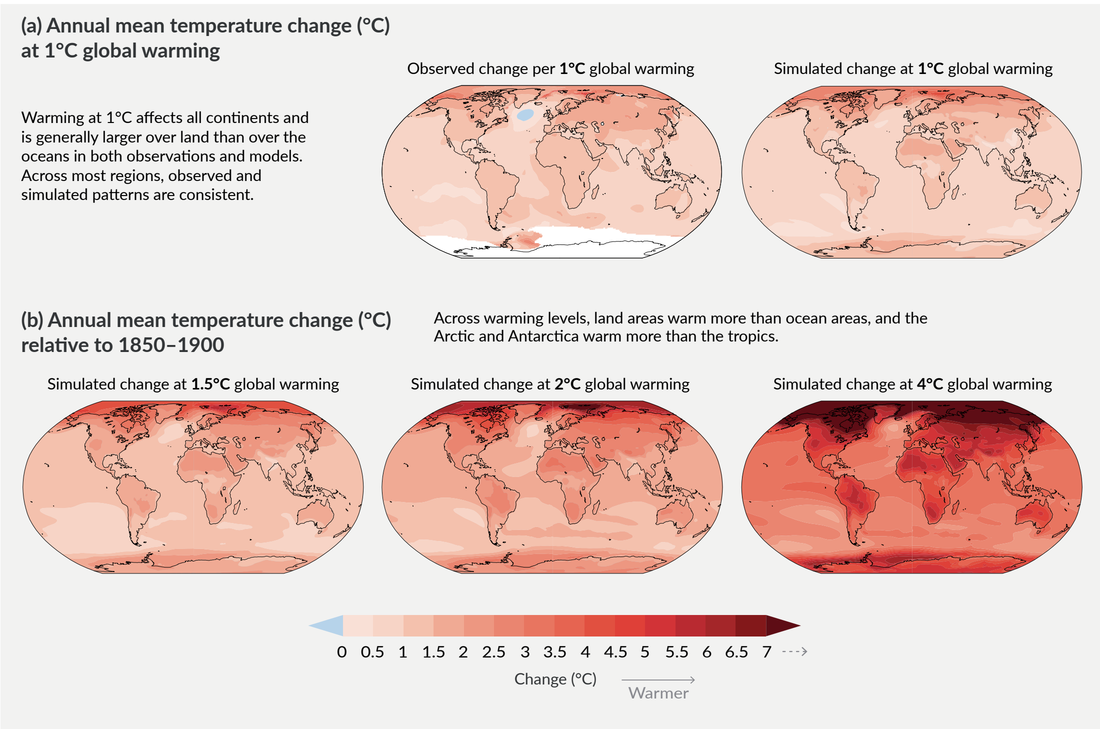

Figure 2.18: Annual mean temperature change in °C (a) at 1°C global warming and (b) relative to 1850–1900 (source: IPCC, 2021)

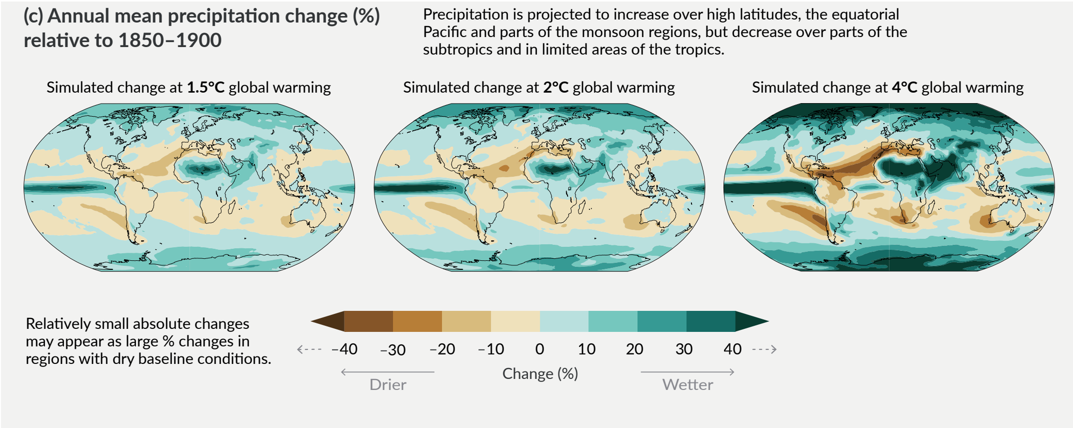

Figure 2.19: Annual mean precipitation change (%) relative to 1850–1900 (source: IPCC, 2021)

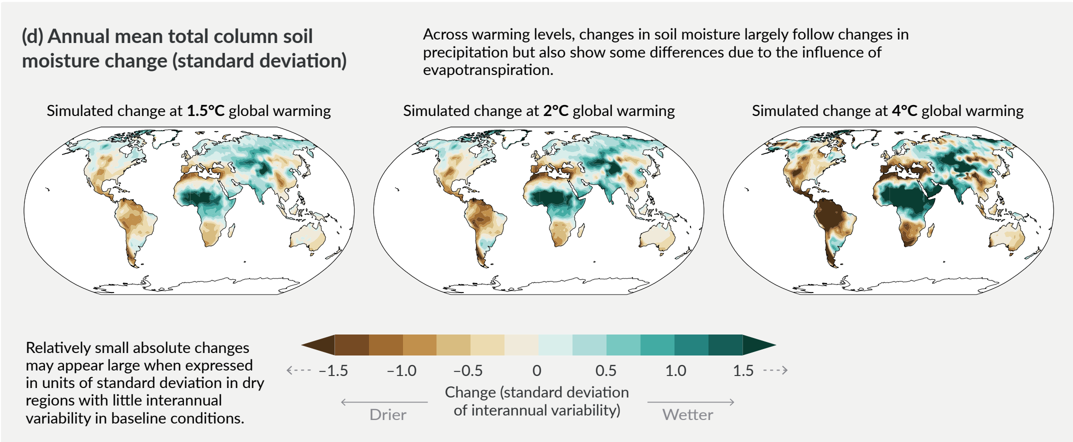

Figure 2.20: Annual mean total column soil moisture change (standard deviation of interannual variability) at 1.5°C, 2°C, and 4°C of global warming (source: IPCC, 2021)

Climate change projection for Bangladesh

2.5 Climate change projection

2.5.1 Climate change projections at specific warming levels

Using the strongest climate science to date, the research project High-End Climate Impacts and Extremes (HELIX) has assessed and modeled future changes to the climate in Bangladesh to the end of this century. The projections are intended to give the Bangladesh government and other organizations evidence to help them make informed, cost-effective, and timely decisions to prepare for the changing climate. They are created to be used by people working in all sorts of organizations in Bangladesh.

2.5.2 Temperature and precipitation

Of the 11 regional climate models consulted, all show that the average Bangladesh summer temperature is likely to rise by 3.24–5.77°C by the 2080s (Fahad et al., 2017). While there is always uncertainty, there is no doubt that the temperature will increase in future, and greater warming is expected in Bangladesh. The south-west and the south-central part of the country are projected to experience a greater temperature rise in future, and a 12% increase in mean rainfall is projected.

The models consulted also describe possible changes in rainfall both temporally and spatially. They project that Bangladesh is facing an increase in precipitation of up to around 12% during the 2020s, 20% by 2050s, and up to 25% during the 2080s. Brahmanbaria, Dinajpur, Nilphamari, and Rangpur districts are projected to be subject to particularly high increases in precipitation during the 2020s and 2050s.. . But rainfall will decrease by up to 8.22% over the south-west of Bangladesh (Fahad et al., 2017). Figure 2.21a below displays the spatial distribution and percentage change in cold nights (TN10p), warm nights (TN90p), cold days (TX10p), warm days (TX90p), and Figure 2.21b shows the spatial distribution and percentage change in extremely wet days (R99p), total wet day precipitation (PRCPTOT), consecutive wet days (CWD), and consecutive dry days (CDD) (Khan et al., 2020).

Index	Definition	Units
TN90p	Percentage of days when TN > 90^{th} percentile	% Days
TX90p	Percentage of days when TN > 90^{th} percentile	% Days
TX10p	Percentage of days when TN < 10^{th} percentile	% Days
TX10p	Percentage of days when TN < 10^{th} percentile	% Days
TXn	Monthly minimum value of daily maximum temperature	°C

Index	Definition	Units
CDD	Maximum number of consecutive days with RR < 1mm	Days
CWD	Maximum number of consecutive days with RR >= 1mm	Days
R10	Annual count of days when PRCP >= 10mm	Days
R20	Annual count of days when PRCP >= 20mm	Days
R95p	Annual total PRCP when RR>95^{th} percentile	mm
R99p	Annual total PRCP when RR>99^{th} percentile	mm
PRCPTOT	Annual total PRCP in wet days (RR >=1 mm)	mm
RX1	Monthly maximum 1-day precipitation	mm
RX5	Monthly maximum consecutive 5 -day precipitation	mm

Table 2.3: Climate change detection and indices: extreme climate indices related to temperature and precipitation (Source: Helix, 2021)

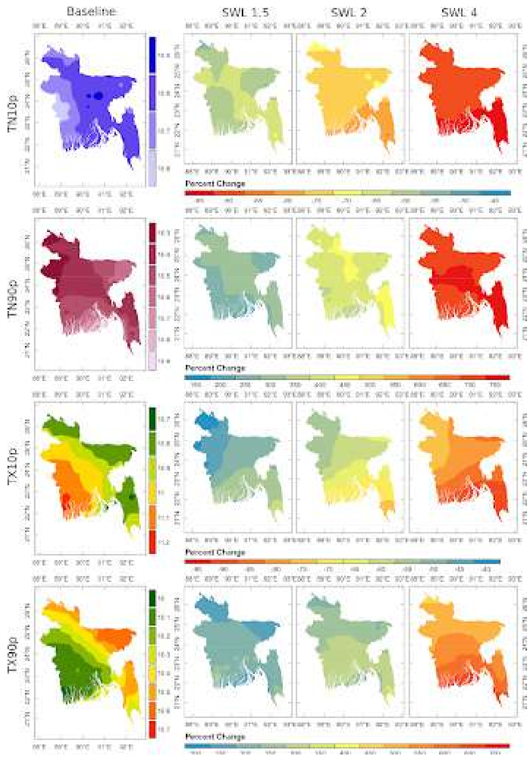

Figure 2.21a: Spatial distribution and percentage change in cold nights (TN10p), warm nights (TN90p), cold days (TX10p), and warm days (TX90p) (source: Khan et al., 2020)

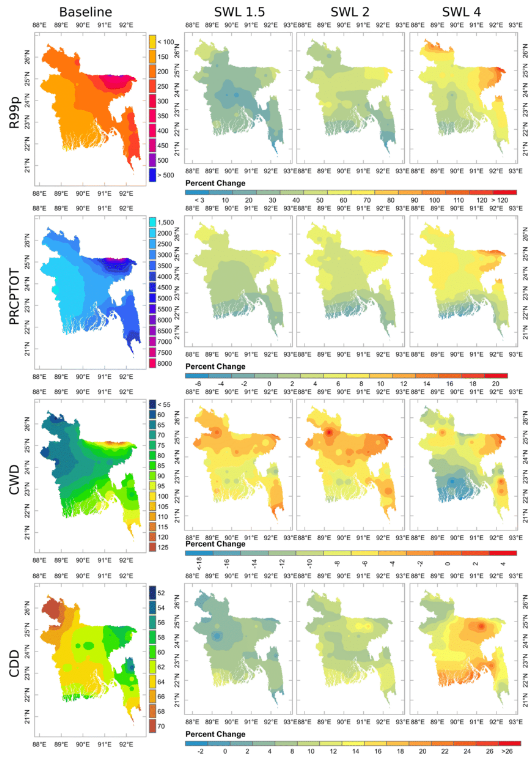

Figure 2.21b: Spatial distribution and percentage change in extremely wet days (R99p), total wet day precipitation (PRCPTOT), consecutive wet days (CWDs), and consecutive dry days (CDDs) (source: ibid.)

2.5.3 Sea level rise and inundation

The projections for inundation patterns are based on the projected sea level rises and considering existing polders with an average height of 4.53 m above mean sea level. Under the high-end climate scenario, RCP 8.5, the mean rise in sea level estimated for the Bangladesh coast varies from 0.50 m to 1.00 m and in extreme cases (by considering subsidence and rapid collapse of Antarctica ice sheets) by up to 1.50 m, with the percentage of coastal area inundated to be 4.3%, 8.4%, and 11.30% respectively (see Figure 2.22). The inundations of the Sundarbans mangrove area in Bangladesh due to sea level rise are expected to be 12% for a rise of 0.50 m, 43% for 1.00 m, and 60% for 1.50 m (see Figure 2.22). It is not possible to align particular magnitudes of sea level rise with specific levels of global warming since the full response of sea levels to warming is much slower, in the order of centuries.

2.5.4 Extreme weather events and flooding

Extreme weather events are likely to become more common as our climate changes. Both the high flows and low flows for the Brahmaputra, Ganges, and Meghna rivers are projected to increase. Percentage changes in the variation of high flows and low flows for the Brahmaputra are projected respectively to be 4% and 3% for 1.5°C, 5% and 10% for 2°C, and 22% and 22% for 4°C, as shown in Figure 2.23 below (Mohammed et al., 2017. The frequencies and intensities of extreme floods are to increase, leading to high water levels, inundation, and flooding all over the country, with a few hotspots and specific areas of the country particularly affected. Flash floods or early monsoon floods might increase in haor areas and some border areas due to heavy non-time occurrence of rainfall. The monsoon, however, will be wetter and flood-generating. At the same time, we must also remain prepared for natural variability in Bangladesh's weather, so for both hot summers and cold winters.

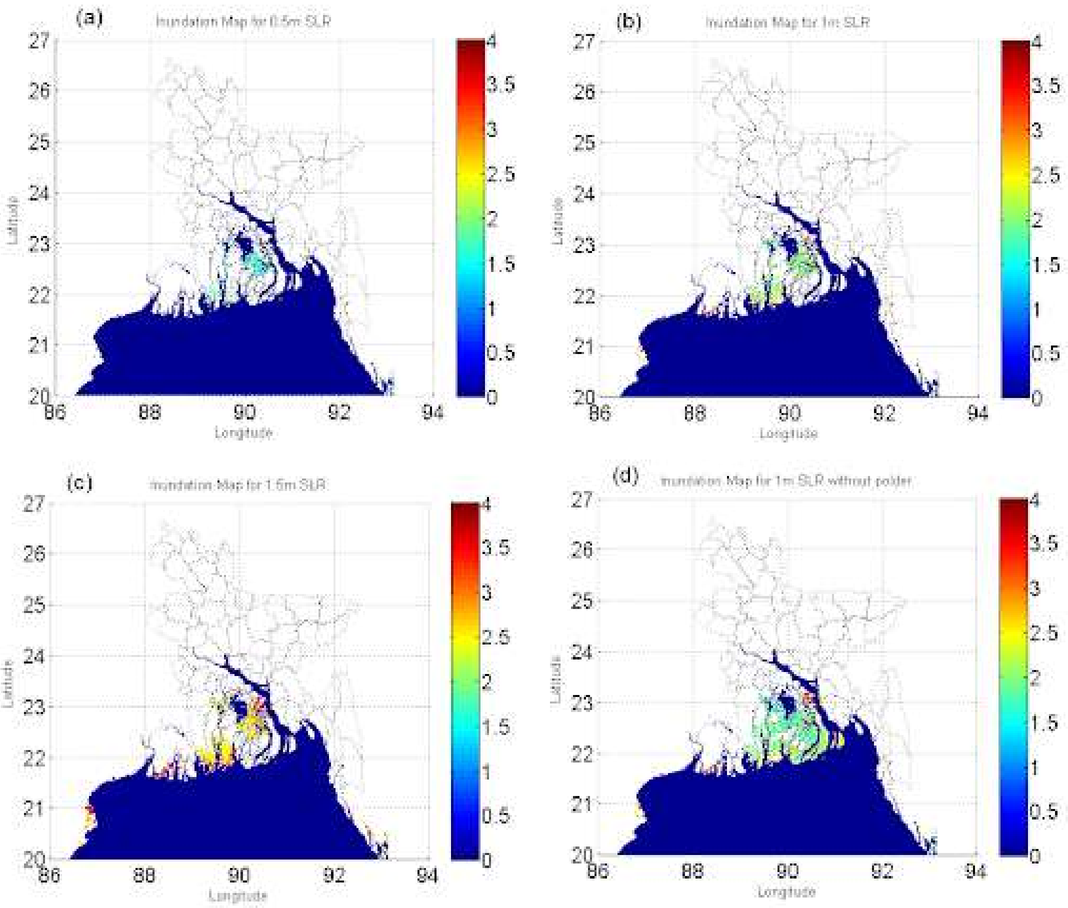

Figure 2.22: Inundation map for a mean sea level rise (SLR) of (a) 0.5 m, (b) 1.0 m, and (c) 1.5 m, as well as (d) 1.0 m without polder (source: Rahman, 2019)

Figure 2.23 below shows the return period curves of (a) extreme precipitation, (b) maximum discharge, and (c) minimum discharge. The shaded regions show the range of values estimated by the 11 climate projections. The solid lines between the shaded areas show the mean of the ensemble ranges:

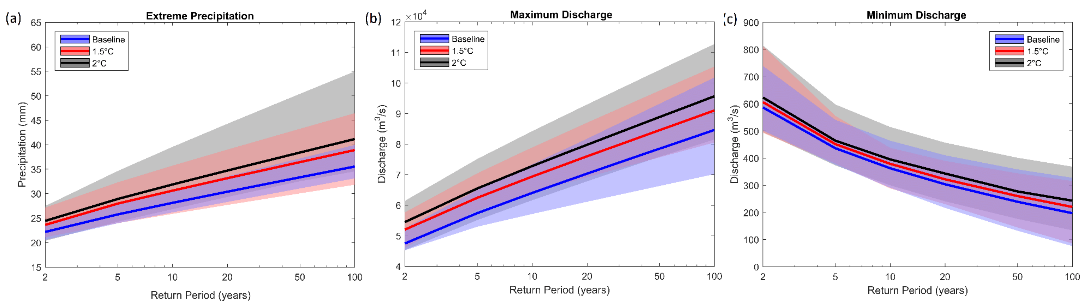

Figure 2.23: Return period curves of (a) extreme precipitation, (b) maximum discharge, and (c) minimum discharge (source: Mohammed et al., 2017)

2.5.5 Agriculture

Bangladesh's yield trends in terms of boro and aman rice are projected to gradually decrease by between 2% and 15% at a specific warming level of 1.5°C; 5% and 20% at a specific warming level of 2°C; and 5% and 25% at a specific warming level of 4°C (Bala et al. 2022)The boro crop will experience these impacts more than will the aman crop. The districts of Sylhet, Sunamganj, Moulvibazar, and Hobiganj are to experience crop loss of 2% at a specific warming level of 1.5°C, 2% at a specific warming level of 2°C, and 7% at a specific warming level of

4°C. The southern region of the country is projected to experience boro and aman rice crop yield losses of 8–10% at a specific warming level of 1.5°C, 8–10% at a specific warming level of 2°C, and 10–12% at a specific warming level of 4°C. The south-central region of Bangladesh's coastal zone is projected to suffer boro and aman rice yield losses of 10–12% at a specific warming level of 1.5°C, 18–21% at a specific warming level of 2°C, and 21–28% at a specific warming level of 4°C. The northern region of Bangladesh is to suffer boro and aman rice yield losses of 4% at a specific warming level of 1.5°C, 4% at a specific warming level of 2°C, and 10% at a specific warming level of 4°C. Overall, due to the warming that will occur in Bangladesh, agriculture throughout the whole country will see losses in food production.

The effects that climate change will have on Bangladesh's economy, infrastructure, society, and environment will vary from place to place throughout the country. The severity of these impacts will depend on how well the country plans for and adapts to the changing climate.

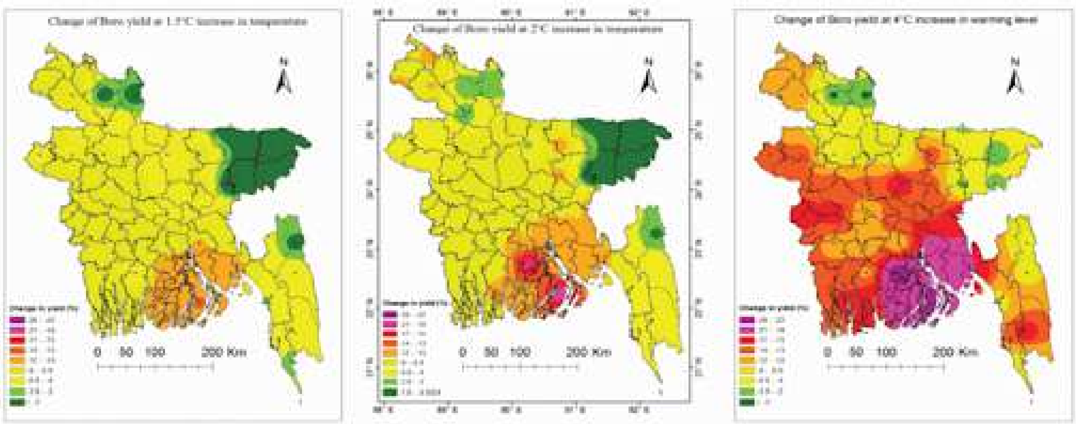

Figure 2.24: Spatial distribution of the changes in boro yields at the specific warming levels of (left) 1.5°C, (center) 2°C, and (right) 4°C (Khan et al., 2020)

Assessment of climate change vulnerability and risks

2.6 Vulnerability and risk assessment

2.6.1 How exposure and vulnerability translate into climate-related risks and impacts

Determining the impacts of climate change depends not only on the nature of changes in the climate, but also on the characteristics and vulnerability of the places and people that experience those changes. The major theoretical and conceptual frameworks of risk and vulnerability as well as the common approaches that have proved successful in understanding climate change vulnerability and risks have been developed for many places. It is now crucial to translate these frameworks and best practice guidelines into practical guidance and recommendations on how best to approach vulnerability assessments.

The risks (or opportunities) posed by climate change are dependent on the interaction of climate-related hazards with the vulnerability and exposure of both human and natural systems as well as their ability to adapt (Field et al., 2014). Risks are considered key when there is a high probability of a hazard occurring or a high vulnerability of the systems exposed (or both), and for which the ability to adapt is severely constrained.. It is also an improvement on previous IPCC frameworks, such as that presented in the Panel's *Fourth Assessment Report*, as it recognizes vulnerability as a dynamic and multidimensional concept where risks are the result of complex interactions among societies/communities, ecosystems, and the hazards arising from climate change. Climate change is not viewed as the risk, but rather the interaction of climatic changes with related hazards and evolving vulnerability and exposure of systems which determines the changing level of risk (Field et al., 2014). Furthermore, vulnerability is context- and location-specific and should be framed within the social, economic, political, and cultural realities of those locations (Vogel and O'Brien, 2004). Vulnerability is expressed differently at different scales: from the individual to the household, to the surrounding community, and to the broader national-level scale (Cutter, 2003).

Figure 2.25 below shows the vulnerability assessment framework taken from the IPCC's special report on *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX)*. Here, we can see that the risk of climate-related impacts results from the interaction of the climate-related hazards with the vulnerability and exposure of human and natural systems.

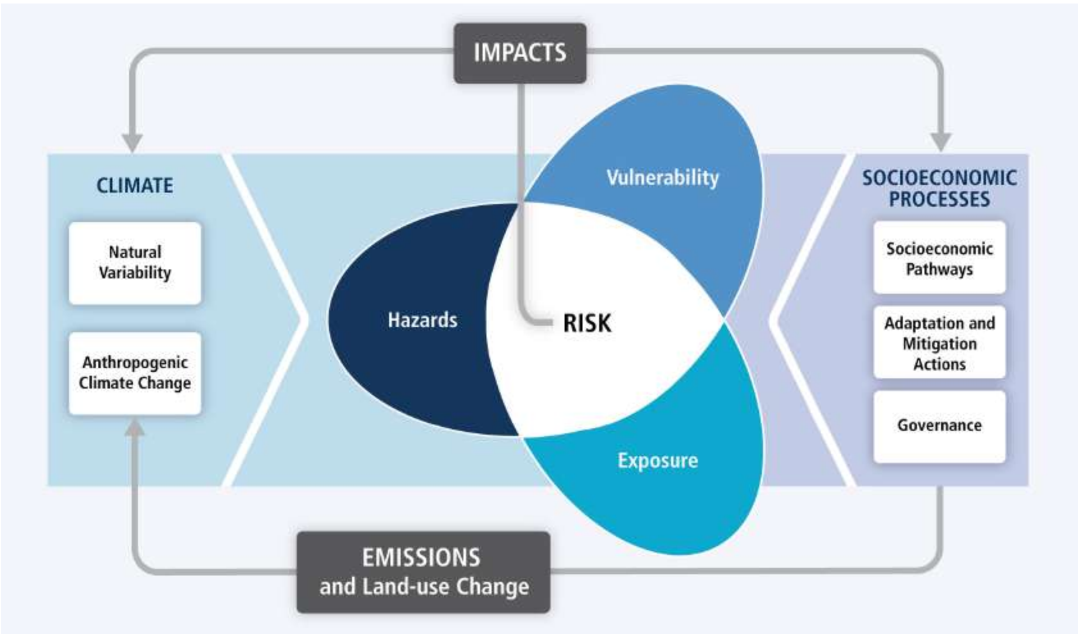

Figure 2.25: The SREX vulnerability assessment framework (Field et al., 2014)

Box 2.3 Gender and vulnerable population aspects of climate vulnerability

a. Women are not well represented in decision-making processes, which constrains their ability to meaningfully participate in decisions on adaptation and mitigation.
b. A global gender gap in earnings and productivity persists across all forms of economic activity; women make between 30% and 80% of male annual income. Restricting job opportunities for women has been costing the region approximately USD 44 billion a year.
c. A study by the Organization for Economic Co-operation and Development classified women's access to land as "very limited" in a number of countries within the Asia-Pacific region.
d. For those developing countries globally for which data was available, only between 10% and 20% of all landholders are women.
e. Burning biomass fuel indoors leads to two million deaths per year (mainly women and children)
f. In 2007 the estimated number of women and girl children who were "missing" – the number of excess female deaths – was 484,000 in Asia (excluding central Asia). Globally, 3.9 million women and girls go "missing" each year.
g. During the past decade in the Asia-Pacific region, an annual average of more than 200 million people were affected and more than 70,000 killed by natural disasters (90% and 65% respectively of global totals for natural disasters). Women and children make up the majority of deaths resulting from water-related disasters.

2.6.2 Common approaches to vulnerability assessments

Vulnerability assessments are the most commonly used tools for identifying, quantifying, and prioritizing key risks of a system to climate change (O'Brien et al., 2009). Vulnerability assessments are often considered prerequisites for the construction of adaptation strategies and policies as they provide information on the circumstances that create risk and the factors that would improve the resilience of the system to respond to those risks. Defining criteria for quantifying vulnerability has proven difficult, but several measures of vulnerability have been developed and applied. These include proxy- or indicator-based approaches, methodologies based on models and geographic information systems (GIS), participatory and multi-stressor approaches, with elements of these different approaches and methods often being used in combination.

2.6.3 Vulnerability of coastal Bangladesh

Coastal Bangladesh is one of the hotspots of climatic variability. Here, climate change impacts are already being felt by the coastal community, which is largely made up of the poorer sections of society. An assessment of the vulnerability of coastal Bangladesh due to climate change considering future (2050) climatic change was carried out through a collaboration of the HELIX project and the Institute of Water and Flood Management at the Bangladesh University of Engineering and Technology. The concepts of exposure, sensitivity, and adaptive capacity were applied in the analysis of both the present and future (2050) scenarios of vulnerability under the changing climate of the coastal belt.

Composite vulnerability indexes, developed through a translation of numerical values, demonstrate the severity of future vulnerability due to climate change. They show the severe future vulnerability (2050) of coastal upazilas (sub-districts) due to climate change increasing ten-fold, from 9 coastal upazilas to 93. In Bangladesh there are 140 coastal upazilas. Therefore, almost the entire coastal belt would be heavily exposed to high vulnerability. Similarly, the number of coastal upazilas with moderate and low vulnerability in the present scenario, 69 and 62 respectively, reduces substantially under the future scenario to 26 and 21 respectively.

Figure 2.26 below shows the area selected for the analysis, which comprises 19 coastal districts made up of 140 upazilas. Figure 2.27 shows the five sensitivity indicators, seven exposure indicators, and 19 adaptive-capacity indicators that were used in the study. A principal component analysis was conducted to determine weight of the indices.

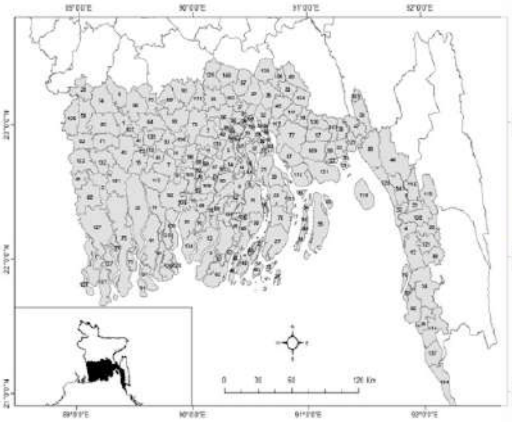

Figure 2.26: The 140 upazilas included in the study area (source: Uddin et al., 2019)

Figure 2.27: The range of indicators used in the study (source: ibid.)

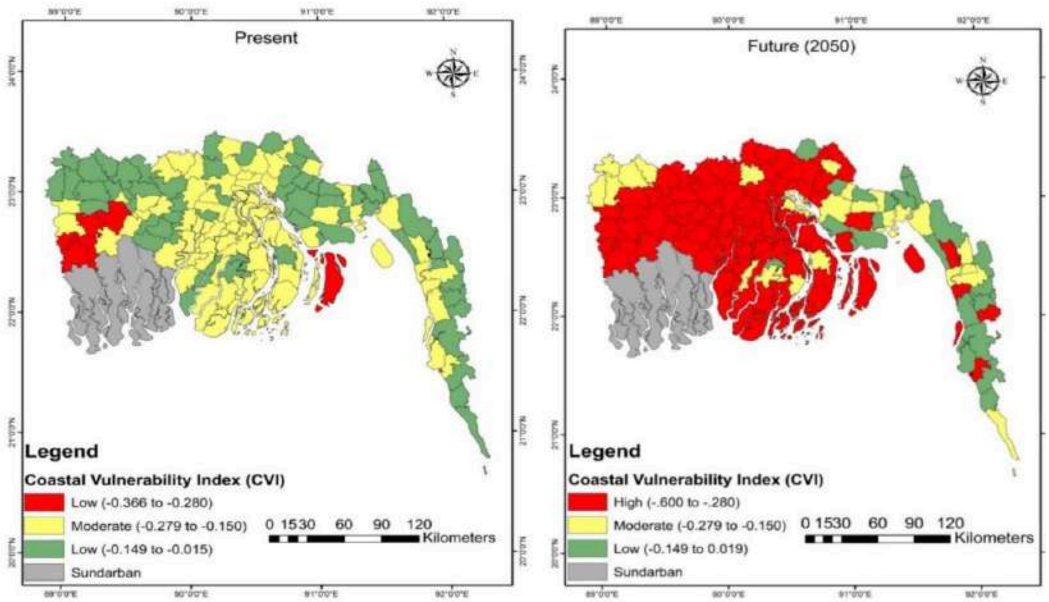

Figure 2.28: Climate vulnerability index (CVI) for (a) present and (b) future (2050) scenarios (source: Author's Own Work)

2.6.4 Climate risk assessment as the foundation for effective climate risk management

To foster long-term resilience, it is paramount to develop locally appropriate, effective, efficient, and practicable climate risk management (CRM) frameworks to avert, minimize, and address losses and damages. Climate risk assessment (CRA) builds the foundation for this. CRAs assess risks and the magnitude of impacts on people, assets, settlements, (critical) infrastructure, value chains, and ecosystems, and they identify suitable solutions. They support decision-makers from the public and private sectors in their forward-looking planning. Recognizing the usefulness of CRAs in the context of development cooperation, the GIZ Global Programme on Risk Assessment and Management for Adaptation to Climate Change (Loss and Damage) (GP L&D), in cooperation with research and practice, has developed a six-step methodology for CRA which is presented below.

Important features of GIZ's six-step CRA methodology include the following:

- The participation of stakeholders in the risk assessment process, which is fundamental to increase awareness and understanding of risks. This will contribute to informed and effective decision-making as well as to the implementation of required CRM measures.
- The matching of information needs with a customized methodology that utilizes various and appropriate methods and tools.
- The assessment of climate risks triggered by the entire spectrum of hazards, from slow-onset processes to extreme weather events.
- The estimation of the risk-tolerance levels of the concerned system (e.g., vulnerable households).
- The identification of a smart mix of risk management measures (e.g., from a range of tried-and-tested climate change adaptation and disaster risk reduction measures including risk finance and insurance schemes).
- Consideration of non-economic losses and damages beyond the evaluation of economic losses and damages.
- The integration of results into a CRM framework that encompasses monitoring and evaluation and supports continuous learning.

Box 2.4. Gender-responsive Climate Risk Assessment (CRA) as part of CRM

Gender-responsive CRA and CRM approaches address vulnerability to and adaptation options for the impacts of climate change based on methodologies that take gender differential priorities, barriers, opportunities, and capacities of both women and men into account. These include the use of gender statistics, gender analyses, and vulnerability assessments, as well as gender-sensitive guidelines and tools for adaptation. However, gender-responsive CRA and CRM goes beyond identifying the vulnerabilities to climate change created by gender norms and applying adequate measures to raise overall resilience. By systematically including key stakeholders in the planning and implementation process of CRM tools, it aims to empower vulnerable groups so they can take active steps to address, minimize, and avert current and future loss and damage and shift unequal power relations. In this context, it is of the utmost importance to work with marginalized groups, such as gender minorities, as part of the larger community in order to "make their vulnerability and capacities tangible and to have them recognized by others.

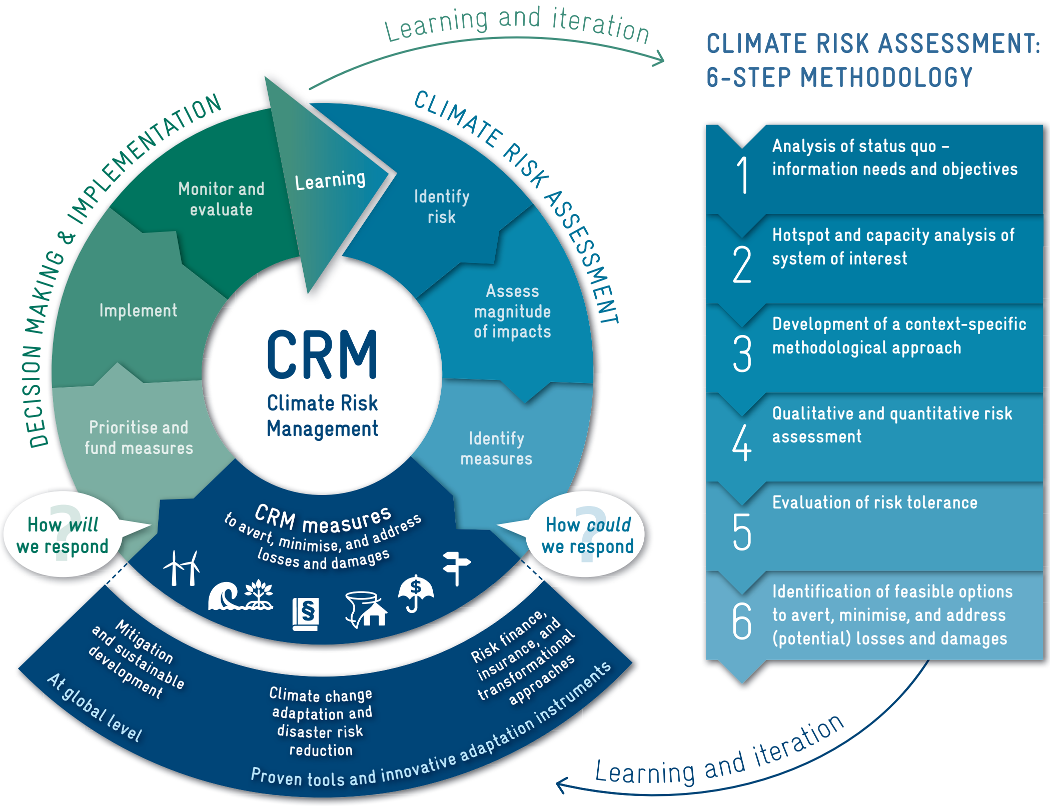

Figure 2.29: GIZ's CRM framework, with the six-step CRA methodology as a main component (source: Mechler et al., 2021)

Step	Guiding Questions	Expected Outcomes	Tools, Methods, Sources
1. Analysis of Status Quo-Information Needs and Objectives.	What is the current state of knowledge? • Which are the relevant institutions to collect necessary data and have mandate to lead the CRA as part of CRM? • Which studies and data already exist? • Which policy frameworks and operating procedures already exist with regard to CRA and CRM? • What are possible regions and sectors of interest in the area? • How can Duplication of efforts be avoided?	• Context profiling: overview of climate (change) risks, other disaster risks, socio-economic data, and institutional set-up • Mapping of relevant stakeholders to be included in the assessment • Analysis of existing policy frameworks, rules, and regulations regarding climate risks and risk management • Identification of potential systems of interest which may include sectors, specific regions, or population groups.	• Literature and policy review • Stakeholder identification and consultation
2. Hotspot and Capacity Analysis of System of Interest	What region and sector are we looking at? • Which sectors and livelihood strategies are crucial for the achievement of development objectives in the area of concern? • Which communities/ regions and sectors have already been identified as highly vulnerable to the impacts of climate change (including considerations of especially vulnerable groups such as youth, women, elderly, and minorities?)	Selection of clearly defined sector/ region based on criteria. Such as: • potential climate (and disaster) risks; • socio- economic and ecological factors; • institutional factors; and • availability of data	• Compilation of climate change-related hazards and their potentials impacts; • Collection of spatial and historical data, such as socio-economic, exposure, weather, and climate data; • Use of geographic information system(GIS) where applicable; • Stakeholders consultation; • Local, national, international, and secondary sources.

Step	Guiding Questions	Expected Outcomes	Tools, Methods, Sources
.	• For which development objectives is information about impacts from projected climate change lacking? • For which sectors and livelihood strategies are adaptation and risk management options still lacking?	.	
3. Development of a Context-Specific Methodological Approac	How can the magnitude of potential climate-related impacts be assessed in the system? • Which existing quantitative and qualitative approaches for assessing risks and impacts can be used and adjusted? • What data and information are available for the specific approaches? • What data has to be collected additionally, with which methods, and at which costs? Which proxies could be used for unavailable data?	Detailed overview of context specific methodology that comprises elements such as: • The description of the methodology, combining quantitative and qualitative approaches; • An overview of main stakeholders and information sources; • An implementation plan including timeframe; and • Specific aspects that may include non-economic losses and damages and effects on informal economic activities in relation to losses and damages.	Further (selected) stakeholder consultation (interviews)
4. Qualitative and Quantitative Risk Assessment	What is at risk? Where and from what? To which extent? • What are the current and projected climate change impacts? • How would socio-economic trends in the system be influenced by implemented or planned measures? • Which indicators need to be selected to evaluate risk components (hazards, vulnerability and exposure)?	• A thorough risk assessment that includes qualitative and quantitative analysis; • Presentation of combination of suitable CRM measures including information on costs, benefits, and framework conditions.	• Assessment according to chosen method, e.g. risk modeling, indicator/ scenario analysis, market price and economic valuation, or compilation of impact chains; • Qualitative assessments and consultation stakeholders may be considered as information source in the case of lack of data;

Step	Guiding Questions	Expected Outcomes	Tools, Methods, Sources
5. Evaluation of Risk Tolerancet	What level of risk tolerance does the affected population exhibit? • What are risk levels for communities, sectors, or livelihood strategies (including considerations of especially vulnerable groups)? • Is the identified risk acceptable (no further actions necessary), tolerance(further incremental actions required to manage risk) or intolerable (transformational actions to avoid risks are necessary)?	• Assessment of risk tolerance that compares different interconnected climate- related risks, such as general health or accidents; • Quantitative assessment of the extent of associated risks; • Evaluation of response mechanisms reaching from incremental to transformational adaptation.	• Field surveys and/or focus groups on risk perception. • Expert- judgment on levels of risk tolerance9 acceptable, tolerance, intolerable).
6. Identification of Feasible Options to Avert, Minimize, and Address (Potential) Losses and Damages	How can we respond using the identified CRM measures from step 4 and 5? • Which measures can effectively prevent/ Reduce potential losses and damages? • At what cost? To what extent? • Which constraints (financial, institutional, and technical) need to be considered? • How will we respond? • Which options are prioritized in consultation with stakeholders and do they cover al risk tolerance levels? • What do respondents and decision- makers consider feasible and relevant?	• Detailed overview of possible CRM interventions including risk levels, relevance/ importance, and feasibility; • Provision of policy-relevant information to support decision-makers in forward-looking planning and implementation of measures.	• Stakeholder-based elicitation of options; • Cost- effectiveness analysis; • Cost-benefit analysis; • Robust decision- making approaches; • Multi- criteria analysis; • Adaptation pathways.

Table 2.4: Six steps for conducting a CRA (developed by GP L&D) (source: Mechler et al., 2021)

2.6.5 Using a participatory approach to promote ownership of risk management in Tanzania: a case study

A CRA was carried out in the water catchment area of Lake Rukwa Basin in Tanzania. The objectives of the assessment, defined in advance, were to directly support stakeholders at the local level and to use the assessment as a basis for the national adaptation plan process and other decision-making processes at the national level. For this reason, stakeholders at all levels were involved in the process from the very beginning. In local forums, the results of the CRA as well as the recommendations for action were translated into concrete activities and action plans.

Risk profiles and information gathered through extensive desk research supported local stakeholders in defining the regional and thematic foci of the assessment. At the first analyst and stakeholder workshop, these thematic foci were finalized, with the participants selecting sectoral focus topics and three regional sub-basins by majority vote. Overall, this strong participatory approach led to the identification and filling of key data gaps, raised awareness about climate and other environmental risks such as water shortages, and promoted ownership through collective decision-making on relevant CRM measures.

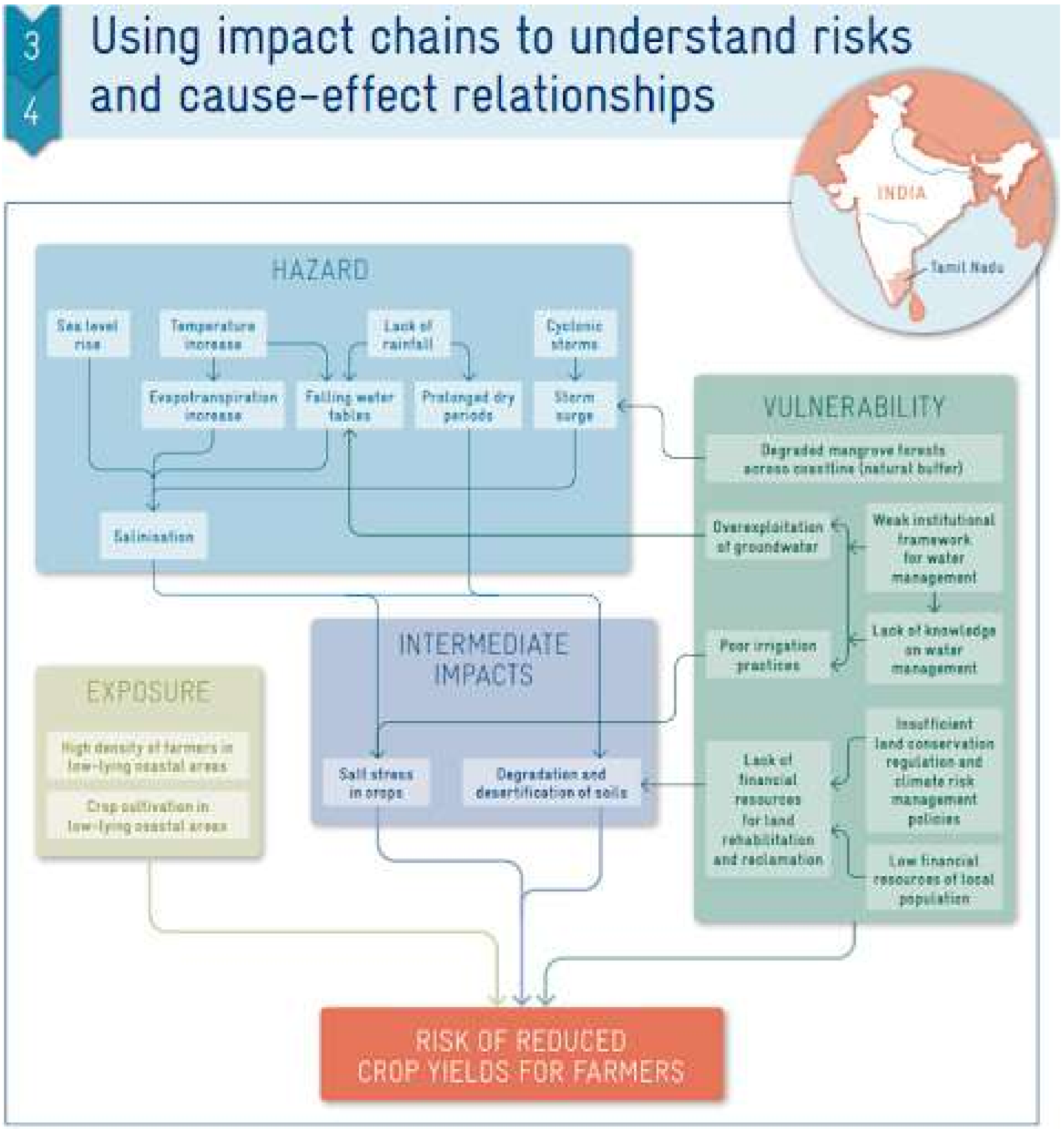

Figure 2.30: Illustrative and hypothetical impact chain for salinization based on a case study in Tamil Nadu (India)

2.6.6 Asian Development Bank support for addressing the climate risks of development projects

The Asian Development Bank's (ADB) Action on Climate Change in South Asia (2013–2018) is a regional capacity-development and technical-assistance project that was implemented in the Bank's six South Asian developing member countries (DMCs): Bangladesh, Bhutan, India, Maldives, Nepal, and Sri Lanka. It was designed to provide the South Asia DMCs with holistic and coordinated support in mainstreaming climate change strategies in development plans, programs, and projects in order to strengthen the pursuit of green growth and climate-resilient development.

Upon the request of the Government of the People's Republic of Bangladesh, the ADB's regional technical assistance supported the project Establishing a Climate Risk Screening System for Mainstreaming Climate Change Adaptation into National Development Budgeting Activities (May 2016–October 2018), which focused on the agriculture and water resources sectors. The project's outputs were (i) developing a climate risk screening (CRS) and climate risk and vulnerability assessment (CRVA) tool using a risk atlas and pilot-testing it for selected investment projects in the agriculture and water sectors that are proposed for inclusion in the annual development plan, and (ii) enhancing the human resource capacity of concerned government agencies, departments, and ministries in conducting CRS/CRVA at the project level.

A CRS is conducted at the conceptual stage of a project, whereas a CRVA is carried out during project preparation. Selected climate and associated disaster risk reduction and disaster resilience measures for addressing significant climate risks are then monitored and evaluated during project implementation. The CRVA will assist planning officials in implementing agencies and ministries to design climate and disaster-resilient projects in the annual development plan through the detailed project proforma and in project appraisal at the planning commission.

For projected medium- or high-risk projects, extensive, downscaled, and high-resolution climate scenarios as well as geophysical data and maps will enable more thorough and localized CRVAs. These risk assessments are done by analyzing both historical and projected climate- or weather-related hazards (H), exposures (E), and vulnerabilities (V) in the project areas. In effect, the overarching goal is to assess current and projected climate risks (R) as the confluence of these HEVs. Such risk assessments may be in the form of risk overlays and their side-by-side comparisons, maps thematically generated via indexing or scoring, the application of criteria-based mapping methodologies, or the combination of all these types.

For multi-hazard risk assessments, spatial databases on hazard, exposure, vulnerability, and risk (HEVR) have been developed for the agriculture and water resources sectors in Bangladesh using GIS tools. An impacts (I) geodatabase has been added in foresight to make it possible to archive these in future for the weighting of HEVs. The climate and hydrometeorological hazards included extreme rainfall and temperature, flood, flash flood, drought, cyclone, storm surge, salinity, erosion, and sea level rise. Apart from hydrometeorological hazards, other geophysical hazards such as earthquakes and landslides were mapped considering the geophysical setting of Bangladesh. Modeled historical and future scenarios of temperature and rainfall were downscaled and mapped, with the latter also involving the application of GIS. The following Figure 2.31 illustrates the ADB framework for CRS and CRVA.

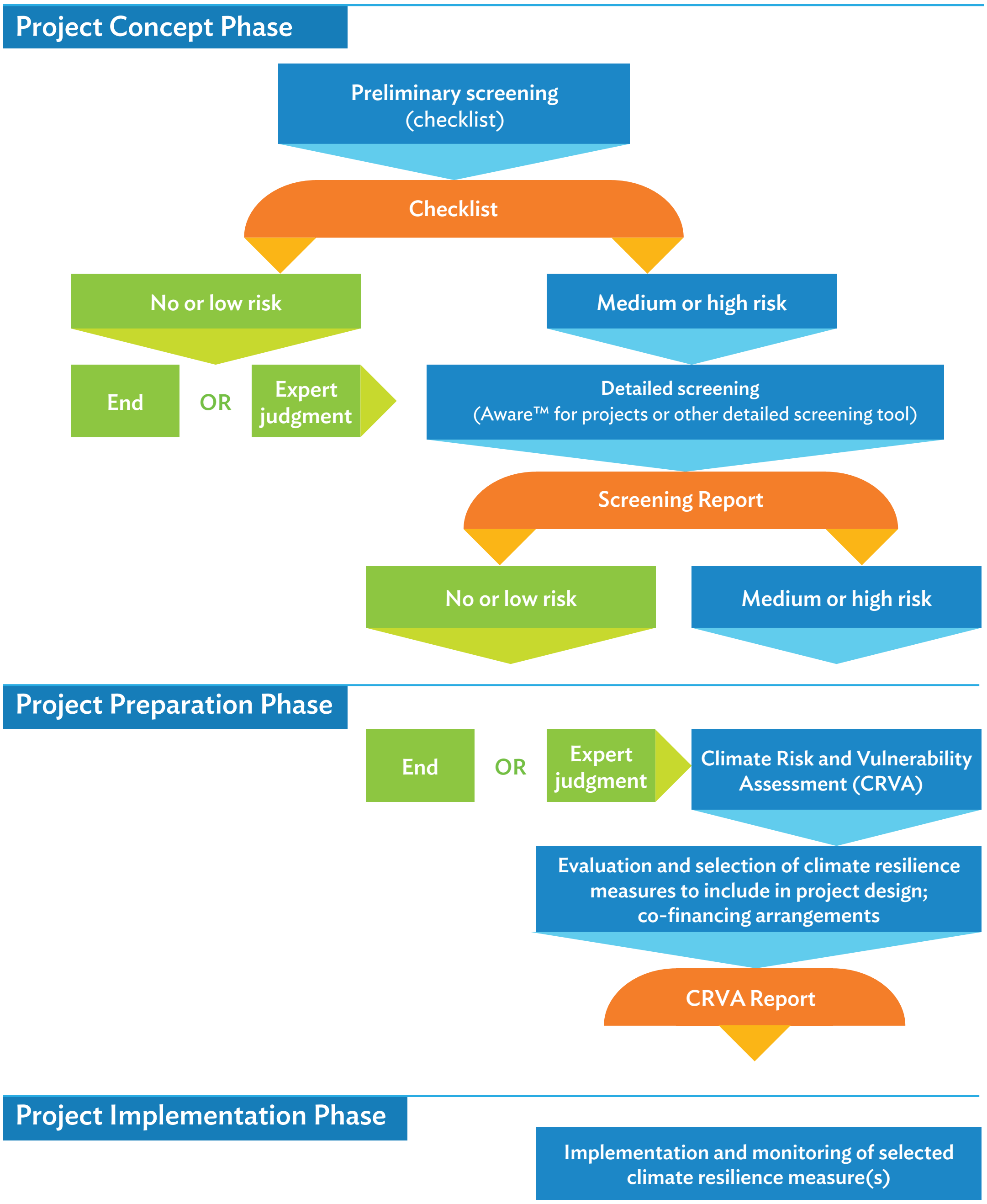

Figure 2.31: ADB framework for CRS and CRVA (source: ADB, 2021)

Box 2.4 Implementation of learning

It is critical to have a better understanding of the vulnerabilities and risks posed by climate change, natural hazards, and disasters on various development programs, particularly for the Bangladesh Planning Commission, Department of Environment (DoE), and Department of Agricultural Extension (DAE).

As the country's official planning authority, the Bangladesh Planning Commission is responsible for approving and distributing budget resources to all development projects in the country. The content of this module will enhance the Planning Commission's understanding of the variability of climate change scenarios, other hazards, exposures, vulnerabilities, and their combinations as risks to which these sectors are exposed. Participants will be able to make concrete decisions in evaluating, establishing, and addressing the climatic sensitivity of development projects in Bangladesh. Also, knowledge of GIZ's six-step methodology of risk assessment will contribute to informing decision-making and making it more effective, and to the implementation of required climate risk assessment measures. .

For further guidance, please read or watch the following:

Documents

Climate risk assessment – an introduction
https://europa.eu/capacity4dev/file/7747/download?token=1AmE4T-s

Nationwide climate vulnerability assessment in Bangladesh:
https://moef.portal.gov.bd/sites/default/files/files/moef.portal.gov.bd/notices/d31d60fd_df55_4d75_bc22_1b0142fd9d3f/Draft%20NCVA.pdf

Climate models, scenarios, and projections
https://science2017.globalchange.gov/downloads/CSSR_Ch4_Climate_Models_Scenarios_Projections.pdf

Videos

Climate impact and risk assessment 2021
https://www.youtube.com/watch?v=PMlLBh2scn0

Future temperature and precipitation projections:
https://www.youtube.com/watch?v=4UAWtQMDimo

How scientists calculate climate change
https://www.youtube.com/watch?v=fSGorwtY-zM

2.7 Group work

- Discuss the possible impacts of climate change on the southern coastal region of Bangladesh. Suggest some adaptation measures.
- Discuss the possible impacts of climate change on the north-eastern haor (backswamp) region of Bangladesh. Suggest some adaptation measures.
- Discuss the possible impacts of climate change on the north-central flood-prone region of Bangladesh. Suggest some adaptation measures.

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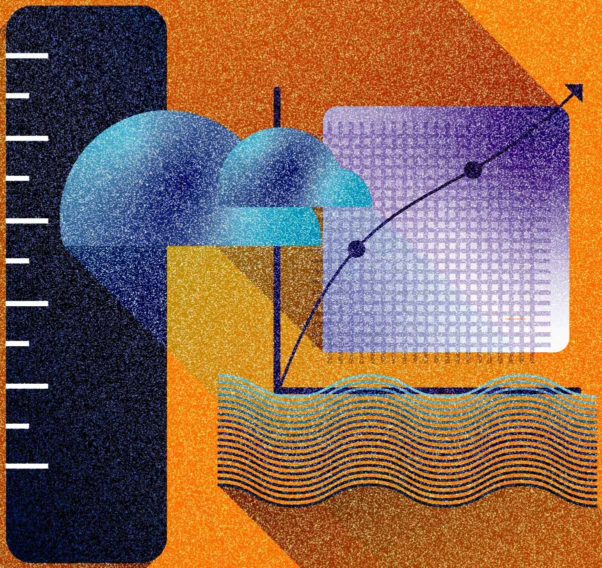
Notes



MODULE 03

Generation, dissemination, and use of climate data, information, and climate services

Overview of the training module

3.1 Brief introduction to the module

Subject

Generation, dissemination, and use of climate data, information, and climate services

Learning outcomes

This module will help learners to understand the need for the analysis and prioritization of adaptation options as a key step in the adaptation process. Learners will be introduced to the basics of decision-making theory with relevant examples, they will be made familiar with the most commonly used metrics to monitor adaptation, and they will learn how to implement a holistic multi-criteria (social, environmental, economic, etc.) analysis of adaptation options.

Topics

- Importance of climate data generation
- Dissemination of climate information
- Usability of climate data and information
- Climate data dissemination practice in Bangladesh
- Generation of future projections

3.2 Climate and information

Every meteorological element that is observed may also be termed a climatic element. The most commonly used elements in climatology are air temperature (including maximum and minimum), precipitation (rainfall, snowfall, and all kinds of wet deposition such as hail, dew, rime, hoar frost, and precipitating fog), humidity, atmospheric motion (wind speed and direction), atmospheric pressure, evaporation, sunshine, and present weather (e.g., fog, hail, and thunder). Properties of the land surface and subsurface (including hydrological elements, topography, geology, and vegetation), of the oceans, and of the cryosphere are also used to describe climate and its variability (WMO, 2011).

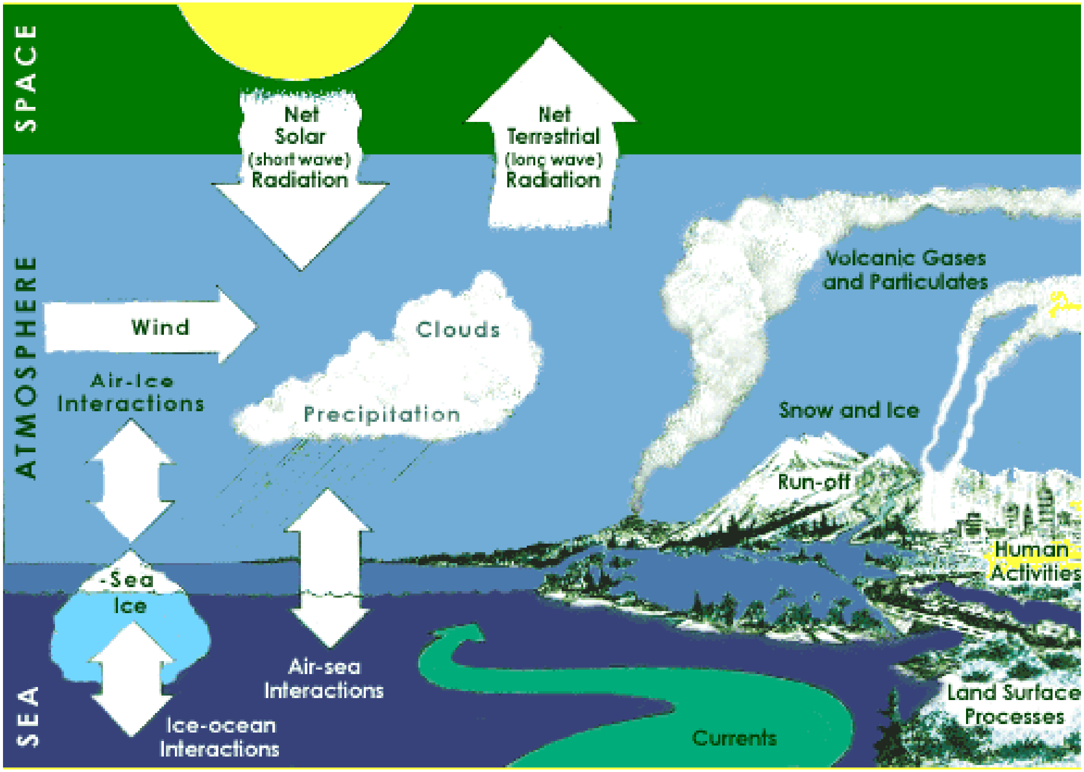


Figure 3.1: Major elements of the climate system (source: Sensoy and Demircan, 2010)

3.3 Importance of climate data and information

Climate observations provide the basis for applications such as weather forecasting, air pollution modeling, and environmental impact assessments. In the current climate, many sectors are affected by extremes in temperature, rainfall, or precipitation. Due to a changing climate, these extremes are likely to change in future. A reference climate is the definition of what is "normal" in a certain climate and is often based on a 30-year mean. It is used by many sectors to optimize their profits, safety measurements, or planning. Maximizing the availability of historical data is essential for long-term climate monitoring, particularly for analyzing trends of extreme events. Climate data are fundamental to the operation and validation of climate models, which are used for generating projections of future climate. Meteorological institutes make descriptions of the current climate of the country and often also draw up scenarios for the future climate. Some examples of sectors that use climate information include the following:

- The wind energy sector uses wind data to estimate the future potential in and most profitable locations or wind energy.
- Agriculture uses precipitation and temperature data to assess the impacts of climate change on crop yields.
- Urban planners use information on urban heat islands to make resilient cities.
- Highways and traffic planners use information on heavy precipitation to build in enough drainage capacity.
- The tourism sector uses information about temperature and precipitation to determine areas with the potential to attract tourists.

Box 3.1 Practitioners' considerations regarding climate data

For each type of climate data, practitioners may need to consider:

- **Historical information** – Data on past conditions and trends can be used for mapping hazards, assessing trends, identifying relationships with historical impacts (such as disease outbreaks and food insecurity), and providing a reference against which to compare current and anticipated conditions. Historical data can also be used for identifying the seasonality of climate, which can, for example, be important information for understanding the monthly distribution shifts of disease-carrying vectors or identifying likely cropping cycles.
- **Current information** – Data on current and recent conditions can be useful for indicating whether potentially impactful weather and climate events, such as severe storms or droughts, have recently occurred or are under way.
- **Prospective information** – Forecasts, projections, and scenarios are useful for anticipating climate hazards, for planning humanitarian operations, and for longer-term recovery and development planning.

Another source of climate data is radiation measurements, which are used for the following purposes: (i) to study the transformation of energy within the Earth-atmosphere system and its variation in time and space, (ii) to analyze the properties and distribution of the atmosphere with regard to its constituents, such as aerosols, water vapor, ozone, and so on, (iii) to study the distribution and variations of incoming, outgoing, and net radiation, (iv) to satisfy the needs of biological, medical, agricultural, architectural, and industrial activities with respect to radiation, and (v) to verify satellite radiation measurements and algorithms.

3.4. Instrument requirements

Box 3.2 Important requirements for meteorological instruments used in data collection

The most important requirements for meteorological instruments used in data collection are the following:

a. Uncertainty, according to the stated requirement for the particular variable.
b. Reliability and stability.
c. Convenience of operation, calibration, and maintenance.
d. Simplicity of design, which is consistent with requirements.
e. Durability.
f. Acceptable cost of the instrument, consumables, and spare parts.
g. Safe for staff and the environment.

(WMO, 2011)

With regard to requirements (a) and (b), it is important for an instrument to be able to maintain a known uncertainty over a long period. This is much better than having a high level of initial confidence (meaning low uncertainty) that cannot be retained for long under operating conditions.

3.5 Measurement standards and definition

A nomenclature for standards of measurement is given in the International Vocabulary of Basic and General Terms in Metrology, which was prepared simultaneously by the International Bureau of Weights and Measures, the International Electrotechnical Commission, the International Federation of Clinical Chemistry and Laboratory Medicine, the International Organization for Standardization, the International Union of Pure and Applied Chemistry, the International Union of Pure and Applied Physics, and the International Organization of Legal Metrology. Some of the definitions set out in this publication are as follows:

a. Primary standard: A standard that is designated or widely acknowledged as having the highest metrological qualities and whose value is accepted without reference to other standards of the same quantity.
b. Secondary standard: A standard whose value is assigned by comparison with a primary standard of the same quantity.
c. Reference standard: A standard, generally having the highest metrological quality available at a given location or in a given organization, from which measurements made there are derived.
d. Working standard: A standard that is used routinely to calibrate or check material measures, measuring instruments, or reference materials
e. Measurement standard: A material measure, measuring instrument, reference material, or measuring system intended to define, realize, conserve, or reproduce a unit or one or more values of a quantity to serve as a reference.
f. International standard: A standard recognized by an international agreement to serve internationally as the basis for assigning values to other standards of the quantity concerned.
g. National standard: A standard recognized by a national decision to serve, in a country, as the basis for assigning values to other standards of the same quantity.

3.5.1 Climate data measurements

a. Result of a measurement: Value attributed to a measure (and the physical quantity that is being measured), obtained by measurement.

b. Corrected result: The result of a measurement after correction for systematic error.

c. Value (of a quantity): The magnitude of a particular quantity generally expressed as a unit of measurement multiplied by a number.

3.5.2 Climate metadata

a. Observations metadata: Time-series data that describe how, when, and where meteorological observations were made and the conditions they were made under.

b. Discovery metadata: Information intended to facilitate the discovery and assessment of a dataset to determine if it is fit for reuse for a purpose that may be at odds with the reason for which it was originally created.

c. Data provenance metadata: Information relevant to climate data that allows end-users, including data managers, scientists, and the general public, to develop trust in the integrity of the climate data.

3.6 Climate data generation

3.6.1 Climate data generation process

The requirements for climate data may be met using in-situ measurements or remote sensing (including space-borne) systems, according to the ability of the various sensing systems to measure the environmental elements needed in terms of global, regional, and national scales and according to the application area. The World Meteorological Organization's (WMO) Integrated Global Observing System (WIGOS), which is designed to meet these requirements, is composed of the surface-based subsystem and the space-based subsystem. The surface-based subsystem comprises a wide variety of types of stations according to the particular application (e.g., surface synoptic station, upper-air station, climatological station, etc.). The space-based subsystem comprises a number of spacecrafts with on-board sounding missions and the associated ground segment for command, control, and data reception. To derive certain meteorological observations by automated systems – for example, of the present weather – a "multi-instrument" approach is necessary, where an algorithm is applied to compute the result from the outputs of several sensing instruments.

Figure 3.2: Observation facilities of Bangladesh Meteorological Department (BMD)

3.6.2 Climate elements and their measurement process

(a) Temperature

Temperature is characterized by the behavior whereby two bodies in thermal contact tend to an equal temperature. Thus, temperature represents the thermodynamic state of a body, and its value is determined by the direction of the net flow of heat between two bodies. In such a system the body that, overall, loses heat to the other is said to be at the higher temperature. Defining the physical quantity temperature in relation to the "state of a body" is, however, difficult. A solution is found by defining an internationally approved temperature scale based on universal freezing and triple points. The current such scale is the International Temperature Scale of 1990 (ITS-90), and its temperature is indicated by T90. For meteorological purposes, temperatures are measured for a number of media. The most common variable measured is air temperature (at various heights). Other variables are ground, soil, grass minimum, and seawater temperature. WMO (1992) defines air temperature as "the temperature indicated by a thermometer exposed to the air in a place sheltered from direct solar radiation."

(b) Atmospheric pressure

The atmospheric pressure on a given surface is the force per unit area exerted by virtue of the weight of the atmosphere above. The pressure is thus equal to the weight of a vertical column of air above a horizontal projection of the surface, extending to the outer limit of the atmosphere.

(c) Humidity

The measurement of atmospheric humidity, and often its continuous recording, is an important requirement in most areas of meteorological activity. Relative humidity is the most frequently used measurement. This is the ratio, expressed as a percentage, of the observed vapor pressure to the saturation vapor pressure with respect to water at the same temperature and pressure.

(d) Surface wind

Wind velocity is a three-dimensional vector quantity with small-scale random fluctuations in space and time superimposed upon a larger-scale organized flow. Surface wind will be considered mainly as a two-dimensional vector quantity specified by two numbers representing direction and speed. The extent to which wind is characterized by rapid fluctuations is referred to as gustiness, and single fluctuations are called gusts.

(e) Precipitation

The total amount of precipitation that reaches the ground in a stated period is expressed in terms of the vertical depth of water (or water equivalent in the case of solid forms) to which it would cover a horizontal projection of the Earth's surface. Snowfall is also expressed by the depth of fresh, newly fallen snow covering an even horizontal surface.

(f) Radiation

The various fluxes of radiation to and from the Earth's surface are among the most important variables in the heat economy of the Earth as a whole and at any individual place at the Earth's surface or in the atmosphere.

(g) Sunshine duration

The first definition was established directly by the relatively simple Campbell-Stokes sunshine recorder, which detects sunshine if the beam of solar energy concentrated by a special lens is able to burn a special dark paper card. This recorder was already introduced in meteorological stations in 1880 and is still used in many networks. Since no international regulations on the dimensions and quality of the special parts were established, applying different laws of the principle gave different sunshine duration values. In order to homogenize the data of the worldwide network for sunshine duration, a special design of the Campbell-Stokes sunshine recorder, the so-called Interim Reference Sunshine Recorder, was recommended as the reference (WMO, 1962).

(h) Visibility

Visibility was first defined for meteorological purposes as a quantity to be estimated by a human observer, and observations made in that way are widely used. However, the estimation of visibility is affected by many subjective and physical factors. The essential meteorological quantity, which is the transparency of the atmosphere, can be measured objectively and is represented by the meteorological optical range.

(i) Evaporation

Evaporation is the process whereby liquid water is converted to water vapor (vaporization) and removed from the evaporating surface (vapor removal). The rate of evaporation is defined as the amount of water evaporated from a unit surface area per unit of time. It can be expressed as the mass or volume of liquid water evaporated per area in unit of time, usually as the equivalent depth of liquid water evaporated per unit of time from the whole area. The unit of time is normally a day. The amount of evaporation should be read in millimeters.

(j) Soil moisture

Soil moisture is an important component in the atmospheric water cycle, both on a small agricultural scale and in large-scale modeling of land/atmosphere interaction. Vegetation and crops always depend more on the moisture available at root level than on precipitation occurrence. Water budgeting for irrigation planning, as well as the actual scheduling of irrigation action, requires local soil moisture information. Knowledge of the degree of soil wetness helps to forecast the risk of flash floods or the occurrence of fog. Nevertheless, soil moisture has seldom been observed routinely at meteorological stations.

(k) Upper air pressure, temperature, and humidity

A radiosonde is an instrument intended to be carried by a balloon through the atmosphere. It is equipped with devices to measure one or several meteorological variables (pressure, temperature, humidity, etc.) and is provided with a radio transmitter for sending this information to the observing station. “Radiosonde observation” is an observation of meteorological variables in the upper air, usually atmospheric pressure, temperature, and humidity, by means of a radiosonde.

(l) Upper wind

The provisions of upper air wind measurement are:

1. Pilot-balloon observation: A determination of upper winds by optical tracking of a free balloon.
2. Upper-air observation: A meteorological observation made in the free atmosphere either directly or indirectly.
3. Present and past weather

The term “weather” is regarded as covering those observations of the state of the atmosphere, and of phenomena associated with it, that were initially not intended to be measured quantitatively. These observations are qualitative descriptions of phenomena observed in the atmosphere or on the Earth’s surface, such as precipitation (hydrometeors falling through the atmosphere), suspended or blowing particles (hydrometeors and lithometeors), or other specially designated optical phenomena (photometeor) or electrical manifestations (electrometeor). Weather is reported in two forms. Present weather is a description of the weather phenomena present at the time of observation. Past weather is used to describe significant weather events occurring during the previous hour, but not occurring at the time of observation.

(n) Clouds

A cloud is an aggregate of very small water droplets, ice crystals, or a mixture of both, with its base above the Earth’s surface, which is perceivable from the observation location. The limiting liquid particle diameter is of the order of 200 μm; drops larger than this comprise drizzle or rain. The observation of clouds and the estimation or measurement of the height of their bases above the Earth’s surface are important for many purposes, especially for aviation and other operational applications of meteorology.

(o) Ozone

Ozone is a molecule made up of three oxygen atoms that is naturally formed by the photolysis of normal oxygen by ultraviolet solar radiation at wavelengths below 242.5 nanometers in the stratosphere. A certain amount of ozone is also produced in the troposphere in a chain of chemical reactions involving hydrocarbons and nitrogen containing gases. Though ozone is a minor atmospheric constituent, with an average concentration of about three parts per million volume (ppmv), the radiation properties of this "greenhouse" gas make it a significant contributor to the radiative energy balance of the atmosphere, and an important regulator of the ultraviolet solar radiation received at the Earth's surface.

(p) Atmospheric composition

Atmospheric composition changes that influence climate can be divided into two main categories: changes in molecular gases that interact with infrared radiation and changes in aerosols (small liquid or solid particles) that absorb or reflect visible radiation. In addition, ozone (O3), which forms naturally in the atmosphere from molecular oxygen (O2), interacts with both ultraviolet and infrared radiation, and its concentration is controlled by chemistry that has been changed substantially by human emissions of various pollutants.

3.6.3 Climate data generation through numerical models

Various types of climate data are being generated by the national meteorological and hydrological services (NMHS) in addition to those of the prestigious climate modeling centers. Such data are generally represented by multidimensional array grids.

Climate models (such as global climate models) are numerical representations of the climate system based on physical, biological, and chemical rules. Their timescales vary, ranging from seasonal to centennial. Climate models are often used to produce climate change projections. Downscaled models, which are derived from climate models but at a much higher resolution, are generated to support regional and local analysis.

Reanalysis is a systematic approach for producing data sets for climate monitoring and research. Reanalyses provide gridded data over a long period for use in climate studies and are created via an unchanging ("frozen") data assimilation scheme and model(s) that ingest all available observations. This unchanging framework provides a dynamically consistent estimate of the climate state at each time step. NMHSs such as the Bangladesh Meteorological Department (BMD) are also generating data of various parameters by running numerical weather prediction models.

3.7 Importance of climate information dissemination

Climate data and information – whether station or satellite generated – can increasingly be accessed freely online. Practitioners without online access, or who require more spatially specific data, may be able to obtain them in person from the country's network management system (NMS) office.

However, this is dependent on national access-to-information laws and on whether reliable data have been generated and archived. Station data can typically be obtained from a country's national meteorological service. Depending on the quality control processes performed by the NMS, these data may be of high or low quality. However, station data are not always available free of charge. Some of the station data provided by the NMS is freely available through the Global Telecommunication System. These data can also be accessed from outside the country. To address the spatial and temporal gaps in climate data as well as the lack of quality-controlled data, approaches are being developed based on the idea of "merging" station data with satellite and modeled data. Some of these methods involve taking advantage of working with climate scientists and meteorologists in both fragile and more stable states to develop a platform in which the now-quality-improved data can be accessed, manipulated, and integrated into the programs of national-level stakeholders and international partners, from inside the country and abroad.

Satellites provide raw data that are continuously archived. If decision-makers are to be able to access, visualize, or manipulate these data, an interface is necessary. In many cases the raw data may be free, but not all interfaces allow free access to their archived data. It should be noted that satellites cannot measure rainfall; correct measurement of rainfall can only be made through rain gauges. Satellite rainfall estimates try to convert radiation measurements into precipitation information.

3.8 Global and regional practice for climate information dissemination

"Dissemination" can be defined as the scattering, spreading abroad, distribution, or dispersion of certain information (Reader's Digest, 1998). "Diffusion of innovations" is considered to be the process by which a new product is spread among users, in contrast with "adoption," which is when it is absorbed and utilized in the decision-making process (Fisher et al., 2000).

Communication is vital for the dissemination of information. Most definitions of communication include five fundamental factors: a sender, a recipient, a mode or vehicle, a message, and an effect (Bembridge, 1991; Mukhala, 2000). So, the message is first conceived by the sender and then encoded into a format that can be sent by a specific medium. This must then be decoded by the recipient before it can be acted on and a return message sent regarding the successful understanding or not of the message (Mukhala, 2000). Therefore, communication must include a sharing of meaning or understanding for it to be successful (Mukhala, 2000). It must also be a two-way process to be considered successful.

There may be several different approaches for disseminating climate information to relevant persons. The nature of meteorological information is always changing, so repeated acts of communication are usually necessary. It is therefore beneficial to adopt a reiterative process. When it comes to disseminating climate information, the points set out in Box 3.3. below should be considered.

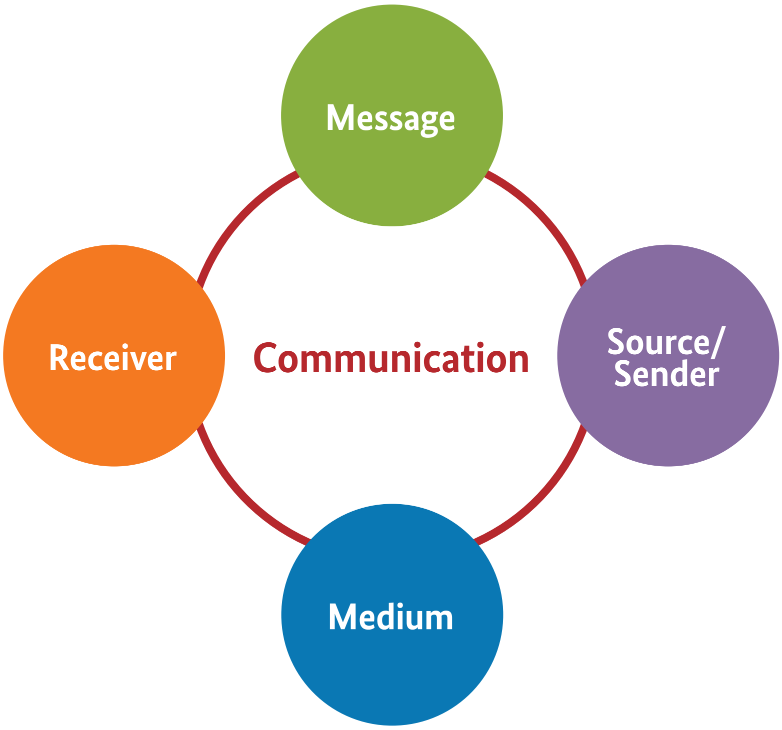


Figure 3.3: Elements of communication (source: Studious Guy, 2022)

Box 3.3 Things to consider for the dissemination of climate information

With regard to the dissemination of climate information, the following points should be considered:

a. Identification of the clients or target groups.
b. Interaction between the service provider and clients to identify the climate-sensitive decisions that are made during the course of business.
c. Development of products or technology for risk analyses using various climate parameters.
d. Interaction with the clients to evaluate the results from the scientific analyses.
e. Introduction and integration of the routine operational forecasts and products of the NMS.

(Veldhuizen et al., 1997)

The method of climate information dissemination is dependent on the target client and on the format of the information (Bembridge, 1991). For smooth dissemination, communication channels can be broadly divided into three groups: mass and electronic media, group contact, and individual contacts. In general, the use of more than one channel gives a greater chance of reaching the client or user (Bembridge, 1991). The individual contacts channel can be time consuming but can also build good rapport and help maintain credibility between the actors. It is a vital part of participatory technology development (Veldhuizen et al., 1997) and of the training and visit method of extension (Benor and Baxter, 1984). It is often useful to focus on a specific homogenous target group that is likely to have sufficiently similar needs and draw benefit from similar information (Bembridge, 1991). This target group may not be existing groups as such, but more a category of clients or farmers who would be able to identify similar weather-dependent decisions. Therefore, the same sort of information can be formulated to address these critical decisions using the same format and language, etc.

The group method allows clients to be exposed to other clients and also to realize the problems of limitations. This encourages them to persevere and to consider alternatives that may have been used by others. It also helps in sharing experiences and opinions and identifying gaps in the knowledge or information flow (Joyce, 2003). Groups can also commit together to take certain action and then support each other throughout the process (Bembridge, 1991).

The use of mass media has the advantage of reaching many more people with each action. The format can be a written article in a newspaper, magazine, or specialized printed pamphlet. Alternatively, content can be distributed via electronic media such as radio, television, , email,   internet, social media and mobile communication etc. However, the disadvantage of the audio-visual media is that receivers must rely on their memory to recall the information at a later stage. Therefore, it is often good to follow up these communications with the provision of printed matter and diagrams, especially if this can be in the local language. The use of electronic media such as email, file transfer protocol (FTP), or the Internet will depend on the level to which these methods are available and accessible among the users or clients who make up the target groups.

Method of climate info. dissemination	Advantages/disadvantages
Extension visit	This is frequently helpful for concentrating on a particular homogeneous target group that is likely to have enough similar needs and benefit from similar information.
Group method	This enables clients to interact with other clients and to become aware of restrictions' issues. This gives them the confidence to keep trying and to think about potential solutions that other people may have employed. It also facilitates the exchange of experiences and ideas and the discovery of knowledge or informational gaps.
Mass media	Each action has a much wider impact through this channel. The drawback of audio-visual media is that viewers must rely on memory to retain the details afterwards.
Electronic media	The degree to which the users or clients that make up the target groups are able to use and have access to electronic media, such as email, file transfer pr-otocol (FTP), or the Internet, will determine how often these platforms are used.

Table 3.1: Advantages and disadvantages of different methods of climate information dissemination

3.9 Climate data dissemination practice in Bangladesh

In Bangladesh's early years as an independent nation, climate information would be disseminated to users over the telephone or in writing by fax or via the postal service. Routine and emergency climate information, forecasts, and early warnings were broadcast through Bangladesh Betar's (the state broadcaster) radio service and, later on, via its television service. Emergency climate information was also disseminated by local volunteers using public address systems or megaphones to raise awareness and prompt communities to prepare. All of these processes were time consuming. With the advent of modern communications technology and its widespread adoption, the process of disseminating climate information has improved. BMD currently disseminates climate information largely on the web, but it also uses email, fax, telephone, print and electronic media, social media, interactive voice response systems, local and regional Bangladesh Betar channels, request-based online data portals, etc. In addition, climate information and products are now distributed to users and stakeholders in accordance with the framework set out in the Bangladesh government's Standing Orders on Disaster (2019).

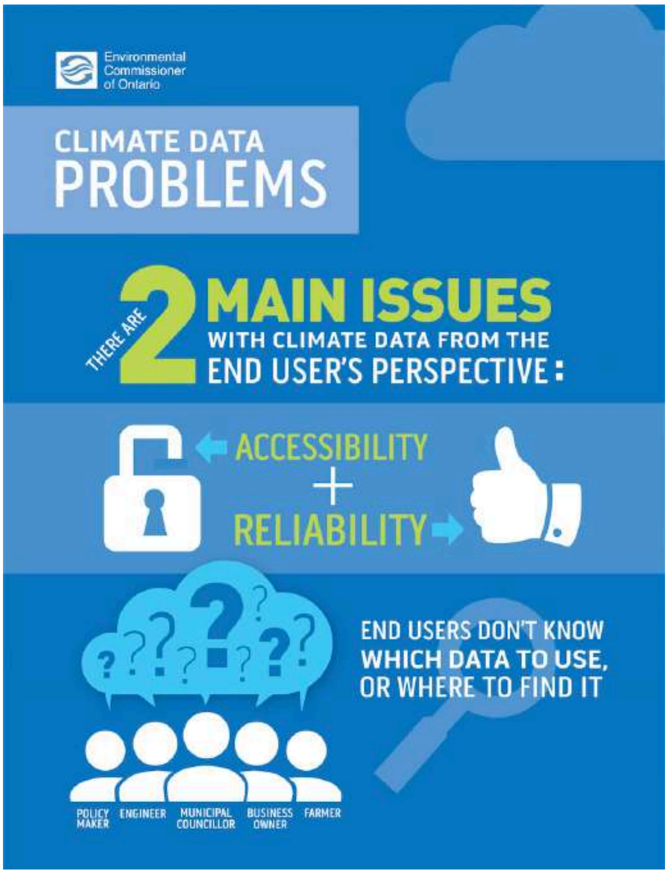


Figure 3.4: The two main problems with climate data (source: WMO, 2019)

The following table provides more information on the roles and services of Bangladesh's national agencies with regard to climate data dissemination:

Institution	Functions
Bangladesh Meteorological Department (BMD)	BMD maintains a weather data library. It supports users with advanced analytical tools and visual representations of data, including animations. The data can be downloaded in commonly used formats, including GIS-compatible formats. Datasets can be selected and procured online. BMD uses 35 ground-based weather stations, 10 weather balloons, 5 radar stations, and 3 rawinsonde stations as well as external data from WMO.
Center for Environmental and Geographic Information Services (CEGIS)	CEGIS collects data and provides additional services to government agencies and the public using space technology and GIS. For its resource and environmental analyses, CEGIS uses analytical tools like water modeling, salinity intrusion modeling, fisheries resources assessment modeling, regional basin modeling, digital terrain/digital elevation models, crop models, etc. Its website does not provide users with the opportunity to download data. To select and acquire data, users must get in contact with CEGIS directly.
Institute of Water Modelling (IWM)	The IWM provides water modeling, computational hydraulics, and allied sciences for improved integrated water resources management. The applications of IWM's modeling tools cover a wide range of water-related areas such as flood control, flood forecasting, irrigation and drainage, river morphology, salinity and sediment transport, coastal hydraulics, port, coast and estuary management, environmental impact assessment, and bridge hydraulics and related infrastructure. IWM uses a surface-water simulation modeling program that offers high-level analytical capabilities for mathematical water modeling.

Institution	Functions
Bangladesh Water Development Board (BWDB)	BWDB's hydrology and river-level data can be accessed through its web portal. Additional data is made available on request for a small fee.
Geological Survey of Bangladesh (GSB)	GSB provides sub-ground condition data and geodata. It also uses satellite data from the Copernicus Sentinel of the European Space Agency, Landsat, and TerraSAR-X. GSB's land-use classifications provide spatial change information on the expansion of urban areas and shifting river courses. The shifting direction of the rivers can be an indicator for the identification of erosion-prone areas. Ground motion maps derived from radar data are used to identify stable areas that make suitable sites for construction. Its data enable the detection and visualization of peak flood levels. The extent and the frequency of inundation can be analyzed at a nationwide scale due to the high temporal resolution of the data (repeat frequency of 6–12 days). At the local level, these geodata can help in estimating the inundation hazard of urban development sites. To obtain data from GSB, it is necessary to contact the Survey directly.
Bangladesh Oceanographic Research Institute (BORI)	BORI's Environmental Oceanography and Climate Division provides climate services on marine, coastal, and estuary environments. It focuses on these environments because they have been suffering diverse forms of degradation, including pollution with xenobiotic compounds, accelerated input of dissolved plant nutrients, discharge of untreated industrial effluents, and physical modifications such as unplanned coastal constructions and developments. BORI does not make its climate data available online. However, the Institute does keep track of tsunamis, sea level temperature, and sea level rise.
Bangladesh Space Research and Remote Sensing Organization (SPARRSO)	SPARRSO and the Survey of Bangladesh are the two government agencies mandated with promoting remote-sensing and topographic information systems. SPARRSO was the first agency that adopted the GIS facility under a project funded by the United States Agency for International Development (USAID) and the US National Aeronautics and Space Administration (NASA). Later on, this project was transformed into CEGIS, which was set up as a public trust in 2002. A similar project on the hydrological modeling of floods and cyclones had previously (in 1996) been transformed into the IWM. According to its website, SPARRSO provides drought and flood information. However, SPARSSO's website is not well maintained and its data cannot be accessed through this site.
Bangladesh Open Data portal	This portal is an initiative of the Prime Minister's Office, the Cabinet Division, Bangladesh Computer Council, Bangladesh Bureau of Statistics, and the Statistics and Informatics Division. At the time of review, this portal's data overlapped with the datasets of the Bangladesh Bureau of Statistics. In our tests, the Open Data portal failed on numerous occasions. A more successful approach was to access the original climate data directly through the websites of the agencies in question.
Disaster and Climate Risk Information Platform (DRIP)	DRIP is operated by CEGIS on behalf of the Bangladesh Planning Commission and the National Relief Program (Bangladesh Disaster Risk and Climate Resilience Program). The interface is designed to provide the disaster and climate risk data and information needed to carry out disaster impact assessments. These assessments were proposed by the National Disaster Management Council of Bangladesh, which is headed by the Prime Minister, to ensure disaster resilient development. DRIP was released in 2021, so certain of its functions were not yet operational at the time of testing (November 2021).

Table 3.2: Climate data dissemination practice

3.10 Climate information for emergency response, development programming and conflict resolution

Climate and environmental information is most useful if it can be integrated into the decision-making process. To be most effective, practitioners should use climate data at a timescale appropriate to their needs. Immediate relief and response operations from peacebuilding practitioners – interventions such as emergency food distribution and health care provision – can draw on weather-based data to support their decision-making. Watches, warnings and alerts, forecasts, and threat assessments covering current conditions and extending out a few weeks will be most helpful for these practitioners in ensuring that the negative impacts of weather conditions on ongoing operations are minimized.

For medium-term preparedness planning, practitioners should start to look beyond current weather conditions to the data on climate variability, specifically the climate variability outlook and predictions for the coming months, seasons, and years. Integrating these medium-term climate considerations into decision-making on, for example, the location of camps for displaced populations or programs supporting the establishment of natural-resource-based livelihoods will help to minimize the chances that these decisions are undermined by climatic forces over time and will increase their resilience. A climate-induced collapse in local livelihoods could, for example, have a detrimental effect on peacebuilding, whereas the integration of climate resilience into livelihood strategies in part through the use of climate data – a focus on using drought-resistant crops in agricultural livelihoods in an area expected to become hotter and drier, for example – could reduce the vulnerability of local communities to longer-term climate trends.

As peacebuilding practitioners transition from immediate humanitarian responses to longer-term development programming, including the rehabilitation and restoration of damaged or destroyed infrastructure, there is a need to integrate climate risks into their work to ensure that it is resilient to longer-term climatic forces. This will require consideration of yearly and decadal climate change projects, as well as longer-term climate change scenarios. The uncertainty associated with these long-term forecasts will increase with time, but it is nevertheless important to consider possible climate futures when making decisions with long-term implications.

Integrating climate data into decision-making processes in fragile states will require an understanding of the operating context and of the ways in which weather and climate interact with livelihoods and conflict dynamics. This should include an analysis of the causes, effects, actors, and dynamics that contribute to the country's fragility, and an identification of how current weather and forecasted climate trends – knowledge based on available climate data – may influence or exacerbate the drivers of fragility today and in the future. Integrating climate information into conflict analyses will help practitioners to form a better understanding of the current and potential conflict dynamics in their operating contexts and to respond accordingly.

Dissemination of forecast data and products

One of the most important roles of a weather service is to provide timely and accurate warnings to the public. BangladeshMeteorological Department (BMD) produces and issues warnings through various dissemination channels. It is of great importance that BMD warnings are relayed to the public in as timely a fashion as possible and that the warnings are for the same geographic location warned by the BMD.. BMD is committed to providing effective meteorological, seismological services and impact of climate change for protection of life, property and the environment, increased safety on land, at sea and in the air, enhanced quality of life and sustainable economic growth. BMD has the following satellite receiving ground stations: a) Himawari and b) NOAA. BMD recently implemented a project titled " Strengthening Meteorological Information Services and Early Warning System under Bangladesh Weather and Climate Services Regional Project (BWCSRP). The objective of the project was to To strengthen capacity of Bangladesh Meteorological Department and to mitigate weather and climate related hazards by improving the accuracy and lead time of weather forecasts and warning and improving the quality of climate Services in Priority sectors.

3.11 Importance of forecast products

The key purpose of forecast products is to enable better decision-making for risk reduction. The optimization of decision-making requires a good understanding of the decision and its impact on the user. Firstly, the event for which the forecasts are provided must accurately represent the weather sensitivity of the user. If the user is then able to identify costs associated with taking protective actions, and the potential losses if they are unprotected and adverse weather occurs, then they may be able to identify the optimal probability threshold for taking preventative action. However, many decisions are not as simple as this would suggest. A user may be able to take different levels of protective or beneficial actions according to how high the probabilities are. Many situations are more complex where there are multiple categories or potential responses, and the best outcome is likely to come from a strong partnership between the user and the NMHS. This helps the NMHS to better understand user needs, and the user to understand the limitations of forecasting capability. Box 3.4 on next page presents some best practices in the dissemination of forecast data.

3.12 Usability of climate data and information

3.12.1 Agricultural and fisheries management

Data collection and sharing is an important task in determining weather and climate impacts on agriculture and food security outlooks. The agriculture and food-security community relies on appropriate and timely phenological, environmental, and climate information at relevant space and timescale data points to make informed decisions. Available, accessible, comprehensive, and useful weather and climate data can help agriculture and food security decision-makers improve their understanding of climate's impact on agricultural development and food systems and their estimates of populations at risk (e.g., risk mapping). Weather and climate data can be particularly helpful to anticipate, prepare for, and respond to agriculture or food-security risks, both on short timescales to address problems triggered by climate extremes (droughts, thermal extremes) and for longer-term risks associated with climate change (increased frequency of cyclones, desertification).

One priority action area is improved data collection and use (meteorological, agrometeorological, climatic, agronomic, pest and disease), which includes the following activities (WMO, 2014):

- Sharing data from existing networks.
- Upgrading the monitoring and data-collection network in rural areas, as well as systematic data archiving and management.
- Improving the reporting of national yield, area, and production statistics, as well as of other data (pests and diseases).

The NMHS databases that are currently available increase climate knowledge and improve prediction capabilities, facilitating agricultural and food-security decision-making in areas ranging from international policy to local operational farm management strategies. Through the analysis of long-term climatic data and use of current weather observations, NMHSs provide agrometeorological advisories and services to the agricultural sectors on a regular basis during the cropping season. These enable farmers, herders, and fishers to make appropriate operational decisions on their livelihoods for the efficient management of natural resources and to improve agricultural productivity.

Box 3.4 Best practices in the dissemination of forecast data

Redundancy for receiving warnings: Utilize at least two and preferably three different paths to receive the national weather service warnings (e.g., internet and phone lines).

Robustness of the core computing infrastructure: Have sufficient computing power and communication bandwidth to

- produce and decode the warning;
- determine who the target recipients are and how they should receive the alerts, and
- send alerts to target recipients in a timely manner.

Excellent internal quality-control processes: These are needed to quickly identify and correct any issues with warning-product generation and dissemination.

Reliability and redundancy of the core computing infrastructure: This infrastructure should be at least doubly redundant, preferably triply, for core functions such as power, internet communication, cooling, and telephony, among other capabilities. The complete computing and telecommunication solution should, at a minimum, achieve extreme reliability of uptime and meet the standards.

Reliability and redundancy of message dissemination: To avoid issues of latency in transmission if a particular technology fails, users and clients should rely on more than one type of technology.

(Source: American Meteorological Society, 2018)

3.12.2 Health Management

Health professionals need observational data from NMHSs in order to establish national- and subnational-level causal linkages between climate conditions and health outcomes. This first order assessment will then inform the further utility of using climate information and services to manage health risks. When strong associations are observed or known, NMHSs provide near-real-time monitoring data of local conditions – for example, air quality can directly inform population advisories or combined data on precipitation, soil moisture, and surface air temperature conditions can be used to monitor the daily-to-weekly suitability of vector-borne disease transmission. Depending on the capacity of the NMHS, the availability and quality of data will vary. NMHSs can support health actions through the provision of weather and climate data, such as in the following examples (WMO, 2014):

a. Data collection and access: Specific measures may be needed as part of the adaptation strategy to improve

   i. the availability of historical and future hazard data, metadata, tools, and methodologies in hazard identification, monitoring, and mapping; but also

   ii. the availability of health exposure, impact, and vulnerability information, and user-capacity to incorporate climate information in routine health decisions.

b. Integrated data management: Health surveillance is analogous to systems for meteorological observations. Integrated data-management systems analyze and monitor social indicators from health surveillance alongside climate and environmental observations. Examples, standards, and tools for integrated data management should be sought.

c. Research and risk assessments: These require integrated data to link historical climate data and observations with qualitative and quantitative health vulnerability and exposure information.

Regional and global data and information products can sometimes be used to supplement locally available data. Applied and operational research is needed to ascertain the relevant temporal and spatial scale of both meteorological and health variables to be used to answer public health questions. Also needed is careful attention to data quality.

3.12.3 Disaster management

NMHSs can provide past climate data, which are essential for quantifying the hazard characteristics of a region, in particular the frequency, severity, and location of climatic extremes. For this, NMHSs retrieve and computerize all available data at the highest temporal and spatial resolution possible in order to capture the characteristic features of particular hazards. While historical climate data remain the prime resource for analyzing hydrometeorological hazard patterns, emerging trends in rainfall and temperature over the past few decades suggest that hazard characteristics may be changing. For instance, what had been a one-in-a-century flood or drought in a given location may now have become a one-in-a-30-year flood or drought. Essentially, the statistics of the past 10 to 20 years may be more representative of the current climate than the longer-term statistics. While there are statistical techniques for generating pseudo-records from relatively short records, the best hope of obtaining data for estimating future risk is through modeling of the climate system. As there is a significant difference between a hazard and disaster – with not every hazardous event becoming a disaster – NMHSs can pay special attention to gathering and documenting the meteorological and related conditions associated with the latter, since the information can often be used later in strengthening resilience during the post-disaster reconstruction phase. The disaster databases compiled by the insurance companies are useful resources for identifying events for which complementary weather and climate datasets could be compiled at the national level.

3.12.4 Water resource management

NMHSs can provide a wide range of data in different formats – point or distributed data, instantaneous or averaged – over different periods of time, to serve a number of purposes for water management. Many meteorological and hydrological models are now designed to produce probabilistic output for risk analysis, so the interfacing of climate data feeds with predictive water models is a complex matter. There are frequent gaps and mismatches between the nature and distribution of climate observing systems and those networks devised for water monitoring (WMO, 2015). An improved climate–water interface will enhance the structure and development of compatible observation networks by extending them to meet user needs and ensure the quality assurance of data. Recent decades have seen a progressive decline in the size and quality of meteorological and hydrological observing networks, especially in countries most at risk from climate- and water-related impacts. Of relevance, from the water perspective, is the World Hydrological Cycle Observing System (WHYCOS), a WMO program aimed at improving basic observation activities, strengthening international cooperation, and promoting the free exchange of data in the field of hydrology. It is implemented through various components (HYCOSs) at the regional and/or basin scale. Improved integration of climate and hydrological networks is seen as a necessary and essential initiative in improving the linkages between the climate and hydrological communities.

Water security in a variable and changing climate continues to be a key concern at the national, regional, and global scales. In addressing this concern, the critical importance of ongoing climate data for the assessment of fluctuations and trends in risks arising from exposure and vulnerability to climate variability and related natural hazards is well recognized for assisting countries and communities in optimal adaptation efforts. NMHSs can provide long time-series of climate data to the water sector in support of hydrological modeling, which will enable a greater understanding of the impacts of climate variability on water resources availability.

NMHSs can also address the need for, and the use and applications of, climate data to address the changes in the demand for water, through changes both in land use and also in the behavior of water users. Past weather and water observations have left an enormous legacy of data that now provide the basis of knowledge on climate variability and change. Water-management design depends heavily on historical data, whereas use of operational data may depend on rapid data delivery and assimilation into models. The technology and systems for electronic dissemination and exchange of data are generally present in most countries. However, in many developing countries, the speed, reliability, and capacity of systems is far from adequate. At the highest level, the WMO Information System is being developed to serve as the coordinated global infrastructure for the telecommunication and management of weather, climate, water, and related data.

3.12.5 Power management

Weather and climate data needs for five focal areas in the energy sector are shown in Table 3.3 below. There are also critical data needs for the different energy subsectors: wind, solar, hydro, and thermal. In the wind-power subsector, vertical gradients in mean wind speed and wind direction, as well as in turbulence intensity above the surface layer are critical to the construction, planning, and operation of wind turbines. The increase in current data needs led to a boom in surface-based remote-sensing techniques such as wind lidars (Emeis, 2014). For offshore wind parks, marine boundary-layer weather and climate variables need to be assessed. Accurate measurements of incoming irradiance are essential to solar power plant project design, implementation, and operations. In the absence of surface radiation measurements, estimates of surface radiation can also be made using meteorological ground measurements such as cloud cover, temperature, visibility, and water vapor in a radiative transfer model (Marion and Wilcox, 1994). Hydropower is obviously dependent on river flow, which depends on the following weather parameters: precipitation and snow amounts; air temperature, which in particular controls the snow melting process in spring in mountain areas; the altitude of the 0°C isotherm, which is of particular importance; and evaporation, which plays a strong role in controlling the water level in large-area reservoirs, in particular in tropical and subtropical regions. Floods and droughts have a strong impact on hydropower generation.

Focal area	Weather and climate data needs
Identification and resource assessment	• In-situ and satellite-derived meteorological data for the assessment of resources and risks. • Model-based, high-resolution historical meteorological data. • Climate change projections.
Impact assessments (including infrastructure and environment)	• High-grade in-situ data. • Detailed site-specific modeling. • Historical dataset and analyses of extreme events. • Projections of potential relevant meteorological and climate trends and changes. • Observations and monitoring of relevant climate-related variables for the identification and mitigation of environmental impacts (e.g., on human health and safety and on wildlife). • Air quality and gas emission database (e.g., carbon-based gases from shale gas extractions). • Database on weather/climate risks to hydroelectricity facilities, solar panel risks to buildings, energy transport risks to communities, etc.
Site selection and financing	• Very-high-grade in-situ data, both in terms of quality of instrumentation and temporal resolution. • Detailed site-specific modeling (e.g., wind-gust estimation, extreme low and high stream flows).
Operations and maintenance	• Site-specific ground station data. • Infrastructure-specific meteorological data. • Database and analyses of historical meteorologically-driven problem (forensic) events for operations and maintenance. • Forecasts at various lead times. • Communication methodologies for warning systems.
Energy integration	• Historical datasets of meteorological/climate variables relevant for energy demand, insurance, and energy efficiency. • Historical datasets of energy demand. • Model-based data to extend observation records. • Ancillary datasets such as energy-system response to weather variables. • Forecasts at various lead times. • Climate projections. • Site-specific ground station data for triggering weather index insurance policies.

Table 3.3: Weather and climate data needs for five focal areas in the energy sector

Generation of future projections

NMHS services on weather and climate extremes depend critically on the availability of high-quality climate observations with sufficient spatial coverage over a long period of time. NMHSs have collected a large amount of historical station observations, but only a few have digitized their entire daily to sub-daily data holdings. Fewer still have homogenized their long time-series and made these generally available. New actions for data rescue and digitization are necessary in many countries to improve the availability and accessibility of historical climate data sets. WMO recommends standard practices and promotes knowledge on techniques, procedures, and organizational matters of climate observations and data management. The Second Report on the Adequacy of the Global Observing Systems for Climate in Support of the UNFCCC (GCOS, 2003) developed the concept of Essential Climate Variables (ECVs) encompassing the atmospheric, oceanic, and terrestrial domains. The concept forms part of the Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC (GCOS, 2010) and has been endorsed by the Group on Earth Observations (GEO) in its work plan for the Global Earth Observation System of Systems (GEOSS). Surface air temperature and precipitation are the prime ECVs for the atmospheric domain.

The success of the Intergovernmental Panel on Climate Change (IPCC) assessments clearly indicates that climate science is advanced most effectively for the benefit of all users when knowledge and information are exchanged internationally and openly. Limiting accessibility undermines the generation of new knowledge about past climate change, potentially hindering the development of proper adaptation strategies. In fact, WMO requires a free exchange of data for the benefit of all countries. The covering letter for WMO Resolution 40 contains the statement that, "As a fundamental principle of the WMO, and in consonance with the expanding requirements for its scientific and technical expertise, WMO commits itself to broadening and enhancing the free and unrestricted exchange of meteorological and related data and products."

The continued accumulation of basic climate data is vital for understanding past and current climate change, improving projections that are well constrained by past observed changes, and developing strategies that ensure first and foremost that new infrastructure and systems are well adapted to current climate change. Climate monitoring is therefore absolutely necessary to provide important guidance as we navigate in the more uncertain world of climate change in near real time and attempt to adapt to those changes effectively and in the most cost-effective manner.

There is increasing concern that weather and climate extremes may be changing in frequency and intensity as a result of human influences on climate. However, natural variability masks anthropogenic trends, creating uncertainty in attributing the causes of climate change. Extremes are part of natural climate variability. Single extreme events cannot be simply and directly attributed to anthropogenic climate change if the event in question could have occurred naturally.

Improved data availability and knowledge of changes in extremes support the detection and attribution of anthropogenic influences on climate. Recent detection/attribution studies suggest that changes in extremes should be nearly as detectable (temperature) as or even more detectable (precipitation) than changes in the mean. Progress in this discipline of climate change research means that scientists will be able to determine (at some pre-specified confidence level) the extent to which anthropogenic influence has increased the risk of a particular extreme event relative to the climate for the same period that would have occurred in the absence of human influence.

3.13 Climate data presentation

This component concerns the recording of details relating to any data processing that has occurred to convert a sensor's signal into its recorded observation value. The following provisions are required:

- Software
- Technology
- Input source, such as instrument, element, etc.

- Data output, including data format and version of format
- Governance guidelines and processes.

It is assumed that tables and charts and GIS are methods of climate data presentation. To avoid repetition and facilitate reading, technology and governance guidelines are treated in the following three subsections: Tables and charts, Visualization (GIS), and Software and programs.

3.13.1 Tables and charts

Tables and charts generate a broad array of tabular and graphical reports to effectively communicate issues relating to climate data. Graphs can be presented in a wide array of formats, including scatter plots, histograms, wind roses, and time-series using one or more variables.

3.13.2 Visualization with GIS

Visualization with GIS involves generating a wide variety of cartographic output to effectively convey climate data issues. It includes spatial data preparation, cartography, and simple point-and-click web maps. GIS's graphical user interface includes photographs, diagrams, scanned documents such as scanned station records, video and recorded audio media, etc.

Meteorological and climatic data visualization and analysis are essential for researchers and forecasters to understand and apply these data. Such data are inherently spatially variable. The use of a GIS therefore represents a useful solution for the management of vast spatial meteorological and climatic datasets for a wide number of applications (Chapman and Thornes, 2003). The powerful mapping capability of GIS is a primary factor that makes it attractive to the atmospheric community (Dyras and Serafin-Rek, 2005). Layer-based visualization also supports the comparison of various aspects of a meteorological data set, and its spatial properties can be highlighted by incorporating geospatial information in GIS.

3.13.3 Software and programs

Various free and open-source software are used for the analysis of meteorological data. Customized software developed by commercial organizations is also used for very specific activities. However, before using these software packages it is necessary to check the following items:

- Software version
- Software language
- Software name
- Location of software source code
- Description of processing applied
- Formula/algorithm implemented
- Processor details (central processing unit's version, type, etc.)
- Date/time covering the period of validity of the method
- Input source (instrument, element, etc.)
- Data output, including data format and version of format.

Although GIS strategies have become increasingly popular in meteorological applications (Dyras and Serafin-Rek, 2005), commercial GIS software packages are normally very expensive and complex to operate for most users in meteorological fields. Furthermore, these packages are not able to conveniently deal with some popular meteorological data formats such as General Regularly Distributed Information in Binary Form (also known as gridded binary or GRIB) and Network Common Data Form (NetCDF). Consequently, the atmospheric science community has developed several customized data visualization and application tools such as the Grid Analysis and Display System (GrADS), Ferret, and NCAR Command Language (NCL). These tools normally use command-line interfaces and are not closely linked with the GIS community. A climate mapping tool was developed for dealing with climate mapping issues (Matuschek and Matzarakis, 2011), but its functions are rather limited.

The development of components with GIS functions is also useful for software developers in satisfying the demands present in meteorological fields for spatial data view and analysis (Rebolj and Sturm, 1999). Providing a programming library that includes both GIS and meteorological data analysis functions would be a benefit for software and application developers. It was therefore considered a worthwhile endeavor to develop a free component-based GIS software suite that can conveniently visualize and analyze meteorological data by supporting most of the popular meteorological data formats and also provide basic mathematical functions for grid and station data sets. The result of this endeavor was the software package MeteoInfo, which promotes the incorporation of GIS in meteorological fields and provides users with a free and effective software tool. . It uses C# programming language for applying GIS technology in meteorological data visualization and analysis. MeteoInfo includes a .NET class library for software developers and a desktop application for end users. The capability for scripting is provided though the inclusion of IronPython. MeteoInfo is freely available at http://www.meteothinker.com.

Box 3.5 Theory into Practice

Implementation of Learning

Climate data are essential inputs for all sorts of socio-economic activities, including day-to-day weather forecasting, early warning, disaster management, sector-specific operation and management, etc. This module helps participants to understand climate data collection procedures, sources of different kinds of data, data presentation techniques, data distribution by the NMHSs, and the ways in which participants will be able to use relevant data to support any kind of decision-making. It has also covered the important climate policies adopted in Bangladesh that address adaptation to and mitigation of future challenges arising due to climate change as they affect different sectors.

For data on Bangladesh's climate, please visit the following:

Temperature data from the Bangladesh Meteorological Department: http://bmd.gov.bd/p/Temperature-Data

Bangladesh Climate Data Portal: http://bmd.wowspace.org/

Bangladesh Climate Database: http://data.gov.bd/dataset/bangladesh-climate-database

3.14 Group work

Develop a case study

Objective: Working in groups, participants are requested to develop a climate information dissemination plan. For this, they must identify the initiator/sender, the recipient, the mode of dissemination, the message, and the effect. When needed, participants are encouraged to refer to specific and relevant policies and plans. Participants are also urged to adopt the view of the target recipient.

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Notes

MODULE 4

Mainstreaming of climate change in national policies, plans and strategies

Overview of the training module

4.1 Brief introduction to the module

Subject

Mainstreaming of climate change in national policies, plans, and strategies

Learning outcomes

This module will help learners to acquire elementary and succinct information, knowledge, and an understanding of the national and sectoral policies related to climate change in Bangladesh. Learners will come away with an improved understanding of the sectoral planning related to national adaptation plans (NAPs) and nationally determined contributions (NDCs) as well as their interlinkage with climate change adaptation and mitigation plans and policies. Learners will develop an overall understanding of entire policy scenarios and will critically analyze gaps and needs for mainstreaming climate change in national planning.

Topics

- Key national climate change plans, policies, and strategies in Bangladesh
- Climate change in key national development policies and strategies
- Synopsis of the NAP sectoral strategies and actions
- Synopsis of the NDC sectoral strategies and actions
- Critical analysis and integration of climate change in Bangladesh

Overview of national plans, policies, strategies, and key issues regarding climate change in Bangladesh

4.2 Key national climate change plans, policies, and strategies in Bangladesh

4.2.1 National Adaptation Programme of Action

Bangladesh developed its first National Adaptation Programme of Action (NAPA) in 2005 based on the country's discussions at the Seventh Session of the Conference of the Parties (COP 7) of the United Nations Framework Convention on Climate Change (UNFCCC) (MoEF, 2005). NAPA 2005 acknowledged Bangladesh's increasing vulnerability to climate change and extreme weather events given the nation's dependence on natural resources for livelihoods, its low economic and social development, and its institutional capacity. The document highlighted the major impacts of climate change on the water sector and disproportionate impacts on the coastal zone. Floods, droughts, water scarcity due to reduced rainfall and increased evapotranspiration in the dry season, sea level rise, and increasing surface and soil salinity are identified as the major impacts of climate change in the country. The plan suggested several priority actions for adaptation such as community-oriented afforestation, salt-tolerant agricultural fisheries, and the provision of safe drinking water in the coastal areas of the country's south.

For Bangladesh's northern regions, the NAPA promotes diversified agricultural and fish production to adapt to the impacts of a changing climate. In addition to region-specific interventions, soft and long-term measures such as enhanced research, training and capacity-building actions, and mainstreaming in the national education system were suggested to prepare the nation to combat climate change.

The development of the NAPA involved the participation and consultation of different stakeholders and actors from both government and non-government entities. However, while the plan highlighted that the worst impacts of climate change will be felt by the most vulnerable communities and marginal groups, it does not address the involvement of these populations in preparing the plans and recommendations. It also outlined several challenges such as the need for institutional capacity-building, funding limitations, and the lack of coordination between governing and implementing agencies (MoEF, 2005).

In 2009, the plan was revised and updated with an emphasis on integrating adaptation into the overall development plan and implementation process for building a climate-resilient and sustainable economy (MoEF, 2009). The revisions highlighted how climate change can negatively impact the national economy in terms of the loss of and damage to wellbeing, livelihoods, biodiversity, land, etc. NAPA 2009 also showcased the Bangladesh government's national and international efforts, commitments, and resource allocations aimed at prioritizing adaptation in the development agenda. These include, for example, the allocation of USD 100 million by Bangladesh's Ministry of Finance for the implementation of adaptation action plans and strategies, the delivery of coastal greenbelt afforestation projects, and the establishment of a multi-donor trust fund to tackle both adaptation and mitigation interventions (ibid.).

One of the notable features of the document is a call for transformation from immediate and short-term actions to medium- and long-term adaptation planning. It highlights the agriculture sector, alongside water, as one of the sectors most impacted by climate change. Furthermore, it prioritizes food, energy, water, and livelihood security, placing an emphasis on the respect and participation of local communities in resource management and extraction.

Finally, the 2009 NAPA recommends the expansion of research and knowledge management through multidisciplinary analysis, the application of models on relevant sectors, and the building of a dedicated center for managing and connecting climate change data, information, and stakeholders. Specific adaptation measures were also suggested for the agriculture, livelihood, health, infrastructure, biodiversity, gender inclusion, and disaster management sectors. The plan addresses the need to develop the capacities of the key government agencies and officials so they can effectively undertake and oversee adaptation interventions and can mainstream climate change in the country's national, sectoral, and development planning.

Drawing on contemporary findings from national and international scientific and research outputs, the 2005 and 2009 NAPA documents both set out detailed physical vulnerabilities to climate change and climate variability as they affect multiple sectors. They also provide justifications for the selection of sectors and priority actions.

4.2.2 Bangladesh Climate Change Strategy and Action Plan

The Bangladesh Climate Change Strategy and Action Plan (BCCSAP) was initially prepared as a live document in 2008 to accommodate national development and political priorities. The preparation of BCCSAP 2009 also involved including the visions and revisions of the relevant ministers and sectors secretariats with a view to strengthening sustainable development, poverty alleviation, and enhanced social wellbeing for people, especially those most vulnerable (women and children) in the country (MoEF, 2009). The plan focuses on developing pro-poor climate change action and strategies to reduce disaster risk and address the need for both adaptation and mitigation. To achieve this, it features a proposal for a 10-year program as well as the following six pillars:

- Food, social, and health security to ensure fundamental needs and services for the poorest communities and marginal groups.
- Enhancement of the existing disaster management system in order to develop a comprehensive one.
- Climate proofing and good maintenance of infrastructure, such as coastal and river protection structures, to protect against increasing natural hazards.
- Research and knowledge management to improve understandings of climate impacts on socio-economic and environmental sectors, financial needs, and global advocacy.
- The promotion of low-carbon development that meets energy demand using climate-friendly sources.
- Building the capacity of public, private, and civil-society entities to realize institutional development and mainstream climate change.

The BCCSAP specifies and provides justifications for the implementation of around 44 programs. It also sets out a governance plan that includes the formation of national environment committees and units headed by the head of state, ministers, and representatives from relevant government ministries and departments. Table 4.1 briefly describes the proposed program, which is estimated to cost around USD 500 million to prepare and initiate and a further USD 5 billion over five years. The BCCSAP therefore represents a step forward on earlier documents (NAPAs), providing succinct plans, programs, and actions that incorporate adaptation and mitigation needs in the country's vision for socio-economic development and do so in a way that prioritizes the most vulnerable people.

The mitigation action plans intend to improve energy efficiency, expand existing renewable and solar energy initiatives, improve thermal energy production and waste management, and reduce emissions from agricultural land. Additional conditional actions include facilitating the replacement of biomass with liquefied petroleum gas (LPG) at the household level, promoting rainwater harvesting at the commercial level, reducing methane emissions from livestock though the mechanization of agricultural practices, and extending reforestation and afforestation initiatives in the country. Bangladesh's 2015 Intended Nationally Determined Contributions (INDCs) also highlighted the country's investment in adaptation with USD 400 million allocated to the Bangladesh Climate Change Trust Fund (BCCTF), which funded more than 236 projects up to mid 2015 (MoEF, 2015). Detailed discussion of the BCCTF is provided in section 4.4. However, implementing key mitigation and adaptation actions is estimated to require about USD 27 billion and

USD 42 billion of investment respectively. The INDC also proposed the development of the Climate Fiscal Framework for resource allocation and effective implementation and the national monitoring, reporting and verification (MRV) system for mainstreaming adaptation initiatives.

Theme	T1	Food security, Social Protection and Health
Programme	P1	Institutional capacity for reach towards climate resilient cultivators and their dissemination
	P2	Development of climate resilient cropping systems
	P3	Adaptation against drought
	P4	Adaptation in fisheries sector
	P5	Adaptation in livestock sector
	P6	Adaptation in health sector
	P7	Water and sanitation programme in climate vulnerable areas
	P8	Livelihood protection in ecologically fragile areas
	P9	Livelihood protection of vulnerable socio-economic groups (including women)
Theme	**T2**	**Comprehensive Disaster Management**
Programme	P1	Improvement of flood forecasting and early warning
	P2	Improvement of cyclone and storm surge warning
	P3	Awareness raising and public education towards climate resilience
	P4	Risk management against loss on income and poverty
Theme	**T3**	**Infrastructure**
	P1	Repair and maintenance of existing flood embankments
	P2	Repair and maintenance of cyclone shelters
	P3	Repair and maintenance of existing coastal polders
	P4	Improvement of urban drainage
	P5	Adaptation against floods
	P6	Adaptation against tropical cyclones and storms surges
	P7	Planning and design of river training works
	P8	Planning, design and implementation of resuscitation of river and khals troughs dredging and de-silation work

Theme	**T4**	**Research and Knowledge Management**
Programme	**P1**	Establishment of a centre for knowledge management and training on climate change
	P2	Climate change modelling at national and sub-national levels
	P3	Preparatory studies for adaptation against sea level rise
	P4	Monitoring of ecosystem and biodiversity changes and their impacts
	P5	Macroeconomic and sectoral economic impacts of climate change
	P6	Monitoring of internal and external migration of adversely impacted population and providing support to them through capacity building for their rehabilitation in new environment
	P7	Monitoring of impact on various issues related to management of tourism in Bangladesh and implementation in priority action plan
Theme	**T5**	**Mitigation and Low Carbon Development**
Programme	**P1**	Improved energy efficiency in production and consumption of energy
	P2	Gas exploration and reservoir management
	P3	Development of coal mines and coal fired power stations
	P4	Renewable energy development
	P5	Lower emission from agricultural land
	P6	Management of urban waste
	P7	Afforestation and reforestation programme
	P8	Rapid expansion of energy saving devices. e.g, Compact Fluorescent Lamps (CFL)
	P9	Energy and Water Efficiency in Built Environment
	P10	Improvement in energy consumption pattern in transport sector and options for mitigation
Theme	**T6**	**Capacity Building and Institutional Strengthening**
Programme	**P1**	Revision of sectoral policies for climate resilience
	P2	Mainstreaming climate change in national, sectoral and spatial development programmes
	P3	Strengthening human resource capacity
	P4	Strengthening gender consideration in climate change management
	P5	Strengthening institutional capacity in the media

Table 4.1: BCCSAP thematic areas and proposed program (MoEF, 2009)

4.2.3 Intended Nationally Determined Contribution plan

In addition to developing national plans, Bangladesh also prepared and submitted its first INDC plan in 2015 for reducing national greenhouse gas (GHG) emissions as required by the Paris Agreement (despite Bangladesh being one of the lowest emitters of GHGs) (MoEF, 2015). The 2015 INDCs comprise the nation's overall mitigation and emission reduction plan for three key sectors: power, transport, and industry. Both unconditional and conditional reduction goals and mitigation actions are proposed to gradually establish a low-carbon and climate-resilient national economy. The country committed to use existing resources and unconditionally reduce emissions by 5% (12 MtCO2e) by 2030 in the three aforementioned sectors. However, with financial, technological, and capacity support these efforts can rise to 15% (36 MtCO2e) on the business-as-usual (BAU) condition (ibid.).

4.2.4 The Roadmap and Action Plan for Implementing Bangladesh NDC: Transport, Power, and Industry Sectors

The Roadmap and Action Plan for Implementing Bangladesh NDC: Transport, Power, and Industry Sectors was developed in 2018 by the Ministry of Environment, Forest, and Climate Change (MoEFCC) in collaboration with respective ministries in order to support the country's Nationally Determined Contribution (NDC) mitigation actions and strategies (MoEFCC, 2018a). The action plan identifies good governance and effective coordination between government, non-government, and civil society actors as essential for the successful implementation of the NDCs. Additionally, it recommends capacity development for advancing the mitigation analysis, policy design, and implementation. The roadmap proposes a governance structure for implementing both the NDC and the National Adaptation Plan (NAP) consisting of advisory, coordination, and implementation wings that will support sectoral adaptation and mitigation actions. It also outlines the need and approaches for (i) financing and accessing public and private funding to support the implementation plans and (ii) developing national MRV systems to track GHG emissions and ensure transparency requirements are met. In total, 28 cross-sectoral actions are suggested, with sectoral measures involving the power, transport, and industry sectors. The power sector aims, by 2021, to work on 35% power generation from coal and 35% from natural gas and to invest in wind and solar capacity that achieves 10% renewable energy in the mix. Bangladesh has already made significant progress in solar home systems, with a goal to provide six million such systems by 2021 (MoEFCC, 2018a). The plan suggests offering government incentives and suitable tariff systems for scaling up the implementation and application of renewable energy in the nation. Additionally, Bangladesh is constructing a nuclear power plant in Rooppur (the first two units of which are estimated to cost USD 12 billion), which can significantly reduce the power sector's dependence on coal and thus reduce the national carbon footprint (MoEFCC, 2018a).

The power sector has outlined challenges regarding funding allocation, relatively large initial costs, and the lack of relevant expertise and experience in promoting and implementing renewable- and clean-energy projects. Land availability has also been found to be a constraint for implementing large-scale government-led renewable energy interventions. The transport sector is working on building a wider, six-lane highway between Dhaka and Chattogram (NH1); on developing a mass rapid transit system, elevated expressway, and circular waterways in the capital; on improving the railway systems to create an energy-efficient transport system, with reduced freight and passenger transport; and on enhancing its market share of these sectors.

The transport sector plans to adopt an "avoid-shift-improve" framework to reduce the demand and need for transport, move over to low-emission systems, and increase fuel and vehicle efficiency. However, the key challenges for moving toward energy-efficient and climate-friendly transportation systems are, in addition to deficits in funding, the lack of data, capacity, and understanding of the overall costing and mitigation co-benefits from the transport sector and the lack of coordination between respective agencies.

The industry sectors intend to focus their work on high-emitting subsectors such as brickmaking (55% of the total GHG emissions from manufacturing subsectors) and textiles and leather (24% of GHG emissions from manufacturing subsectors) and on emerging sectors such as food and chemicals (with 3% and 4% GHG emissions from these manufacturing subsectors respectively), cements, ready-made garments, etc. (MoEFCC, 2018a). The roadmap for industry recommends developing and implementing a policy, management, and financing framework and measures for achieving energy-efficiency in this sector in Bangladesh. Additional suggestions are for government to engage in concerted data collection efforts to improve sectoral understanding;

awareness raising on carbon emissions from this sector; and the facilitation, promotion, and strengthening of the environmental permits system and of green buildings that perform well in the Leadership in Energy and Environmental Design (LEED) rating system. The sector has highlighted that there is a lack of technical capacity and expertise for the identification and implementation of energy-efficient interventions, that the capital and financing available for relevant projects is deficient, and that the incentives for industrial investment and improvements in energy efficiency are low as energy subsidies reduce the cost of energy.

4.2.5 Mujib Climate Prosperity Plan

Bangladesh has also published its preliminary report for the Mujib Climate Prosperity Plan, which aims to integrate climate resilience and foster low-carbon economic growth to enhance national prosperity and partnerships. The aim of this plan is to move the nation from vulnerability to resilience to prosperity with four major objectives (Mujib Plan, 2022).

a. Reach high upper-middle-income status in a single decade by increasing growth and maximizing resilience. This includes incorporating financing to address loss and damage, building locally led adaptation hubs, increasing gender inclusion, promoting the digital economy, and enhancing financial protections with the expansion of the green economic partnership.
b. Consolidate a climate-resilient, low-carbon, resource-efficient, gender-responsive, and socially inclusive economy that promotes the rapid growth of employment opportunities, develops the skills relevant for green tech jobs, and ensures protection from heat stress in the workplace.
c. Promote physical and psychological wellbeing by enhancing mobility, ensuring clean air, and developing special health programs, and support arrangements to develop sustainable traditional lifestyles, practices, and living.
d. Transform the nation into a net green energy exporter by securing resilience and energy security (reaching 30% renewable energy by 2030 and at least 40% by 2041) and independence.

The Mujib Plan also mentions the country's flagship energy projects, including the Mujib Bongoposagor Independence Array, which is the first large-scale hybrid renewable energy and adaptation infrastructure project to restore and protect the coastline and natural habitats. The plan will serve as the national climate resilience strategy and foresees investment opportunities of about USD 80 billion over the next decade in energy, water, transport, supply chains, and value chains. About 62% of the investments are expected to be in adaptation and 25% in enhancing resilience, with the remainder going to loss and damage and low-carbon co-benefits. It is proposed to seek potential financing through international investment and through national funding via public-private partnerships (PPP) and investment tools from Bangladesh Bank such as preferential refinancing rates, differentiated capital requirements, special leasing facility windows, de-risking instruments, etc.

4.3 National climate change funding policies

4.3.1 Climate Change Trust Act

To implement the strategic plans and programs outlined in the BCCSAP (MoEF, 2009) and to respond to national climate change impacts, in 2010 the Government of the People's Republic of Bangladesh enacted the Climate Change Trust Act (GoB, 2016). The trust fund provided for in this act is designed to initiate and implement adaptation, mitigation, and capacity-development measures, as well as projects and programs that will simultaneously tackle the impacts of climate change and ensure sustainable development. The trust can carry out research and awareness initiatives aimed at building the capacities of institutional, social, and local entities to deal with climate-related natural disasters. It can also assist in implementing relevant short- and long-term programs in concert with the relevant government ministries and department. It is proposed that the board of trustees will be headed by the minister in charge of the MoEFCC, and its members will include ministers and officials from associated sectors such as water resources, agriculture, finance, disaster management, etc. The board can allocate a maximum of 66% of the total trust fund to the implementation of the BCCSAP program, while the remainder can be used for other purposes. A technical committee, mostly comprising officials from different ministries, will work under the board to formulate the budget, actions plans, and policies. The fund can accept local, national, and international government and donor funds to fulfil adaptation and mitigation needs in the country. The country has already allocated some USD 400 million from the annual budget to the trust fund.

4.3.2 Climate Change Resilient Fund

With the support of development partners (EU, UK, etc.) and the World Bank, Bangladesh has also established the Climate Change Resilient Fund (BCCRF) to implement initiatives addressing the six pillars identified in the BCCSAP. Managed by the Government of the People's Republic of Bangladesh, with technical support from the World Bank, this multi-donor trust fund received USD 190 million in grant funds (GED, 2013) to build a climate-resilient nation. The intention is that government institutions implement 84.6% of total activities, while NGOs and community-based programs undertake 10% of the activities (World Bank, 2022).

Box 4.1 Third National Communication to the UNFCCC

Bangladesh submitted its Third National Communication in 2018 to showcase its commitment as a signatory to the UNFCCC and disseminate the status quo of climate change mitigation and adaptation responses, strategies, and actions in the country (MoEFCC, 2018b). The communication document outlined overall physical vulnerabilities and impacts of climate change across different sectors and highlighted relevant actions and strategies that may require or may be applied in future interventions. Alongside reaffirming the situation of natural and climate disasters in Bangladesh and their impacts on natural resources, livelihoods, and the economy, the Communication also shared a nationwide GHG inventory covering major sectors including (1) energy (electricity generation including biomass burning, transport, and energy consumed by the industrial sector), (2) industrial processes and product uses (IPPU; namely, cement manufacturing and fertilizer), (3) agriculture (ruminant livestock, livestock management, and rice cultivation), (4) land use change and forestry (changes in forest cover and woody biomass, changes in forest land use and forest resources removal), and (5) waste and refuse management (municipal waste, and domestic and industrial waste water treatment/management).

The Communication suggests that, while Bangladesh's energy sector emissions remain within the committed limit, emissions from the power sector may increase in future and therefore require a policy framework and regulations for a low-carbon development pathway. The GHG inventory suggests that all potential sources in the country contribute to a total of 152.27 MtCO2e emissions, which can increase by 150% from the base year of 2011 and 2012 to 339.69 MtCO2e in 2030. Power, transport, and industry can collectively increase emissions by 264% from 64.20 MtCO2e to 233.76 MtCO2e over the same timeline (MoEFCC, 2018b). Thus, potential mitigation action will require national and global finance to reduce emissions from these major sectors and to facilitate the implementation of renewable energy options such as solar PV, biomass, and wind. Additionally, due to its impacts on infrastructure, a 2°C rise in global average temperature can incur a 1.5% loss in Bangladesh's annual gross domestic product (GDP) by 2050 and a further 0.62% loss by 2100, while a 4°C global average temperature rise could see a 2% and 1.07% loss respectively. The Communication therefore stresses the importance of mainstreaming and integrating climate change aspects in national development, poverty reduction, and legal frameworks, which entails concerted action from all stakeholders and actors including all advisory, implementation, coordination, and knowledge-generation agencies.

4.4 National development strategies

4.4.1 National Sustainable Development Strategy

The initial draft of Bangladesh's National Sustainable Development Strategy (NSDS) (2010–2021) was drawn up by the MoEFCC. However, the Strategy was ultimately assigned to the Planning Commission's General Economics Division, which went on to develop strategies for delivering sustainable economic growth that balances social, environmental, and development needs in the country (GED, 2013). The NSDS identifies climate change as a challenge for and barrier to sustained economic growth and development, considering it to be a cross-cutting area along with good governance and gender and disaster risk reduction. The strategy mostly follows the BCCSAP's directions and guidelines on the sectoral impacts of climate change on agriculture (food security), water resources, natural disaster, and urban development. Afforestation, climate-stress-tolerant crops, climate-proof coastal polders, the mainstreaming of climate change, and the utilization of relevant funds are stated as the notable strategic elements for dealing with risks associated with disaster and climate change. Additional strategies include adaptation actions, mitigation, technology transfer, and capacity building in agriculture, industry, energy, and the urban housing sectors. The NSDS also found the adverse impacts of climate change to be an impediment to livelihood development and the achievement of the Millennium Development Goals, which now requires adaptation to these impacts. The Strategy suggests several plans and strategic measures, including enhancing regional cooperation for data and knowledge generation and for innovation in adaptation for agriculture and disaster management; integrating climate change into social safety net programs so development investment is risk proof; building gender sensitivities into adaptation strategies and actions; and conducting urban community risk assessments to evaluate cities' disaster and climate-change risks. Finally, the NSDS also recommends building the capacities of government ministries, departments, and other technical stakeholders so they can be included in the respective sectoral planning, programs, and funding for disaster risk reduction and climate change adaptation. It also stresses the importance of using the Trust Fund and BCCRF, accessing necessary information, and ensuring the livelihoods of the most marginal and vulnerable communities through adaptation.

4.4.2 Country Investment Plan for Environment, Forestry, and Climate Change

In 2017 the then Ministry of Environment and Forests (MoEF) prepared the Country Investment Plan (CIP) for Environment, Forestry, and Climate Change (EFCC) (2016–2021), a process that involved extensive multi-stakeholder and multi-ministerial consultation at the divisional, district, and local levels (MoEF, 2017). The CIP sought to improve the provision of ecosystem services for poverty alleviation and enhance environmental and human wellbeing and benefits to build resilience in the face of climate change. The CIP, which was published as a live document, aligns its strategies with prior national short- and long-term environmental, climate change, and development plans such as Vision 2021, BCCSAP, and the Sustainable Development Goals.

The CIP focuses on four key pillars and 14 programs, and it has 43 sub-programs to be implemented by at least 77 government agencies (ministries/divisions/departments). About 40% of the total investment plan of USD 11.7 billion is already financed by the government and development partners. The first three pillars still require an average of USD 2 billion for the implementation of investment programs and projects in environmental protection, sustainable forest management, climate change adaptation and mitigation, and environmental governance.

No	Programme title	Financing (USD million)			
		CIP Total	Existing	Gap	Gap (%)
Pillar 1: Sustainable development and management of natural resources					
1.1	Enhanced sustainable management of and socio economic benefits from, forests	885	54.2		94
1.2	Biodiversity conservation	538.5	44.9		92
1.3	Sustainable management of wetlands, rivers and marine ecosystems	693.1	490.5		29
1.4	Soil and groundwater management	343.5	52.8		85
	Total (Pillar 1)	**2460.1**	**642.3**	**1817.8**	**74**
Pillar 2: Environmental pollution reduction and control					
2.1	Reduced industrial pollution	651.6	65	586.6	90
2.2	Reduced municipal and household pollution	2868.2	1040.5	1828.7	64
2.3	Reduced pollution from agriculture and others	198.6	3.3	195.3	98
	Total (Pillar 2)	**3719.4**	**1108.8**	**2610.6**	**70**
Pillar 3: Adaptation and resilience o, and mitigation of,, climate change					
3.1	Disaster risk reduction	1654.7	724.1	930.5	56
3.2	Sustainable infrastructure development	2202.4	1705.5	496.9	23
3.3	Mitigation and low-carbon development	783.3	255.6	321.7	42
3.4	Increased resilience at community level	251.6	36.2	215.4	86
	Total (Pillar 3)	**4892**	**2921.4**	**1970.6**	**40**
Pillar 4: Environmental governance, gender, and human and institutional capacity development					
4.1	Improved legislative regulatory and policy framework	82.5	6.5	76	92
4.2	Improved stakeholder participation and gender equity in the EFCC sectors	416.5	4.3	412.2	99
4.3	Improved organizational capacity and processes for evidence-based decision making	109	29.6	79.4	73
	Total (Pillar 4)	**608**	**40.4**	**567.6**	**93**
	Total cost of CIP	11679.5	4713	6965.5	60

Table 4.2: Four key pillars of the CIP-EFCC and their recommended programs (MoEF, 2017)

While environmental governance has the largest gap in financing overall, several sub-programs such as pollution control from agriculture, stakeholder perceptions, and gender equity are almost 100% underfinanced. For this reason, this cross-sectoral investment framework stresses the importance of strong political commitment to the planning, mobilization, coordination, and implementation of the proposed EFCC programs.

4.4.3 Perspective Plan of Bangladesh 2021–2041

In 2020, Bangladesh's Planning Commission published a major long-term planning document, Making Vision 2041 a Reality: Perspective Plan of Bangladesh 2021–2041, with the objective of completely eradicating poverty and transforming the nation into a high-income country by 2041 (GED, 2021). One of the Plan's key strategies is to build resilience to climate change and other environmental challenges in the country.

Food security, nutrition, and agriculture are highly prioritized in the Perspective Plan, which puts forward inter-sectoral policies for developing a modern, diversified, and climate-resilient agricultural system over the long term. Its strategic initiatives include transforming the unfavorable agri-ecosystem through productive sustainable agricultural practices, crop intensification that avoids the need for converting more land to agricultural use, the development of climate-resilient crop and livestock production systems, and adaptation to adverse impacts of climate change.

The Perspective Plan emphasizes enhancing local adaptive capacity with improved climate research and information, climate-smart production technologies, heat- and salinity-tolerant crop production, effective irrigation with optimization of water use, and early warning systems. It also encourages good agricultural practices such as conservation agriculture, the integrated plant nutrition system, and integrated pest management. Water conservation and management are also prioritized, with an emphasis on scaling up integrated water management, flood control and prevention schemes, the prevention of surface water pollution, improved flood early warning and irrigation systems, and irrigation improvement. For the forestry sector, the Perspective Plan includes strategies for public-private partnerships as a means to promote the uptake of reforestation and afforestation.

These strategies seek to integrate environmental and climate change aspects in order to ensure the green economic growth needed to transform Bangladesh into a developed economy. Alongside them there are also institutional and policy reform strategies that include the implementation of the Delta Plan (discussed in the next section) to reduce vulnerability and build resilience to climate change, and the adoption of a green tax for fossil fuel consumption and an emission tax for industry. The strategies also include innovative options for acquiring funding from public, private, and global sources such as the Green Climate Fund.

4.4.4 Eighth Five-Year Plan (2021–2025)

In 2021 the Planning Commission of the Government of the People's Republic of Bangladesh published the country's Eighth Five-Year Plan (2021–2025) with the aim of providing strategic guidelines for the implementation of the Perspective Plan 2021–2041 and Bangladesh Delta Plan 2100. This Five-Year Plan also integrates climate change and environmental challenges into its core strategies for recovering from the economic stress due to the COVID-19 pandemic, developing relevant sectoral plans to eradicate extreme poverty, meeting the Sustainable Development Goals, and becoming an upper-middle-income country by 2031. Resilience to climate change and natural disasters is also one of the core themes of this Five-Year Plan, with water resources, agriculture, air pollution, the sustainable use of natural resources, increased forest coverage, and biodiversity all identified as key sectors for reducing long-term climate risk and adapting to the negative impacts of climate change.

The Five-Year Plan also gives high priority to the integration of climate change in national growth strategies, institutional reforms, and fiscal policy management through the factoring of environmental costs into the macroeconomic framework, the adoption of a green tax and an industrial emission tax, and the reduction of air and water pollution. The Five-Year Plan focuses heavily on the implementation of the country's long-term water management strategy, the Bangladesh Delta Plan 2100, which incorporates land, environment, climate change, and biodiversity in climate adaptation and risk reduction. The re-excavation of rivers, canals, and wetlands, the assimilation of the Climate-Smart Integrated Coastal Resource Database, and the optimization of water usage and economy are planned to ensure long-term water management and security, and sustainable agriculture.

The Five-Year Plan's strategic priorities include investment in agriculture sector innovation and research to increase crop productivity, the breeding and introduction of saline- and drought-tolerant crops, harvesting and production technology, and climate-resistant seed. There will also be a focus on areas that experience severe erosion, drought, waterlogging, and salinization. The Plan's strategies on climate finance and investment include the integration of environmental conservation in budgetary management; the proper governance, coordination, and budget-tracking systems required to facilitate the acquisition of global climate funding; the application of the Climate Fiscal Framework and Medium-Term Budget Framework developed by the Ministry of Finance; and third-party monitoring of the Climate Change Trust Fund (CCTF), parliamentary oversight, etc., to ensure transparency in spending and fiscal management.

The Five-Year Plan also highlights the previous development of a pro-poor climate change management strategy and the mainstreaming of climate change and disaster management in national planning with a focus on adaptation, risk reduction, low-carbon development, a decarbonized economy for a net zero-carbon economy, research and innovation, and investment in and initiatives for local government.

Some of the Plan's other key strategies outlined for dealing with the impacts of climate change and ensuring sustainable economic growth include improving the information and adaptive capacity of local government; designing and developing climate-resilient road transportation; exploiting renewable energy resources; setting up the Climate Change and Health Promotion Unit to strengthen and build the capacity of health systems; setting up a fund for the housing of climate-affected and displaced communities; promoting enhanced cooperation with actors from civil society and non-government organizations (NGO) for the development of effective adaptation actions, coordination, and knowledge sharing at the local level; and developing a gender-inclusive climate change response framework. Furthermore, the Plan acknowledges the challenges related to the lack of data, institutional memory, human resources, technical skills, and capacity in the MoEFCC, Forest Department, and Department of Environment (DoE); the lack of coordination among sectoral ministries and departments; the absence of local government institutions for environmental management; and the gaps in financing for the effective design, policy development, and implementation of climate change programs (the total public expenditure of Bangladesh's water, land, and environment ministries comprises only 0.39% of the country's GDP). However, to overcome the institutional and financing challenges, the Five-Year Plan sets out numerous recommendations and future strategies, such as making the Bangladesh Delta Plan 2100 into the umbrella plan for coordinating adaption and mitigation plans and strategies; getting the DoE involved in promoting adaptation and mitigation technology transfer from developed countries through the Climate Technology Centre and Network and the Joint Crediting Mechanism; developing and maintaining proper management information systems in the DoE and Forest Department; building the capacity of and operationalizing the BCCTF in order to optimize the Climate Change Trust Fund; and engaging Bangladesh's Economic Relations Division in efforts to access international funds. Finally, the Five-Year Plan provides for comprehensive policy development that integrates disaster risk reduction and adaptation as a means to address loss and damage due to the sudden shocks and extreme and slow-onset events caused by climate change.

Synopses of sectoral strategies and actions

4.5 Synopsis of the NAP sectoral strategies and actions

Multiple sectors and sectoral adaptations have been highlighted in previous climate change plans, policies, and strategies. The majority of these policies, including the national development policies, emphasized adaptation in the areas of water resources, agricultural and food security, coastal zone and urban transition, and disaster management. This and the next section (4.5 and 4.6) provide synopses of the sectoral strategies contained in the latest climate change policies such as the BCCSAP (MoEF, 2009), the Roadmap and Action Plan for Implementing Bangladesh NDC (MoEFCC, 2018a), the Third National Communication to the UNFCCC (MoEFCC, 2018b), and the Nationally Determined Contribution (MoEFCC, 2021). For example, the 2018 Third National Communication (TNC) provides a short inventory of adaptation approaches based on the temporal aspects and impacts of climate change where anticipatory and reactive actions mean measures taken to adapt to future and present climate change impacts respectively.

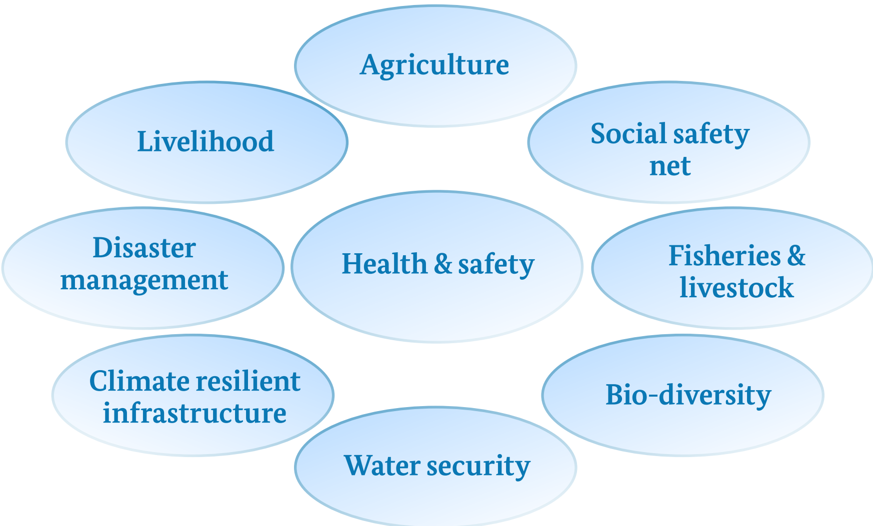

Figure 4.1. Major adaptation sectors in Bangladesh (source: MoEFCC, 2018a)

In the water sector, the BCCSAP and TNC recommend improving early warning systems by reviewing and updating the hydrometeorological data network with river stage and topography information, the dissemination of 10-day forecasts, and awareness-raising and training for local people. The adaptation strategies they propose for dealing with water-related issues and disasters, such as flooding, storm surges, droughts, etc., include the construction of cyclone shelters, the enhancement of coastal flood protection embankments and drainage systems, the raising of roads and railways for flood proofing, the provision of potable drinking water, and possible industrial relocation. In addition, they suggest that the water sector develop comprehensive and participatory actions and investment plans for coastal, char, hilly, and wetland regions that consider the potential impacts of climate change on income, health, and employment.

The key strategies proposed for adaptation in agriculture include: food security; improved climate-resilient cropping, fisheries, livestock systems, and saline-tolerant crops; agricultural research; the development of surveillance systems for new and existing disasters; capacity development of vulnerable communities and marginal groups (such as women and children); livelihood diversification; and the implementation of programs that ensure access to basic environmental services (water, sanitation, medicine, etc.) and social services (social safety net, and the development and piloting of individual, household, and communal insurance schemes).

Strategies planned to help farmers cope with climate change include: research and field trials for heat, drought, and saline-tolerant rice variants and other foods and vegetables; the identification of agro-economic zones vulnerable to climate change; the development of inclusive seed production, management, and supply systems; the promotion of production systems (mulching, raising beds) resilient to climate change; and the effective dissemination of these techniques and approaches to farmers. Further adaptation strategies recommended for this sector include the assessment of threats to and vulnerabilities of the livestock and poultry sectors and the development of adaptation approaches such as the strengthening of veterinary service systems.

The adaptation program's recommendations for fisheries include identifying potential threats to fish spawning and growth in coastal, brackish, and freshwater zones, and developing appropriate adaptation approaches such as pond fisheries and river cage aquaculture.

The key adaptation strategies for the disaster management sector include developing improved and accurate short-, medium-, and long-term early warning systems for different natural disasters in the regions in which they are likely to occur, and improving community, institutional, and government capacity to manage disasters in accordance with existing policies and plans. Recommendations for infrastructure and urbanization include the repair and rehabilitation of existing coastal and river embankments and drainage infrastructure in urban and rural areas, and the implementation of surveys and preparations for GIS-based analyses and a database of existing and potential future needs. To address the increase in flooding, drainage issues, and erosion due to climate-change-related storm surges and sea level rise, the adaptation strategies provide for the design and build of new infrastructure and a coastal green belt. For urban areas, the climate adaptation strategies emphasize assessing, designing, and investing in drainage capacity and needs in major cities (Dhaka, Chattogram, Rajshahi, and Khulna) and towns (Cumilla, Mymensingh, Barishal, etc.) as well as preparing strategies to plan for future infrastructure needs in the light of potential changes in hydrology and socio-economic conditions. Additionally, soft, non-structural measures for urban areas include physical and hydrodynamic modeling and training on river management and erosion; planning and implementation of upazila-level river restoration and de-siltation plans to improve the river network and flow; and floodplain zoning according to different vulnerabilities. Table 4.3 below lists by sector the strategies proposed for adapting to the impacts of climate change in Bangladesh.

Sector	Potential adaptation action and strategies
Agriculture	• Develop, disseminate, and promote through agricultural extension crops that are flood-, drought-, salinity-, and disease-tolerant. • Ensure crop varieties are provided on a priority basis. • Adjust crop varieties and cropping patterns. • Develop and strengthen early warning systems. • Provide information based on agro-metrology and agro-climatic data as well as forecasts for planting and harvesting times with possible yield of crops. • Enhance irrigation and water use efficiency by introducing crops that require less water and technologies that ensure the efficient use of irrigation water in cultivation practices. • Coordinate efforts to address the likely impacts of climate change and take the adaptation measures required. • Replicate the adaptation options (validated) from the Livelihoods Adaptation to Climate Change I and II projects and from other ongoing projects in vulnerable areas of Bangladesh involving the Department of Agricultural Extension (DAE). • Develop suitable cropping patterns based on agro-ecological zones. • Provide agricultural risk insurance. • Share information on the management of climate change in South Asia and the related science, data, tools, and methodologies. • Restore wetlands and increase the water storage capacity and connectivity of river systems.

Sector	Potential adaptation action and strategies
	• Promote regional cooperation on climate change adaptation, primarily in the water and agriculture sectors. • Carry out the construction/reconstruction of strong water infrastructure. • Build the capacity of DAE staff and other stakeholders to address climate change issues and management.
Water	• Check and strengthen embankment systems along the coastal zones in accordance with their expected future vulnerability. • Implement proper, long-term tidal river management to avoid waterlogging. • Excavate (remove silt from) river systems to improve drainage capacity during peak flood periods. • Build and maintain cyclone shelters and more-climate-proof housing. • Strengthen local disaster committees, giving these local efforts the knowledge and financial support they need to solve their water-related problems locally. • Promote research on water-related hazards. • Promote early warning and preparedness for all hazards (flood, cyclone, river erosion, drought).
Fisheries and livestock	• Protect and improve floodplain capture-fisheries habitat by excavating silt from *beel* (lake-like wetland area), river, and canal beds; establishing sanctuaries; and improving connectivity. • Enhance culture fisheries by retaining water for longer periods through pond deepening, the removal of sludge, the plantation of trees on pond dikes, the promotion of floating macrophytes, the installation of pumping facilities, and the harvesting of run-off water. • Raise the height of dikes further to reduce pond overtopping during floods. • Screen for and develop shallow-water and temperature-tolerant fish species. • Screen for and develop and grow salt-tolerant crop species in the coastal area. • Encourage polyculture involving paddy with fish. • Encourage alternative livelihood options during the fish breeding season. • Employ feeding and drinking-water management practices that minimize the effects of heat stress. • Improve livestock housing facilities with shade, cooling, and ventilation to reduce the impact of heat stress on resident livestock. • Raise the platform/plinth level of livestock housing and *killa* (platforms for livestock in times of high water) in coastal and flood-prone areas. • Provide training to develop veterinary services' capacity for and raise farmers' awareness about the enhanced risk of climatic disasters.
Forestry	• Develop a national strategy for integrated, ecosystem-based water resources management to protect aquatic plants and animals. • Develop adequate technical and institutional resources and mobilize financial resources to adapt to climate change impacts on the ecosystem and forestry sector. • Maintain and manage protected areas and ecologically critical zones to conserve threatened species.

Sector	Potential adaptation action and strategies
	• Create buffer zones or migration corridors for ecosystems that can allow the migration of plants and animals following pole-ward shifts in habitat distribution due to changes in temperature and precipitation.. • Mitigate drainage congestion in coastal areas by increasing infrastructure drainage capacity. • Protect the areas that provide shelter to already threatened populations of plants and animals and that are particularly threatened by the effects of climate change. • Augment swamp forests in the *haor* and *beel* wetland areas to conserve aquatic animals. • Implement aforestation and reforestation programs and increase area coverage to reduce dependency on primary forests. • Enhance afforestation programs in the reserved forest areas. • Promote natural regeneration in degraded forestlands and develop the social forestry sector by selecting appropriate species and by selecting proper placement from a safe environment perspective. • Undertake afforestation, including the expansion of coastal greenbelt, to protect the mangroves and coastal wetlands. • Conserve threatened species. • Conserve and protect the habitats of plants and animals.
Infrastructure	• Improve livestock housing facilities with shade, cooling, and ventilation to reduce the impact of heat stress on resident livestock. • Raise the platform/plinth level of housing for livestock in coastal and flood-prone areas. • Redesign and improve roads, rail lines, embankments, and other infrastructure to ensure they remain functional during floods. • Increase the number of openings (bridges, culverts) to minimize drainage congestion. • Maintain and improve existing shelters and build additional shelters. • Research and develop designs for climate-smart and cheap housing. • Dredge navigation routes and canals.
Health	• Enhance the capacity of existing health infrastructure and build new health infrastructure. • Increase human resources to ensure health services are maintained during adverse events caused by climate change. • Strengthen the capacity of health professionals, including doctors and nurses, to deal with future adverse events related to climate change. • Raise public awareness about diseases and health conditions that can arise due to floods, cyclones, heatwaves, cold waves, etc. with the aim of reducing their occurrence. • Raise the levels of hand tube wells and sanitary latrines to reduce the threat of water contamination. • Conduct research on vectors, parasites, and virus mutation and adaptation to changing climate to support the development of future health support system strategies.

Sector	Potential adaptation action and strategies
Urban areas	• Implement in full the existing policies and plans for the development of built-up areas, and revise urban plans in the light of climate change impacts, paying special attention to elevations, drainage congestion, etc., in urban areas. • Mainstream adaptation to climate change in urban development policies and programs (disaster management, water, health, and industry). • Ensure that city authorities properly monitor, guide, and control their city's development activities in line with the existing planning guidelines. • Revise and implement building codes with due consideration to the climate change urban greening program, including rooftop gardening. • Preserve, maintain, and improve drainage areas. • Improve water use efficiency, and design in alternative sources of water such as rainwater harvesting facilities. • Ensure adequate financial resources and human public health resources (including training) for surveillance and emergency response and for prevention and control programs. • Run awareness-raising programs at the community level to disseminate knowledge and information on climate change and its impacts. • Strengthen and build the capacity of the relevant ministries and agencies, providing them with training programs, seminars, and workshops.

Table 4.3: Sector-wise adaptation action and strategies (source: MoEFCC, 2018b)

Box 4.2 Gender dimension in climate policy

Question: *Why is it important to integrate gender into climate change policy?*

Women and men contribute differently to the causes of climate change, are differently affected by climate change, react differently to its impacts and, given the choice, favor different options to mitigate and deal with the consequences of climate change. These differences are based on gender roles and responsibilities in most societies and on gendered access to resources and political influence. Often, there is a lack of basic gender-disaggregated data. Sometimes, the existing data and research does not recognize gender aspects at all, or it focuses on women as the group most vulnerable to climate change impacts. However, if women are perceived only as victims, this may keep women trapped in limited roles and further enhance gender disparities, particularly within the field of adaptation. For instance, in the adaptation context women should be treated not as victims but, more importantly, as agents of coping and survival strategies.

Addressing the gender dimension of the causes of climate change is critical in order to reveal underlying power relations and to analyze the gender implications of mitigation strategies and solutions. To prevent the consolidation – or even expansion – of inequality by climate policy, the structures and factors that cause or sustain discrimination must be identified and addressed. Key to analyzing this and to bringing about change are the important general dimension of care work, the distribution of and access to all forms of resources, and the gender composition in planning, decision-making, and social power relations.

Both women and men are important actors in designing consensus climate policies. Women are generally more sensitive to risk and more willing to change lifestyles, while men more strongly believe in technical solutions. Addressing gender aspects in climate change policy means neither blaming one part of the population nor romanticizing the other. It is about drawing on a larger pool of ideas. Ignoring these different perspectives would mean losing out not only on ideas, visions, and potential solutions, but also on support for strong climate policies.

4.6 Synopsis of the NDC sectoral strategies and actions

Bangladesh's latest Nationally Determined Contribution (NDC) in 2021 provides a comprehensive analysis of overall mitigation commitments and conditional efforts that contribute to reductions in global emissions through a specific plan of future actions (MoEFCC, 2021). This NDC considers (i) energy, (ii) industrial processes and product use (IPPU), (3) agriculture, forestry, and other land use (AFOLU), and (4) waste as the major emitting sectors (land use, land-use change, and forestry [LULUCF] were not included in the earlier NDC, mitigation roadmap, and communication documents).

This NDC update has rigorously revised the GHG emission inventory for all sectors, considering 2012 as the base year, and for three potential scenarios: business as usual (BAU), unconditional, and conditional. The base year accounted for a total of 169.05 MtCO2e, with energy contributing the most (55% of the total) followed by the sectors of AFOLU (27.35%), waste (14.26%), and IPPU (3.32%). Without any mitigating measures and following national and global trends, the BAU scenario can increase overall emissions by 2.4 times to 409.4 MtCO2e in 2030. Most of these GHG emissions come from the energy sector, which comprises 76.3% of the total (312.54 MtCO2e), while AFOLU comprises 13.5%, waste 7.55%, and IPPU 2.7%. In terms of subsectors, industry, power, and transport make the largest contributions of about 25%, 23%, and 9% of the total emissions respectively.

Bangladesh has pledged to reduce, in 2030, its overall emissions by 27.56 MtCO2e or 6.73% below the BAU for that year. These reductions will come from the energy sector (95.5%), AFOLU (2.3%), and waste (2.2%). The conditional commitment that involves external financial and technological assistance will raise Bangladesh's reduction to 61.9 MtCO2e or 15.12% below BAU in 2030, with the energy sector responsible for 96.46% of this reduction, the AFOLU sector for 0.65%, and the waste sector for 2.97%. In both the BAU and conditional cases, the GHG emissions reductions in the IPPU sector remain unaltered. The 2021 NDC also provides a detailed action plan for each sector and subsector, along with the estimated implementation costs for both the conditional and unconditional scenarios (MoEFCC, 2021).

In general, the mitigation actions envision Bangladesh's transformation into a low-carbon, climate-resilient, middle-income economy being realized within its national carbon footprint limits. The 2021 NDC highlights the importance of (a) developing a workable MRV system for ensuring verification and transparency and (b) enhancing the MoEFCC's and DoE's capacity to lead on the implementation of the NDC. Furthermore, national and global financing; regular and proper data collection, management, and updating; and technical support are crucial for overcoming the barriers to and challenges in meeting the commitments in future.

As already mentioned, the energy sector is given the highest priority in the mitigation plan. For the base year of 2012, the energy sector contributes the highest total GHG emissions of 93.09 MtCO2e (or 55.07% of the total). The five subsectors that contribute most to energy sector emissions are power, transport, industry, household, and brick kilns (a total of 82.62 MtCO2e). Based on the unconditional and conditional scenarios, the aim is to achieve about 95.4% and 96.4% of the total emissions reductions from the energy sector. From the sectors (and subsectors) of AFOLU and waste, the commitment in the unconditional scenario is to reduce their total emissions by around 2.3% and 2.2% respectively and in the conditional scenarios (where international financial and technical support is provided) by around 0.65% and 2.97% respectively. The NDC's sectoral strategies and actions for mitigation under the unconditional scenario are summarized in Table 4.4 below.

Sector	Description	Actions by 2030
Energy		**Power**
	Implementation of renewable energy projects Enhanced efficiency of existing power plants Use of improved technology for power generation	• Implementation of renewable energy projects (911.8 MW). • Grid-connected solar (581 MW) and wind (149 MW). • Biomass (20 MW), biogas (5 MW), new hydro (100 MW), solar mini-grid (56.8 MW). • Installation of new gas-based combined-cycle power plant (3,208 MW). • Efficiency improvement of existing gas turbine power plant (570 MW). • Installation of prepayment meters.
		Transport
	Improved efficiency of the transport subsector Promotion of a transport system that uses fuels generating lower emissions Improvement of inland water transport system	• Reduction in road traffic congestion (5% improvement in fuel efficiency). • Widening of roads (from 2 to 4 lanes) and improvement of road quality. • Construction of bicycle lanes. • Electronic road pricing or congestion charging. • Reduction of private cars and promotion of electric and hybrid vehicles. • Development of urban transport master plans to improve transport systems in line with the urban plans for all major cities and urban areas. • Introduction of intelligent transport systems to manage public transport, ensuring better performance and enhancing reliability, safety, and services. • Promotion of a modal shift from road to rail (10% modal shift of passenger kilometers) through different transport projects such as the creation of multi-modal hubs, the Padma Bridge, etc. • Procurement of modern rolling stock and signaling systems for the railways. • Electrification of the railway system and double-track construction. • Improvement and enhancement of the inland water transport system by improving navigation for regional, sub-regional, and local routes; improving the maintenance of water vessels to enhance engine performance; introducing electric water vessels; etc.

Sector	Description	Actions by 2030
		Industry
	Increased energy efficiency in the industry subsector through enforcement measures and the use of improved technology	• Achieve 10% energy-efficiency improvements in the industry subsector through measures that adhere to Bangladesh's Energy Efficiency and Conservation Master Plan.
		Agriculture
	Enhanced use of solar energy in agriculture	• Installation of 5,925 solar irrigation pumps (generating 176.38 MW) for agriculture.
		Brick kilns
	Promotion of advanced technology and the use of non-fired brick	• 14% emissions reduction achieved by banning fixed chimney kilns and encouraging advanced technology and non-fired brick use.
		Residential and commercial
	Promotion of advanced technology and the use of non-fired brick	• Use of energy-efficient appliances in residential and commercial buildings, achieving a 5% and 12% reduction in emissions respectively.
		F-gases
	Meeting of Montreal Protocol targets	• Reduction in the use of ozone-depleting gases (HCFCs) in air conditioning by 2025, in line with the Montreal Protocol targets.
AFOLU		**Agriculture**
	Meeting of Montreal Protocol targets	• Methane emission reduction from rice fields by scaling up alternate wetting and drying in dry-season rice fields (50,000 ha of cropland). • Rice varietal improvement for 1,111,000 ha of cropland. • Nitrous oxide emission reduction from nitrogen-based fertilizer on 209,000 ha of cropland management (leaf-color chart, soil-test-based fertilizer application, less tillage barn management, etc.). • Improvement of fertilizer management (deep placement of urea in rice fields, training, awareness raising) on 50,000 ha. • Bringing more area under pulse cultivation. • For methane emissions from enteric fermentation, replacement of high-producing animals with low-producing crossbred cattle (large ruminants – 0.94 million; small ruminants – 0.89 million).

Sector	Description	Actions by 2030
		• Feed improvement that involves the use of a balanced diet and beneficial micro-organisms for livestock (large ruminant – 0.51 million; small ruminant – 0.68 million). • Reduction in methane and nitrous oxide emissions from manure through better management and the promotion of mini biogas plants (57,000 plants). • Awareness-raising and capacity building of relevant stakeholders including government, Civil Society and Private Sectors.
		Forestry
	Reduction of deforestation Reforestation/ afforestation Forest restoration Increased tree cover	• Increase in forest cover from 22.37% (2014) to 24%. • Afforestation and reforestation in coastal areas, islands, and degraded areas (150,000 ha). • Restoration of deforested forests, comprising 137,800 ha of sal (Shorea robusta) forest in the hills and plains. • Restoration of degraded forests, comprising 200,000 ha of sal forest in the hills and plains. • Tree plantation on roadsides, embankments, private land, etc.
Waste		**Power**

	Improved municipal solid waste management	• Establishment of:
		  • a waste-to-energy plant in Dhaka,
		  • an incineration plant in one city in the country, and
		  • a regional integrated landfill and resource recovery facility in one city in the country.

Table 4.4: Possible sectoral strategies and actions for mitigation under the unconditional scenario (source: MoEFCC, 2021)

For the conditional scenario, major actions and strategies are scaled up in all sectors with additional actions. For example, in the energy sector, the road-to-rail modal shift increases from 10% to 25% and the emissions reduction from brick kilns increases from 14% to 47%. In this scenario, work is also carried out to promote green industry and carbon financing. Gas leakage projects achieve a 51% reduction in emissions, and forest conservation is also expanded with the potential to generate alternative incomes for around 55,000 families. The conditional scenario also proposes the installation of incineration plants in three cities and the establishment of wastewater treatment plants in several cities in order to reduce emissions in the waste sector (MoEFCC, 2021).

4.7 Critical analysis and integration of climate change in Bangladesh

From the earlier sections, it is evident that Bangladesh has formulated short-, medium-, and long-term national climate change and development policies, plans, and strategies to deal with climate change. However, two challenges in particular feature in nearly all the policies. Firstly, the lack of human resources and capacity in the mandated government agencies (especially the MoEFCC) and teams of officials is one of the key constraints holding back the effective planning, design, and implementation of climate change projects and programs. Secondly, the lack of technical expertise, of experience in good governance, and of in-depth knowledge on physical vulnerabilities (Chowdhury et al., 2021) as well as the lack of coordination between the respective government agencies hinders the successful implementation and efficacy of adaptation and mitigation actions. For example, the country is still lacking when it comes to the design and implementation of new renewable-energy-based projects and officials lack the skills and knowledge to deliver such projects (MoEFCC, 2018a). While some of the policies list the government ministries and departments relevant to different sectors, there is no discrete coordination mechanism in place for overall and sectoral management and the implementation of climate change strategies and interventions. Additional challenges include the following:

- Most government ministries and departments do not explicitly address concerns around climate change in their mandates, resulting in the fragmented implementation of relevant projects (Stock, 2020).
- The country lacks adequate climate and weather-related data and high-resolution local-level climate projections that would make feasible and facilitate better adaptation and mitigation measures.
- In cases where sectoral data are available, concerns exist about the quality and quantity of the data and information. Moreover, many ministries and departments still lack a consolidated database of relevant climate projects and information.
- Overall funding and financing mechanisms are inadequate to fulfil the adaptation and mitigation strategies, actions, and projects. While the government has allocated funding from multiple national and global sources, the country needs more funding to effectively implement the planned and proposed activities to deal with the impacts of climate change.

Finally, the national policies and their formulation process are heavily top-down, with no real engagement from the local communities who are bearing the brunt of the negative impacts of climate change. However, those involved in the process claim that communities' concerns are included through consultation exercises (Stock, 2020).

In light of the above, four recommendations can be made to effectively integrate climate change as a standalone and cross-sectoral issue in national policies, planning, and strategies.

1. Plans and programs should be implemented to upgrade the institutional and individual capacities of government and of local and civil society actors. This will help in aligning stakeholders with the policies and with the need for adaptation and mitigation. Cross-sectoral and bilateral exchanges and the appointment of experts from various backgrounds may also enhance the capacity of the mandated agencies.
2. The immediate development of a nationwide MRV system should be initiated to mainstream and effectively coordinate all climate-change-related actions and interventions in the country, with MoEFCC taking the lead. This Ministry should therefore be prioritized for any interventions to build capacity and increase human resources.
3. As proposed in a number of policies, international advocacy and negotiations for acquiring global climate funding should be planned, designed, and enacted in future. The country can then use these additional funding resources to deliver climate-resilient sustainable development before 2041. The Government of the People's Republic of Bangladesh can also consider forming a national governing, technical, and advisory committee to prepare and plan for the global negotiation and fund acquisition processes. Additionally, national funding mechanisms, such as carbon and industrial taxes, can be assessed and implemented as ways to generate revenue for investing in national climate interventions and the protection of natural resources (Barbier, 2020). Furthermore, the funding and compensation for developing countries should be considered for Bangladesh given it is one of the world's lowest-emitting countries of GHGs.

4. Local communities and governments should be empowered through direct involvement in the climate adaptation and mitigation actions and the processes to design, implement, and manage projects. Government can work to identify innovative and dynamic strategies to facilitate and coordinate this kind of involvement, and it can carry out the monitoring and evaluation of locally led activities.

To conclude, research and knowledge management in the area of climate change and its impacts in different sectors – one of the pillars of the BCCSAP – should be significantly enhanced and upgraded. This will require the incorporation of technological innovation and local approaches and also of recent developments in climate science and analysis. Furthermore, the establishment of a standalone climate change research wing under public-private ownership, the development of a database on technology transfer, and assistance from the global north and south will all help to improve action-based climate change research and implementation in Bangladesh.

Box 4.3: Theory into practice

Implementation of learning

This module has provided a succinct analysis of Bangladesh's major national climate change and development policies and has shared the key sectoral strategies for enhancing adaptation and mitigation efforts in the country. Challenges, limitations, and recommendations have also been drawn from the analysis of relevant policies from the past 30 years. While the effective mainstreaming of climate change in national policies requires contributions from all stakeholders and actors, it is the government agencies and officials that have the greatest potential to effect change. This module's content will therefore help government officials working in this arena in the following four ways:

Firstly, it will help them to align themselves and their departmental activities with major national climate change plans, goals, and strategies.

Secondly, it will not only consolidate their understanding and knowledge of national climate change and development policies, but will also assist them in undertaking the relevant monitoring and evaluation processes and projects that require government intervention and assessment.

Thirdly, by improving officials' comprehension of the national and sectoral requirements for climate change adaptation and mitigation, the module will build these officials' capacity in the policy arena and develop their leadership capacity within their department and beyond.

For further guidance, please read or watch the following:

Documents

Eighth Five-Year Plan (Bangla only):
http://plancomm.gov.bd/site/files/8ec347dc-4926-4802-a839-7569897e1a7a/8th-Five-Year-Plan

Bangladesh Climate Change Strategy and Action Plan 2009:
https://www.iucn.org/downloads/bangladesh_climate_change_strategy_and_action_plan_2009.pdf

Nationally Determined Contributions of Bangladesh:
https://moef.portal.gov.bd/sites/default/files/files/moef.portal.gov.bd/notices/e5820e3c_2cd7_4e4d_baf3_5e613b37348a/Bangladesh%20NDC%20implementation%20roadmap_final_12%20June%202017_clean%20version.docx

National Sustainable Development Strategy (NSDS) 2010–2021:
http://nda.erd.gov.bd/en/c/publication/national-sustainable-development-strategy-nsds-2010-2021

Bangladesh Delta Plan:
https://oldweb.lged.gov.bd/UploadedDocument/UnitPublication/1/756/BDP%202100%20Abridged%20Version%20English.pdf

Videos

Ground zero to climate adaptation: Local climate fighters in Bangladesh bringing global solution:
https://www.youtube.com/watch?v=M4nOLjgoKU8

Working Group

Locally led action – Global Center on Adaptation:
https://gca.org/programs/locally-led-action/

Exercise

Section 4

4.8 Group work

Pick a policy and highlight gaps in implementation and operational challenges, working through the following steps:

1. Each trainee selects one national policy or one sectoral policy in their area of interest.
2. Trainees then identify and assess the potential gaps in the policies and in the implementation of the plans outlined in the policy.
3. Finally, trainees outline the operational challenges for implementing the strategies and provide recommendations for overcoming them.

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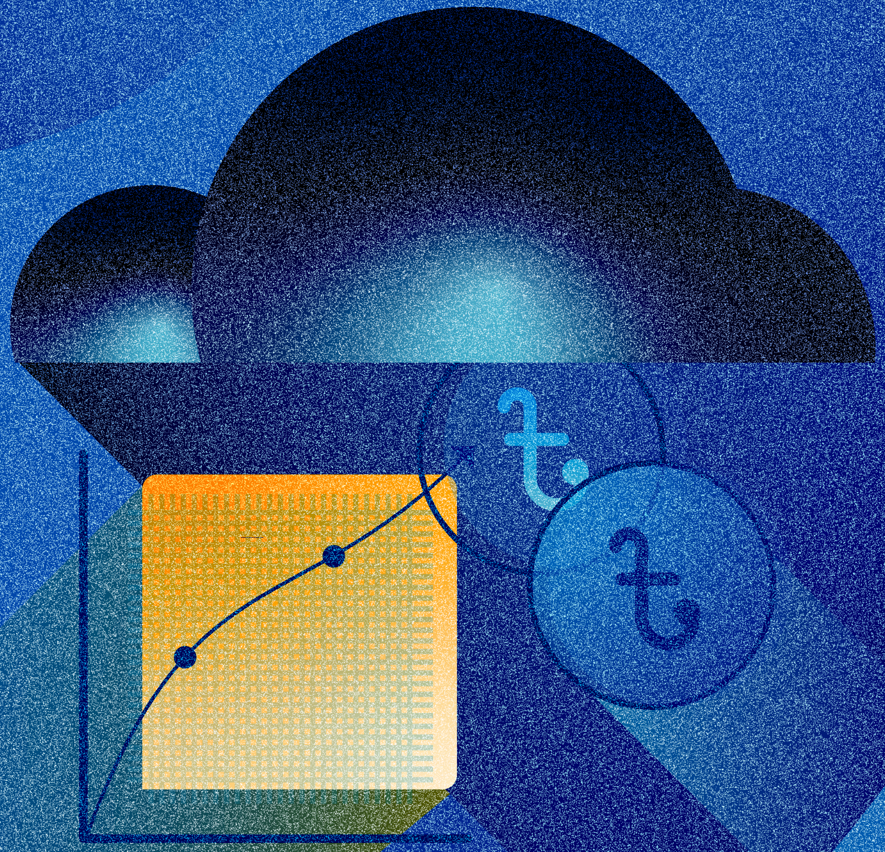
Notes



MODULE 5

Economics of climate change: impacts and adaptation

Overview of the training module

5.1 Brief introduction to the module

Subject

Economics of climate change impacts and adaptation

Learning outcomes

This module will provide learners with an understanding of the basic concepts and approaches of the economics of adaptation from both the micro and macro perspectives. Trainees will learn about the relationships and trade-offs between adaptation and development and between adaptation and mitigation. They will also come away with a practical understanding of the political economy associated with the application of the tools and approaches for adaptation investments.

Topics

- Private adaptation: micro-economics
- Market, policy, and behavioral failures in adaptation
- Public policy: the macro-economics of adaptation
- Costing adaptation: damage function, net present value
- Adaptation and development: competitive or complementary?
- Adaptation and mitigation: competitive or complementary?
- Economic instruments for adaptation
- Review of adaptation costing in Bangladesh's NDCs and NAP

5.2 Definition of economics

Economics is a social science that deals with how people and countries take decisions to satisfy multiple needs and demands in the face of resource constraints and environmental uncertainty. Seen through this perspective, the economics of climate change adaptation has an important role to play in mobilizing limited resources for addressing prioritized adaptation options. In this context, this module on the economics of adaptation will include an understanding of the extent of loss and damage climate change imposes on Bangladesh, and of the basic assessment tools and approaches from the micro and macro perspectives. It will therefore be necessary to explain the market, policy, and behavioral failures in adaptation, and the nature of public economics as it relates to adaptation, its relationship with development and mitigation, and the trade-offs involved. The module also includes estimates of the financing needed for adaptation in Bangladesh.

5.3 Types of adaptation approaches

Climate change may be due to internal processes and external forcing such as sunlight enters through the greenhouse gas layer and warms inside. Some external influences, such as changes in solar radiation and volcanism, occur naturally and contribute to the total natural variability of the climate system. Other external changes, such as the change in the composition of the atmosphere that began with the industrial revolution, are the result of human activity (IPCC, 2007). Recent changes in the climate are widespread, rapid, intensifying and unprecedented in thousands of years (IPCC, 2021).

- Natural causes: The Earth's climate varies naturally as a result of interactions between the ocean and the atmosphere, changes in the Earth's orbit, fluctuations in energy received from the sun, and volcanic eruptions.
- Anthropogenic/Human-Induced causes: The main human influence on global climate is likely to be emissions of greenhouse gases (GHG) such as Carbon Dioxide (CO2), Nitrous Oxide (N2O) and Methane (CH4) (UNEP, 2008). Anthropogenic environmental change are caused or influenced by people, either directly or indirectly.

5.4 Private adaptation: microeconomics

There are important economic distinctions between the roles of private and public actors. Adaptation actions taken by an individual or private entity accrue benefits directly back to the adaptor, and others are excluded. Examples include insulating homes, building stronger buildings, irrigating individual farms, or relocating out of an area prone to flooding. These examples indicate well-defined property rights, where benefits are clearly individual, and others can be excluded. But there are private actions, such as establishing a deep tube well in an open field, that generate adaptation benefits for the public. There are clearly defined features of this type of public good. First, the benefits are non-rival in that they do not reduce the benefits for others, and those benefits are non-excludable – i.e., they are enjoyed by anyone living in that area. But the benefits might be congested in the sense that there is a long line for collecting water. In such cases, adaptation public goods may be supplied through the participation of numerous private actors, which requires the coordination and commitment of private actors. These can be called club goods, where benefits are exclusive to the group members. So, the incentives for individual actions for adaptation where benefits are dispersed are not there.

Individual coping mechanisms or adaptations can be explained by conventional micro-economics. Households and firms usually respond to climate risks by adjusting their behavior, particularly in the agriculture sector. There is not much research about private adaptation behavior. For example, the International Institute for Environment and Development (IIED) has carried out a study in rural areas of Bangladesh which shows that households in the country spend about USD 2 billion a year on addressing climate risks (Eskander and Steele, 2020). However, in most cases adaptation is analyzed normatively and through the lens of public policy because there are adaptation gaps and market imperfections that require government intervention.

5.5 Market, policy, and behavioral failures in adaptation

Adaptation has many of the characteristics of a public good in that it benefits many and nobody can be excluded from enjoying those benefits. In such cases, the private party cannot capture all the gains. For example, if an individual pays to build a sea wall to protect a coastline or develop an improved irrigation system, the gains generally go to others in the area too. Conventional economic theory and reality indicate that such actions will not deliver appropriate levels of private investment, causing an undersupply of adaptation. This is market failure in adaptation. This therefore calls for public action, usually taken by the government or some international organization (Fankhauser, 2016).

Adaptation may also face market failures such as externalities, information asymmetry, and moral hazards (Osberghaus et al., 2010). For example, greenhouse gas emissions are a case of externality, where costs are socialized and benefits are privatized. As a consequence, some socially desirable actions may not be privately profitable. For example, flood mitigation measures may not be implemented, in spite of their benefits, in cases where flood risks are partly assumed by insurance or post-disaster support, thus transferring risk to the community. There are also externalities given that adaptation actions taken by one household, firm, or even country may create higher damages for others. This is the case with transboundary waters, when increased irrigation in one country creates water scarcity downstream (Goulden et al., 2009). Indian policy with shared river waters in the Ganges is an example. Trans-sector effects can also occur – for instance, when adaptation in one sector creates needs in another sector. Incentives for private adaptation actions may also be lacking for public goods and common resources without property rights (e.g., biodiversity and natural areas, tradition, and culture). Adaptation may exhibit increasing returns or large fixed costs, leading to insufficient adaptation investments (see, for instance, Eisenack, 2013). In such contexts, public norms and standards, direct public investment, tax measures, or national or international institutions for adaptation coordination are needed to avoid maladaptation.

5.6 Behavioral obstacles to adaptation

Economic agents adapt continuously to climate conditions, though not always using the available information, especially long-term projections of consequences (Camerer and Kunreuther, 1989; Michel-Kerjan, 2006). Individuals often defer choosing between ambiguous choices (Trope and Lieberman, 2003) and make decisions that are time inconsistent. They also systematically favor the status quo and familiar choices. Also, individuals value profits and losses differently (Tversky and Kahneman, 1974). Behavioral issues may lead to suboptimal adaptation decisions. Particularly important is the fact that the provision of climate information needs to account for cognitive failures (Suarez and Patt, 2004). Individual behavioral barriers extend to cultural factors and social norms that can support or impair adaptation.

5.7 Public policy: macro-economics of adaptation

Apart from adaptation economics being at the individual level, there are macro-economic issues as well. While there is little analysis on the link between adaptation and traditional macro-economic issues like trade, price stability, and economic growth, many adaptation concerns can be analyzed at an aggregate, economy-wide level. People’s vulnerability and exposure to climate risks depend on, among other factors, economy-wide policies on economic diversification, spatial planning, urban design, and infrastructure. Adaptation is closely linked to these broader economic decisions and may have implications for macro-economic aggregates like outputs and investment.

Besides, there are distributional issues in adaptation costs and benefits in adaptation. Governments can play a variety of roles in mediating these distributional inequities and uncertainties by providing subsidies to individuals to encourage actions that will be in their benefit, such as offering tax breaks for the adoption of energy- or water-saving technologies; subsidizing the provision of insurance; and investing in informational campaigns and decision-support systems that enhance individual innovation and risk management.

Gaps in "adaptive capacity" – i.e., in the ability to respond to climate risks – have been linked to factors such as literacy, income, income distribution, institutional quality, health spending, and access to finance (Fankhauser, 2016). However, a complete list of all relevant aspects of adaptive capacity and how they interact is still lacking. Most measures of adaptive capacity simply add up the various contributing factors. Market and policy failures affecting adaptation include insecurity over land titles, which can disincentivize investment in adaptation. In the property market, there may be asymmetric information between buyers and sellers about the risk profile of dwellings. There may be issues of moral hazard related to insurance cover or with at-risk communities holding out for government assistance. Path dependence may affect the choice between protection and relocation, with highly vulnerable locations defended because of their economic or historical significance. The presence of these barriers implies an important role for public policy to overcome market failures, correct policy distortions, and incentivize private adaptation.

Box 5.1 Roles of government in adaptation

The first role for government is to provide a policy environment that is conducive to effective private adaptation by incentivizing the right actions and removing potential distortions. While this is uncontroversial, relatively little has been written on specific adaptation policies that would achieve this aim and capacity building. Yet there is no generally agreed adaptation policy toolkit in the same way as there is consensus on the key planks of low-carbon policy. Instead, adaptation policies are considered in their sector contexts, as refinements to existing policy interventions. Adaptation is "mainstreamed" in the discussion on, for example, integrated water resource management, coastal zone planning, water pricing, weather insurances, and payments for ecosystem services.

The second role for government concerns the provision of climate-resilient public goods. This covers the need to "climate proof" both conventional public goods such as transport networks and public goods specifically dedicated to adaptation such as flood defenses and climate information services (e.g., early warning systems).

The third role of public policy is assistance for vulnerable groups that cannot adapt sufficiently themselves. The presence of an adaptation gap in poor countries and among poorer population groups suggests the need for capacity building, technical assistance, and help with response plans. Emergency services also play an important role in protecting the most vulnerable. The role of social safety nets is to aid post-disaster recovery and redistribute income toward the poorest and most vulnerable. Aid agencies provide such support either in the form of cash transfers, which can also help to stimulate local markets, or in kind, in the form of food and shelter for example. Transfers may either be unconditional or tied to particular behavior, such as school attendance.

Cost of adaptation

5.8 Cost of adaptation: damage function, net present value

Adaptation benefits are the reduction in damages plus any gains in climate-related welfare that occur following an adaptation action. Simplistically described, the cost of adaptation is the cost of any additional investment needed to adapt to or exploit future climate change (UNFCCC, 2007). A full accounting needs to consider the resources spent to develop, implement, and maintain the adaptation action along with accruing reduced damages or welfare increases involving monetary and non-monetary metrics. A fraction of climate change damage can be reduced at no cost (e.g., by changing sowing dates in the agricultural sector). With increasing adaptation cost, climate change costs can be reduced further. In some cases, sufficiently high adaptation spending can take residual cost to zero. If barriers and constraints impose a suboptimal situation, the marginal costs and benefits of adaptation are not equal, possibly because there is too much investment in adaptation, so that investing USD 1 in adaptation reduces climate change residual cost by less than USD 1, or because there is not enough investment in adaptation and investing USD 1 more in adaptation would reduce residual cost by more than USD 1 (Chambwera et al., 2014).

Defining the costs and benefits of an “adaptation project” raises conceptual issues. Many actions have an influence on the impact of climate change without being adaptation projects per se (e.g., enhanced building standards). Many “adaptation projects” have consequences beyond a reduction in climate change impacts or an increase in welfare from exploiting opportunities. Also defining the adaptation component requires the definition of a baseline (i.e., establishing what the impact of climate change in the absence of the adaptation action would be and what alternative projects would be implemented in the absence of climate change) and the definition of “additionality” (i.e., the amount of additional loss reduction or welfare gain that happens because of the project). For instance, the building of new infrastructure may be marginally more costly because of adaptation to climate change but would still be undertaken without climate change, thus only a fraction of that cost and the resultant benefits would be labeled as occurring because of adaptation. In the climate change context, residual damages are those damages that remain after adaptation actions are taken. This is what we call loss and damage, which are beyond adaptation (IPCC, 2014).

The costs and benefits of adaptation are incorporated in a damage function, as above. Conceptually, the damage function, D(T), was defined as the least-cost combination of adaptation costs, AC, and residual damages, RD (see Box 5.2.).

Box 5.2 Damage function and NPV calculation

$\mathrm{D}(T) = argminA\ (AC\ (A, T) + RD\ (A, T))$, where A is the adaptation effort and T is global mean temperature.

$NPV = NPV^E - NPV^L = (CL^\delta - C^E) + (B0^E - 0) + \delta\ (B1^E - B1^L)$, where δ is the discount factor and the superscribed E and L denote the strategy to adapt either early or later. We know $B0^L = 0.\delta$ because late adaptation cannot have early benefits by definition. The three components of this simple equation point to three generic reasons why adaptation might be brought forward.

The damage functions simply combine estimates of adaptation costs (in particular those related to coastal protection and changes in energy demand) with estimates of residual damages (e.g., changes in agricultural yields). However, the optimality assumption allows modelers to ignore adaptation decisions and focus on other issues of interest, such as the optimal emission reduction path or the social cost of carbon.

Also, there is a time lag between investments in adaptation actions and the benefits accruing from them. So, with two time periods (early and later, denoted by the superscripts E and L) and three NPV (net present value) components (costs C, early benefits B0, and later benefits B1), the difference between the two NPVs can be written as shown in Box 5.2 above.

The first reason to accelerate adaptation is that early action may be cheaper than action later on, even after factoring in discounting – that is, $(CL^{\delta} - C^{E}) > 0$. This case is associated with the risk of locking in climate vulnerabilities that are difficult to reverse.

The second reason to prioritize adaption is if acting now secures substantial early benefits – that is, $B0^{E}$ is large. This category is associated with win–win solutions, which make sense both as an adaptation measure and for broader economic or environmental reasons. Examples include ecosystem-based adaptation like mangrove protection.

The third reason to prioritize adaptation is if the long-term benefit of adaptation would be materially affected by a delay – that is, $(B1^{E} - B1^{L})$ is large. This category is associated with adaptation measures that are slow to ramp up and need time to come to fruition. Examples include research and development of climate-resilient products and processes. Capacity building arguably also falls into this category, although it will have immediate benefits as well.

Figure 5.1. below provides a graphical representation of the link between the cost of adaptation (on the x-axis) and the residual cost of climate change (on the y-axis). The left panel represents a case where full adaptation is possible, while the right panel represents a case in which there are unavoidable residual costs:

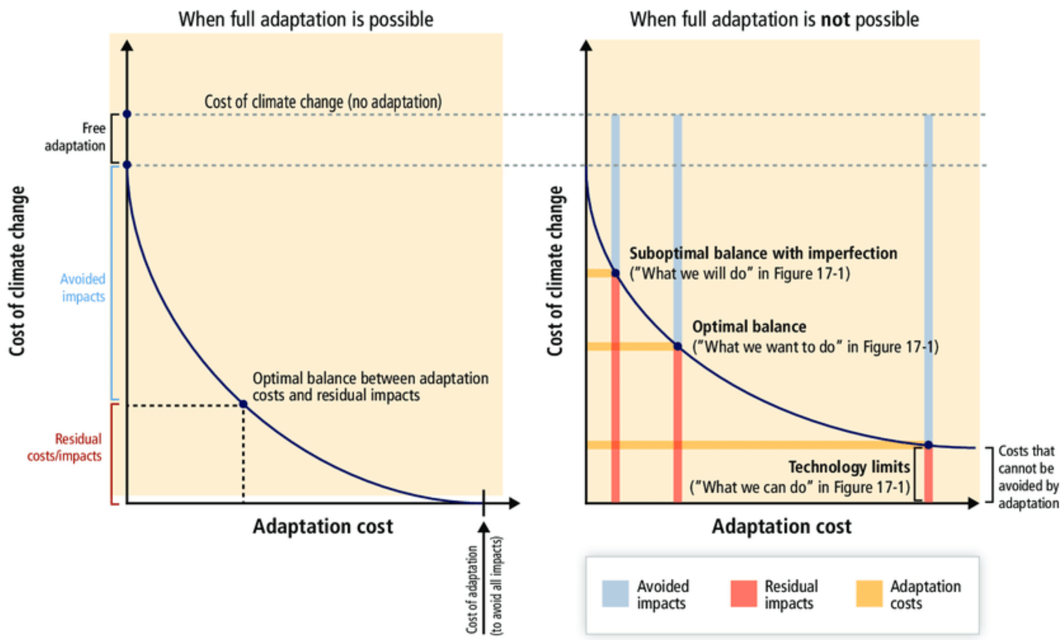


Figure 5.1: Links between the cost of adaptation and the residual cost of climate change in a case where full adaptation is possible (left) and a case in which there are unavoidable residual costs (right) (source: Chambwera et al., 2014)

Adaptation, mitigation, and development: competitive or complementary?

5.9 Challenges for development economists

Development economists are concerned that unmitigated climate change will hit poor people particularly hard and may put development achievements at risk. But the climate risks poor countries face is also to a considerable extent determined by the development decisions they take.

The challenge for development planners therefore is to make future economic development more climate-resilient

(OECD, 2013)

The practical question that follows is how climate-resilient development differs from conventional development. It is claimed by some that economic development is the best form of adaptation, implying that conventional and climate-resilient development are one and the same (Fankhauser, 2016). A similar conclusion is drawn about how climate extremes have a negative impact on growth in developing countries, but that no such effect is found in developed countries. Development, it appears, immunizes against climate risk. Yet, there are differences between traditional and climate-resilient development, and they are important (Fankhauser and McDermott, 2016). To work these differences out, it is useful to recall the basic determinants to climate risk. The risks associated with a given climate hazard are a function of the vulnerability and exposure of an economy to that hazard (IPCC, 2012). Vulnerability and exposure can be reduced through appropriate adaptation actions. However, while economic development will generally lead to higher levels of adaptation, vulnerability and exposure may either increase or decrease, depending on the choices that are made.

The link between economic development and the level of adaptation has shown that development progress affects both the supply and the demand for adaptation (Fankhauser and McDermott, 2014). On the supply side, the ability of economic agents to deal with climate risks is a function of technical capacity (e.g., information, skills), institutional factors (e.g., governance, quality of public services), and financial aspects (e.g., income, assets, access to credit). Many of these factors – such as skills, good institutions, and access to credit – are strongly associated with development progress. As a consequence, the efficiency of producing the good "adaptation" (or climate protection) is likely to increase with higher levels of development. On the demand-side, there is a powerful income effect. Adaptation has a positive income elasticity, and as income per capita rises, the demand for climate protection goes up. The combination of the two effects produces a significant increase in the provision of adaptation as societies develop. The effect of economic development on vulnerability and exposure is less clear. As countries develop, they typically move away from agriculture into industry and eventually services. Sectors become more productive through the accumulation of physical and human capital. The location of economic activity may shift from rural areas to urban centers.

Although agriculture is highly vulnerable to climate risks, a structural shift into industry and urban living improves resilience only if those sectors and locations are subject to lower risks than agriculture, which they may or may not be (Fankhauser and McDermott, 2016). Much urban development has occurred along highly vulnerable coastlines (Hanson et al., 2011). Migrants to urban areas often end up in neighborhoods that are subject to flooding and other environmental risks. So, the type of development clearly matters.

Adaptation practitioners are responding to this observation by trying to incorporate climate risks more explicitly and proactively into development plans (see, for instance, World Bank, 2016, and Ranger et al., 2014). They argue that the most effective way of improving climate resilience is by influencing the choices development planners make on issues like agricultural diversification, urban design, infrastructure investment, and coastal development (Fankhauser and McDermott, 2016). Indeed, the time when these decisions are taken is a natural "entry point" to introduce adaptation into development planning.

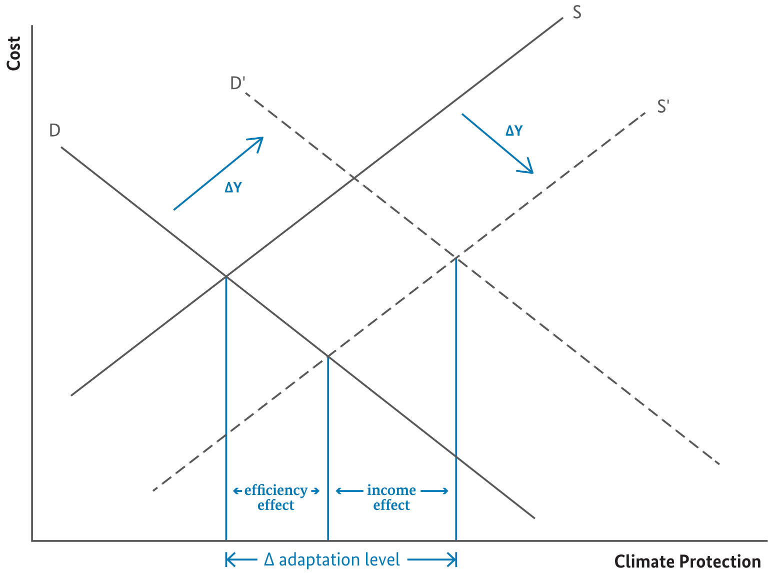


Figure 5.2: The supply and demand for adaptation as a function of income and efficiency effects (source: Fankhauser and McDermott, 2014)

There is a relationship between adaptation and socio-economic development, particularly in lower-income countries. In terms of complementarity between the two, studies show that both development and adaptation can be enhanced via climate-resilient road development (World Bank, 2009), agricultural investments that enhance income, heat tolerance, and drought resilience (Butt et al., 2006), or improvements in public health infrastructure that increase capability to deal with climate-enhanced disease and other diseases (Samet, 2010). In addition, development in general can increase adaptive capacity through enhancements in human and other capital. Finally, adaptation efforts may reduce adaptation deficits regarding vulnerability to the existing climate and enhance general development (Burton, 2004). Thus, development goals can be generally consistent with adaptation goals, with one possibly being an ancillary effect of the other, although this is not always the case. For example, it was found that urbanization of flood-prone areas increases vulnerability and adaptation needs, while better protection may trigger additional development in at-risk areas and create increased vulnerability to extreme events. The discussion on climate-resilient development is closely linked to the debate on climate finance.

Box 5.3 Dimension of the vulnerable population

Question: *Could economic approaches bias adaptation policy and decisions againstthe interests of the poor, vulnerable populations, or ecosystems?*

Answer: A narrow economic approach can fail to account adequately for such items as ecosystem services and community value systems, which are sometimes not considered in economic analysis or undervalued by market prices, or for which data are insufficient. This can bias decisions against the poor, vulnerable populations, or the maintenance of important ecosystems. For example, the market value of timber reflects neither the ecological and hydrological functions of trees nor the forest products whose values arise from economic sectors outside the timber industry, such as medicines. Furthermore, some communities value certain assets (historic buildings, religious sites) differently than others do. Broader economic approaches, however, can attach monetary values to non-market impacts, referred to as externalities, placing an economic value on ecosystem services like breathable air, carbon capture and storage (in forests and oceans), and usable water. The values for these factors may be less certain than those attached to market impacts, which can be quantified with market data, but they are still useful to provide economic assessments that are less biased against ecosystems.

However, economic analysis, which focuses on the monetary costs and benefits of an option, is just one important component of decision-making relating to adaptation alternatives, and final decisions about such measures are almost never based on this information alone. Societal decision-making also accounts for equity – who gains and who loses – and for the impacts of the measures on other factors that are not represented in monetary terms. In other words, communities make decisions in a larger context, taking into account other socio-economic and political factors. What is crucial is that the overall decision framework is broad, with both economic and non-economic factors being taken into consideration.

A frequently used decision-making framework that provides for the inclusion of economic and non-economic indicators to measure the impacts of a policy, including impacts on vulnerable groups and ecosystems, is multi-criteria analysis (MCA). However, as with all decision-making approaches, the challenge for MCA and methods like it is the subjective choices that have to be made about what weights to attach to all the relevant criteria that go into the analysis, including how the adaptation measure being studied impacts poor or vulnerable populations, or how fair it is in the distribution of who pays compared to who benefits.

5.10 Adaptation and mitigation

The exposition so far has treated adaptation as the response to an exogenously given change in climate. This is the reality in which adaptation decisions occur. Although most adaptation actors emit greenhouse gases, their carbon output is too small to have a tangible impact on the global climate. They are “climate takers.” Yet, from an aggregate perspective, the relative role of adaptation and mitigation in the global response to climate change is an important question. Policymakers generally think of the two measures as complements, in the sense that the optimal policy response contains both adaptation and mitigation (Watkiss et al., 2015). However, in strict economic terms adaptation and mitigation are more likely to be substitutes – that is, a reduction in the cost of one is likely to lower demand for the other (Buob and Stephan, 2013). If adaptation is cheap and effective there will be less demand for mitigation. More adaptation reduces the marginal benefit of mitigation, and vice versa.

There is more agreement on the ramping up of activities, with mitigation generally kicking in earlier than adaptation. Inertia in both the climate and economic system means mitigation benefits have longer lead-times (Bosello et al., 2010). Integrated assessment models also offer insights into how the adaptation/mitigation choice depends on factors such as the discount rate (which affects mitigation more heavily) and climate uncertainty (which often favors reactive adaptation). While these findings are important, they are mostly of theoretical interest. International decision-makers are not yet at a point where they need to fine-tune their mitigation and adaptation choices at the margin. After a flurry of activity in 2009–2011, aggregate research on the mitigation/adaptation trade-off has levelled off, perhaps also influenced by broader criticism of integrated assessment models.

Box 5.4 Institutional and governance issues in the mitigation/adaptation trade-off

There continues to be interest in institutional and governance issues and the adaptation/mitigation trade-off in particular sectors. Adaptation and mitigation funding requires coordination as these two are competing uses for scarce resources. They also compete with consumption and non-climate investments. For example, some adaptation strategies use land (a shift from crops to livestock), as does mitigation via afforestation or biofuels, and all three would reduce ongoing crop production. Nevertheless, considering both adaptation and mitigation widens the set of actions and lowers the total cost of climate change (Field and Barros, 2014).

5.11 Economic instruments of adaptation

Economists generally favor policies based on voluntary actions influenced by incentives, either positive or negative, over mandates or uniform policies. Examples of these include insurance markets, water markets, and various payments for environmental services (PES) schemes (Chambwera et al., 2014) A second consideration in policy design is cost effectiveness – that is, the extent to which governments make the best use of their resources. The measurement of the net effect of a policy is challenging because it is difficult to anticipate what would have occurred without the policy.

Finally, policies must be carefully designed to avoid perverse outcomes that run counter to the policymaker's objectives. A classic example is found in policies that encourage the adoption of water-saving technology. Research shows that subsidizing irrigation water conservation leads farmers to increase total water use by increasing the acreage under irrigation. This is an example of what is often called the rebound effect (Roy, 2000), whereby increases in efficiency of resource use result in more being demanded.

Box 5.5 Lack of economic instruments for adaptation

With the exception of the literature on insurance- and trade-related instruments, there is relatively little literature on the use of economic instruments for adaptation. One reason is that, apart from insurance, few adaptation policies work directly via economic incentives and markets. The potential of economic instruments in an adaptation context is, however, very limited. We can distinguish the following incentive-providing instruments relevant for the key sectors of (a) insurance schemes (all sectors; extreme events), (b) payments for environmental services (water, ecosystems), (c) regulatory measures and incentives (building standards, zone planning), and (d) research and development incentives (agriculture, health) (Chambwera et al., 2014).

a. Insurance-related schemes

Insurance-related formal and informal mechanisms can directly lead to adaptation and provide incentives or disincentives. Informal mechanisms include reliance on national or international aid or remittances (Cohen and Sebstad, 2005). Another informal mechanism is the inclusion of climate change risk under corporate disclosure regulations. Formal mechanisms include insurance, microinsurance, reinsurance, and risk pooling arrangements. In contrast to indemnity-based insurance, index-based insurance insures the event (as, for example, measured by lack of rainfall), not the loss, and is a possibility for providing a safety net without moral hazard. However, this suffers from basis risk, the lack of correlation of loss to event. This model is being practiced in many developing countries.

b. Payments for environmental services

Payments for environmental services (PES) interventions pay landholders or farmers for actions that preserve the services to public and environmental health provided by ecosystems on their property, including services that contribute to both climate change adaptation and mitigation. There are ample cases of mitigation-focused PES schemes (Wunder and Börner, 2011) and, more recently, evidence has emerged of the use of PES in adaptation in the form of pilot and location-specific interventions. Potentially well-designed PES schemes offer a framework for adaptation, and there is a view among development agencies that, with more experience and guidance on implementation, PES might well contribute to adaptation as one of a multitude of feasible measures (e.g., taxes, charges, etc.).

Work on improving resource pricing and water markets often begins by citing the implications of future water shortages and the potential for conflict. Techniques frequently cited for resolving these conflicts include the establishment of water markets or water pricing schemes, which is in itself also often associated with social conflicts. Traditionally water markets facilitate transfer from lower- to higher-valued uses, but pricing rules can also function through urban fees and real estate taxes (as they do for water supply and urban stormwater regulation in many countries). Some studies make the case that water markets and pricing improve climate change adaptation in a number of countries.

c. Regulatory measures

The government can incentivize or disincentivize adaptation/maladaptation through appropriate regulatory measures, such as building codes, different fiscal and financial instruments, land zoning, etc.

d. Research and development

For adaptation, research and development is extremely important. Adaptation has a historical legacy, where communities have age-old experiential learning about coping mechanisms. While those mechanisms were mostly reactive, these experiences can be brought in, with an appropriate fusion of scientific knowledge. In this regard, action research based on learning-by-doing is crucial. Also, investments in sustainable adaptation technology will give rise to better outcomes in adaptation.

Box 5.6 Theory into Practice

Implementation of Learning

Participants completing this module will have a practical understanding of the political economy of adaptation investment tools and methodologies. Equipped with this knowledge of the economics of adaptation from different perspectives, they will be able to identify effective adaptation options/measures and indicators for monitoring overall progress. Participants will also be able to formulate national adaptation plans, develop project proposals on climate change adaptation, and effectively integrate climate change adaptation issues into national strategies and plans.

For further guidance, please read the following documents and see the attached video.

Documents

Economics of climate adaptation – identifying cost-effective adaptation measures to climate change
http://sdg.iisd.org/commentary/guest-articles/economics-of-climate-adaptation-identifying-cost-effective-adaptation-measures-to-climate-change/

Economics of adaptation to climate change
https://www.worldbank.org/en/news/feature/2011/06/06/economics-adaptation-climate-change

Economics of adaptation – IPCC
https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-Chap17_FINAL.pdf

Economics of climate adaptation – an integrated approach to climate change adaptation
https://ehs.unu.edu/news/news/economics-of-climate-adaptation-eca-an-integrated-approach-to-climate-change-adaptation.html

Video

Economics of climate adaptation
https://www.youtube.com/watch?v=wFnybSWyhMw

Lecture

The economics of climate change mitigation and adaptation:
https://www.youtube.com/watch?v=uFea6c2PANs

Working Group

The economics of climate adaptation – Swiss Re
https://www.swissre.com/our-business/public-sector-solutions/thought-leadership/economics-of-climate-adaptation.html

Estimated cost of adaptation in Bangladesh

5.12 Adaptation cost

Bangladesh's Nationally Determined Contribution (NDC) estimates that overall adaptation measures will cost USD 42 billion (2015–2030). The majority of the financing will go toward comprehensive disaster management followed by river flood and erosion protection (MoEF, 2015). As there is synergy between the NDC and the National Adaptation Plan (NAP), it is important to take this estimated cost as a demand value for adaptation finances. However, these values are based not on rigorous cost estimations.

Adaptation measures	Estimated investment required (billion USD, 2015–2030)
Food security and livelihood and health protection (including water security)	8
Comprehensive disaster management	10
Salinity intrusion and coastal protection	3
River flood and erosion protection	6
Building climate-resilient structures	5
Rural electrification	3
Urban resilience	3
Ecosystem-based adaptation (including forestry co-management)	2.5
Community-based conservation of wetlands and coastal areas	1
Policy and institutional capacity-building	0.5

Table 5.1: Estimated costs for key adaptation measures in Bangladesh's INDC (MoEF, 2015)

Exercise .... Section 7

5.13 Group work

Divide into two groups and, in each group, discuss the following questions:

a. Given there is significant uncertainty about the effects of adaptation measures, can economics contribute much to decision-making in this area? If you think it can, please select some points to elaborate on why you believe this to be so.

b. Propose some ways in which economic instruments can facilitate adaptation to climate change in developed and developing countries?

c. What are the current practices in your region for estimating adaptation/economics that have a particular focus on supporting adaptation decision-making through economic analysis? What are the challenges and what are the solutions?

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Notes

MODULE 6

Integrating Climate Change Adaptation and Disaster Risk Reduction in Bangladesh

Overview of the training module

6.1 Brief introduction to the module

Subject

Integrating CCA and DRR in Bangladesh

Learning outcomes

This module will help learners to develop an understanding of the nature of climate change adaptation (CCA) and disaster risk reduction (DRR) and of the similarities and differences between the two. It will also help trainees to develop ways and means for integrating CCA and DRR in Bangladesh.

Topics

- CCA and resilience in the UNFCCC and the Paris Agreement
- DRR in the international and UNFCCC regimes
- Similarities and differences between CCA and DRR
- Status of funding for CCA and DRR
- Challenges for the integration of CCA and DRR

6.2 Outline of the discussion on the interlinkages between CCA and DRR

Since the 2000s, climate change adaptation (CCA) and disaster risk reduction (DRR) have been increasingly discussed. Historically, disaster management has been mostly reactive, while climate change adaptation is anticipatory in nature. Both nationally and internationally, these two tasks are still performed by different agencies with differing missions. Lately, there have been discussions on how to integrate CCA and DRR, as there are synergies between the two. Integrating CCA and DRR efforts can deliver huge financial benefits in terms of avoided losses from investments in pre-disaster preparedness and responses. How is Bangladesh doing in this regard? What is the level of coordination/cooperation between these two tasks in Bangladesh? This module will explore both the conceptual and practical issues of the integration and application of CCA and DDR in the context of Bangladesh.

6.3 CCA and resilience in the UNFCCC and Paris Agreement

Resilience in ecology is concerned with the longer-term survival and functioning of populations of species and ecosystems in changing environments. Resilience in human systems concerns the preservation of values and activities of societies and the wellbeing of citizens. However, being resilient to climate shocks requires building human systems better than those that came before.

The text of the United Nations Framework Convention on Climate Change (UNFCCC) does not contain any definition of adaptation or any dedicated article (it uses the word five times in different articles in the whole text). However, the Intergovernmental Panel on Climate Change (IPCC) defines CCA as “adjustments in natural or human systems in response to actual or expected climate stimuli or their effects that moderate harm and exploit beneficial opportunities” (IPCC, 2022). This means that CCA reduces the harm that could have been inflicted by disasters in a business-as-usual scenario. Note, then, that adaptation does not stop climate change; this is the function of mitigation.

With the UNFCCC overwhelmingly focused on mitigation – i.e., the reduction of greenhouse gas emissions as the solution to climate change – CCA started out as an afterthought in the process. The Convention assigns responsibility for mitigation largely to the industrial countries, to be performed on a voluntary basis. As a result, little mitigation has been achieved. In 1997 the Kyoto Protocol was adopted, the provisions of which obligate developed countries to reduce their emissions. Despite this, the results achieved by developed countries, except for the European Union (EU) countries, remain unsatisfactory.

Since the first decade of the 21st century, climate events have started becoming the “new normal,” increasing in both frequency and magnitude. As a result, and fueled by the growing climate justice movement, the demands from developing countries, particularly from the Least Developed Countries (LDCs) and Small Island Developing States (SIDS), became stronger. At the 2015 Conference of the Parties (COP 21), the Paris Agreement was adopted. The Agreement contains a dedicated article (Article 7) on adaptation, which defines adaptation as a global responsibility and stipulates global cooperation to this end. Also, it includes a global goal on adaptation, and efforts are now being made to work towards achieving this goal, both at the agency and academic levels.

6.4 DRR in the international and UNFCCC regimes

DRR is a process of reducing disaster risks through the management of their causal factors. It reduces exposure to hazards, lessens the vulnerability of people and assets, improves the management of land and environment, and enhances preparedness for adverse events (UNISDR, 2009). While CCA has a long-term perspective, DRR addresses near-term disasters and their responses. That said, it should be noted that adapting to unfolding disasters will enhance capacity to cope with increased climate disasters in future.

International action on DRR takes place within the framework of the UN International Strategy for Disaster Reduction (UNISDR), which reflects a shift from the traditional disaster response to disaster prevention and preparedness. The Strategy was implemented through the Hyogo Framework for Action 2005–2015, which is based on five priorities that are fully compatible with CCA objectives and processes:

1. Ensure that DRR is a national and local priority, with a strong institutional basis for implementation.
2. Identify, assess, and monitor disaster risks and enhance early warning.
3. Use knowledge, innovation, and education to build a culture of safety and resilience at all levels.
4. Reduce the underlying risk factors.
5. Strengthen disaster preparedness for effective response at all levels.

For its part, the Rio+20 outcome document, The Future We Want, adopted at the 2012 Rio+20 Summit states:

> *We stress the importance of stronger linkages among disaster risk reduction, recovery, and long-term development planning, and call for more coordination and comprehensive strategies that integrate disaster risk reduction and climate change adaptation considerations into public and private investment. (UNEP, 2012)*

DRR was addressed in the UNFCCC negotiations as an aspect of CCA, one associated with vulnerability reduction and efforts to increase climate resilience. The Conference of the Parties (COP) process has referred to international DRR initiatives carried out under and outside of the Convention. For example, the Cancún Adaptation Framework invites all Parties to enhance climate-change-related disaster risk reduction strategies, taking into consideration the Hyogo Framework for Action "where appropriate." At COP 17, Parties were encouraged to make use of the information contained in the IPCC's 2012 special report Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation when considering approaches to address loss and damage.

In practice, the UNFCCC handles DRR issues through its Nairobi Work Programme, which addresses DRR under its focal area on the "impacts of and vulnerability to climate-related risks and extreme events" and in coordination with the above-mentioned initiatives.

The adoption in 2015 of the Sendai Framework for Disaster Risk Reduction (UNDRR, 2015), the Paris Agreement, and the 2030 Agenda for Sustainable Development provided a clear mandate for increased coherence in countries' approaches to climate and disaster risk reduction. Interventions to adapt to climate change and reduce disaster risks share common objectives, but too often they are developed and deployed through administrative silos. The wide range of institutions and government officials responsible for managing climate hazard exposures and reducing vulnerability often miss potential synergies and duplicate efforts.

Article 7 of the Paris Agreement established the global goal on adaptation of "enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change, with a view to contributing to sustainable development and ensuring an adequate response in the context of the temperature goal" of "[h]olding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels. The goal is therefore grounded in Articles 2 and 7 of the Paris Agreement (UNFCCC, 2020).

In a globally connected world, climate risks are affecting people, ecosystems, and economies across borders, which requires international cooperation on adapting to climate change. Specifically, the UNFCCC remains a critical space for coordinating global action on climate change, including building resilience and adapting to the adverse effects of a warmer world.

6.5 DRR in the Hyogo and Sendai frameworks

Adopted in 2005, the Hyogo Framework for Action 2005–2015 included a program with five priorities for addressing DRR, mentioned in section 6.4 above. Despite this, over the course of the Hyogo Framework, progress on managing underlying disaster risk drivers remained limited in most countries. In general, institutional, legislative, and policy frameworks failed to sufficiently facilitate the integration of disaster risk considerations into development decisions. Consequently, hazard exposure in both higher- and lower-income countries increased faster than vulnerability decreased. In other words, new risks were being generated faster than existing risks were being reduced.

At the end of the Hyogo Framework's implementation, UN Member States recognized that efforts had not led to reduced physical losses and economic impacts. They concluded that the focus of national and international attention must shift from protecting social and economic development against external shocks, to transforming growth and development to manage risks in a holistic manner.

As a follow-up, in March 2015 the UN Member States meeting in Sendai, Japan, adopted the Sendai Framework for Disaster Risk Reduction 2015–2030. The Sendai Framework marked a clear shift from managing the impact of disasters to managing and reducing risks that lead to disasters. In other words, a shift from reaction to prevention. This makes the Sendai Framework much more ambitious to implement and monitor than its predecessor, the Hyogo Framework. The Sendai Framework clearly states that, in order to reduce the frequency and impact of disasters, what is required is to better understand disaster risks and to improve risk governance so that existing risks are reduced and the potential of new risks is minimized.

The Sendai Framework identifies four priorities for action, and its focus on prevention is concretized in seven targets for Member States to achieve. Four of the seven targets (a. to d.) are outcome-focused, seeking reductions in human and material losses from disasters. The remaining three targets (e. to g.) are input-focused, pursuing nationally led and owned mechanisms to reduce disaster risk. The four priorities for action are:

1. Understand risk in all its dimensions.
2. Guide and incentivize both public and private sectors to address disaster risk through strengthened risk governance.
3. Put in place multi-hazard early warning systems, protect productive assets, and improve the safety and functionality of critical infrastructure.
4. Strengthen disaster preparedness.

Understanding disaster risk – the first of the Sendai Framework's four priorities – has been particularly challenging. Several regional bodies have stepped up to assist countries in improving their disaster risk understanding. The European Commission compiles a regional risk overview based on the national risk assessments of 34 countries. The African Union initiated an African science and technology DRR advisory group and, as a result, 25 countries of sub-Saharan Africa now have online disaster loss databases and 16 have developed their risk profiles.

As for the second priority on strengthening disaster risk governance, some countries have started putting in place crucially important legal frameworks covering disaster risk reduction and response. The third priority for action in the Sendai Framework is generally understood to mean investing in DRR for resilience. Yet, despite the importance of such investments, financing them has so far proved to be difficult. To address the reality characterized by the systemic nature of risks, it is imperative to move away from working on distinct areas of risk (e.g., spatial, geographic, temporal, disciplinary) when designing and implementing interventions and, instead, adopt a coherent, coordinated approach across sectors. Recognizing that risk reduction cannot occur without climate action has become clearer: DRR will not be successful if it fails to cohere with CCA. Indeed, the coordinated implementation of development objectives has the potential to deliver resilience to a wider range of threats and risks. A further benefit of having coherent approaches includes transaction cost reductions due to overlapping activities and avoided duplication of data collection and reporting.

The parallel development of the global agendas of the Sendai Framework, the Paris Agreement, and the Sustainable Development Goals (SDGs) resulted in limited alignment across the agreements and their different actions and commitments. Since the implementation of these agendas got under way, it has become evident that, in order to build synergies and mutually beneficial opportunities across policies and practices, it is necessary to replace silo approaches with the institutionalization of coherent approaches.

The assessment, dissemination, and communication of risk information is critical for meeting the Sendai Framework's first priority. Risk information, however, involves a wider range of data inputs than the existing hazard-based approach, and includes information on vulnerability, capacity, exposure of communities and assets, hazard characteristics, and the environment. The global- and regional-level goals are very important to achieve the development and dissemination of scientific tools and techniques for acquiring and sharing disaster losses and relevant disaggregated data and statistics. This will help strengthen disaster risk assessment and modeling, while multi-hazard forecasting and early warning systems will provide reliable information for understanding disaster risk and emergency response.

6.6 Principles of "build back better"

In December 2006, on the second anniversary of the 2004 Indian Ocean Tsunami, the United Nations Secretary General's Special Envoy for Tsunami Recovery, former President of the United States Bill Clinton, issued a report with the title Key Propositions for Building Back Better (UN, 2006). Since then, "build back better" (BBB) has become the mantra of post-disaster reconstruction programs. Disasters have been recognized and leveraged as opportunities for change and improvement and, in some cases, are even considered as a "helpful interruption" to previously unchallenged inadequate policies and practices, such as those that disadvantaged certain groups (e.g., persons with disabilities). BBB includes efforts to prevent re-creating or exacerbating pre-disaster vulnerabilities in the process of reconstruction. By strategically embracing and optimizing institutional, financial, political, and human opportunities, positive externalities are believed to arise from disasters, which can lead to safer and more resilient communities. As a consequence of the growing prominence of BBB, many organizations involved in disaster recovery, rehabilitation, and reconstruction have re-labeled their activities as espousing BBB.

BBB signifies an ideal reconstruction and recovery process that delivers resilient, sustainable, and efficient recovery solutions to disaster-affected communities. The motivation behind the Build Back Better concept is to make communities stronger and more resilient following a disaster event. United Nations Environment Programme statistics from 2008 show an increase in the number of natural disasters over time attributed to growing populations, urban growth in risk-prone areas due to scarcity of land, and global warming. Along with their increasing frequency, recent disasters show an increase in magnitude and resulting destruction according to studies by the Red Cross. Both natural and anthropogenic disasters have increased at an almost exponential rate over timeover the last few decades. Yet, despite this, post-disaster activities remain inefficient and poorly managed and need to be improved. Hence the emergence, as mentioned above, of the Build Back Better concept that takes post-disaster reconstruction as an opportunity to not only reconstruct what was damaged and return the community to its pre-disaster state but to also seize the opportunity to improve its physical, social, environmental, and economic conditions and thus create a new state of normalcy that is more "resilient." The term "Build Back Better" is useful as it suggests that the successful recovery of communities following disasters needs rehabilitation that not only enhances the built environment but also addresses the psychological, social, and economic climates in a holistic manner to improve overall community resilience.

6.7 Similarities and differences between CCA and DRR

Based on the discussion above, and to facilitate comparison, Table 6.1 below summarizes the key features of CCA and DRR. After this, the differences and similarities between the two are then presented.

CCA's scope of activities	DRR's scope of activities
• CCA tackles the vulnerability to climate extremes that arise due to climate-related hazards CCA focuses on physical exposure and bases its discussions on science • CCA-related strategies are concerned with future climate projections and scenarios and not with humanitarian assistance • CCA involves the following activities: (a) observation, (b) assessment, (c) planning, (d) implementation, and (e) monitoring and evaluation	• DRR addresses vulnerability related to all categories of hazard, including natural hazards and extreme events • DRR looks at risks more broadly, addressing those due not only to climate, but also to earthquakes, volcanic eruptions, tsunamis, etc. • DRR involves the following modes of response: (a) pre-disaster response including prevention, mitigation, and preparedness, (b) disaster emergency response, and (c) post-disaster response including recovery and development
Funding	**Funding**
• High level of political interest • Funding streams sizable and increasing • Special Climate Change Fund • Least Developed Countries Fund • Hyogo Protocol Adaptation Fund • Green Climate Fund (GCF) • Global Environmental Facility (GEF)	• Low to moderate level of political interest • Funding streams ad hoc and insufficient • National civil defense/emergency response • International humanitarian funding • Multilateral banks • Bilateral aid
Assessment tools	**Assessment tools**
• Vulnerability assessment • Risk assessment • Monitoring • Mapping • Modeling	• Disaster loss and damage database • Risk assessment
International frameworks	**International frameworks**
• UNFCCC, IPCC • Kyoto Protocol, Paris Agreement • COP Decisions	• Hyogo Framework for Action (2005–2015); Sendai Framework for Disaster Reduction (2015–2030) • United Nations Office for Disaster Risk Reduction; Global Platform for DRR • World Conference on Disaster Reduction

Table 6.1. Key features of CCA and DRR

6.7.1 Differences between CCA and DRR

CCA	DRR
Climate-related hazards only	Encompasses all geophysical risks
Long-term view	Builds on past experience
Encompasses changes to average conditions	Focuses on extremes only
Forward-looking perspective	–
Origins in science	Origins in humanitarian assistance
High level of potential interest	Low to moderate level of political interest
Funding streams growing and sizable	Funding streams ad-hoc and insufficient

Table 6.2. Differences between CCA and DRR

6.7.2 Similarities between CCA and DRR

Common concerns
- Reducing vulnerabilities
- Enhancing resilience

Common principles
- Bottom-up approach
- Capacity building
- Relation with poverty reduction
- Cross-cutting developmental issues
- Gender considerations
- Sustainable development dimension
- Role of cities, regions, and local authorities
- International cooperation
- Time frames (2015–2030)

6.8 Status of funding for CCA and DRR

6.8.1 Financing of CCA

There is an urgent need for CCA funding in developing countries, which require an estimated USD 70 billion to meet their adaptation plans. Moreover, according to UN Environment's *The Gathering Storm, Adapting to climate change in a post-pandemic world – Adaptation Gap Report 2021 (UNEP, 2021),* released in January of that year, this figure could reach up to USD 300 billion in 2030 and USD 500 billion in 2050.

In reality, though, the supply of adaptation finance falls far short of meeting these estimated needs. The Organization for Economic Co-operation and Development (OECD) claims that climate finance rose by 11% in 2018 compared to 2017, totaling USD 78.9 billion, with bilateral climate finance accounting for USD 32.7 billion (26% of official development assistance or ODA) and multilateral for USD 29.6 billion. However, Oxfam's calculations (Carty et al., 2020) reduce this number more than three times, showing only USD 19–22 billion as climate-specific net assistance, of which USD 6–7 billion is for adaptation (ibid.). Over-reporting the climate relevance of supported projects by applying the Rio markers of "principal" or "significant" (see Figure 6.1. below) and reporting loans at face value (rather than their grant-equivalence) causes most of this inflation in the OECD estimates. In 2017–18, it is estimated that only 20.5% of bilateral climate finance went to Least Developed Countries (LDCs) and 3% to Small Island Developing States (SIDS), and a majority of this finance was in the form of loans and non-grant instruments (ibid.), and the share of loans is increasing. In 2016–17, only 3% of the private finance mobilized was for adaptation. All these numbers speak for themselves: the Copenhagen Accord and the Paris Agreement are not being met. Moreover, even for the LDCs, two thirds of climate finance comprises loans. While an increasing share of ODA is delivered as climate finance, ODA is reducing overall.

Box 6.1 Challenges in integrating DRR and CCA: the case of Bangladesh

The challenges in integrating CCA and DRR in Bangladesh are:

- Resources and funding mechanisms
- Coordination and collaboration
- Implementation and mainstreaming
- Scale mismatches
- Lack of effective governance
- Political, social, and cultural structure
- Competing actors and institutions
- Inadequate information, communication, and knowledge sharing
- Lack of community involvement
- Policy gaps
- Difficulty in distinguishing DRR and CCA from development work

(Source: Islam, Chu and Smart, 2020)

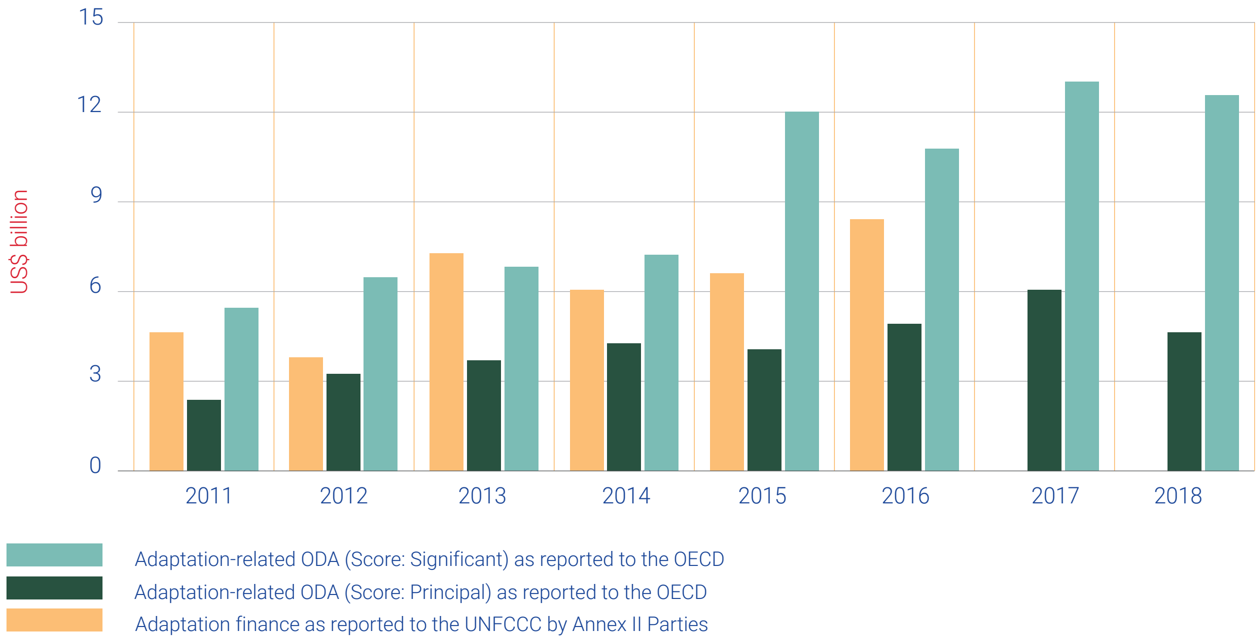

Figure 6.1. Adaptation-related ODA and finance as reported to the OECD (source: UNEP, 2021)

6.8.2 Financing of DRR

Reducing risk is critical to sustainable development. It is also indispensable in reducing the humanitarian burden. Disasters affect 350 million people on average each year (UNOCHA, 2018). Investing in risk reduction and building resilience saves more than lives and livelihoods; it is also a good return on investment. While the trend for financing related to disasters has been on the increase since 2010, this has largely comprised the financing of activities undertaken in the aftermath of events rather than of those focused on prevention and preparedness.

Given its extraordinary mandate and given the multi-dimensional nature of risk and its cascading impacts, the United Nations Office for Disaster Risk Reduction's (UNDRR) average recurring budget is remarkably small. Over 99% of UNDRR's work is funded through voluntary contributions by a diverse donor base. UNDRR encourages increased voluntary financial contributions through the United Nations Trust Fund for Disaster Risk Reduction.

A UNDRR report (2021) mentioned that financing for disaster risk reduction makes up a small fraction of overall development aid. USD 133 billion of financing was made available for DRR between 2010–2019, which is 11% of overall aid (USD 1.17 trillion). Of this, just a fraction – USD 5.5 billion (4.4%) – was aimed at promoting risk reduction measures before disasters strike, compared to USD 119.8 billion (95.6%) spent on post-disaster response. Of the overall aid financing between 2010–2019, the USD 5.5 billion spent on pre-disaster risk reduction accounts for just 0.5%. In other words, for every USD 100 spent on development aid, only USD 0.50 are invested in defending that aid from the impact of disasters. Every USD 1 invested in risk reduction and prevention can save up to USD 15 in post-disaster recovery, and every USD 1 invested in making infrastructure disaster-resilient saves USD 4 through fewer disruptions and reduced economic impacts. Spending USD 800 million on early warning systems in developing countries would avoid losses of USD 3–16 billion per year (ReliefWeb, 2021).

Integrating CCA and DRR in Bangladesh

6.9 Integration of CCA and DRR

There is an increasing convergence between elements of the CCA and DRR agendas in so far as climate-related stress directly affects vulnerability and exacerbates disaster risks. However, greater emphasis is needed to bring about coherence and synergy between the two plans (CCA and DRR) as well as in their implementation and monitoring. Parallel tracks of DRR, CCA, and sustainable development are emerging, hence the need to advocate for an integrated approach.

However, at present there is no such integration between CCA and DRR in Bangladesh, as evidenced by the country's latest National Plan for Disaster Management (NPDM) 2021–2025. For the NPDM, Bangladesh has developed an elaborate disaster management structure for the national through to the local level. This includes the district- and union-level committees such as the Earthquake Preparedness and Awareness Committee, the Cyclone Preparedness Program Implementation Board, the Cyclone Preparedness Programmer Policy Committee, and so on. The Disaster Management Bureau, under the Ministry of Disaster Management and Relief (MoDMR), coordinates the implementation of these bodies' respective policies and programs. The NGO Coordination Committee on Disaster Management is tasked with reviewing and coordinating activities with non-governmental organizations (NGOs).

The Ministry of Environment, Forest and Climate Change (MoEFCC) is primarily responsible for developing, planning, and coordinating all projects related to the environment and climate change. Other relevant ministries also work with MoEFCC on developing climate change adaptation policies and projects. Many other public, private, and civil society actors and international agencies work directly and indirectly with the MoEFCC. At the regional and local levels, relevant government departments are responsible for implementing policies and programs related to the environment and climate change.

What is needed is for the system to ensure a close working relationship between the policy units within each of the ministries and to set up a wing or cell dedicated to tackling the issues of disaster risk management (DRM) and CCA within sectoral laws, policies, plans, projects, and programs. Arrangements must be put in place to enable operational agencies to implement decisions and prepare reports of actions. For this reason, there are significant advantages in installing focal points in all the line ministries as well as in the Prime Minister's Office.

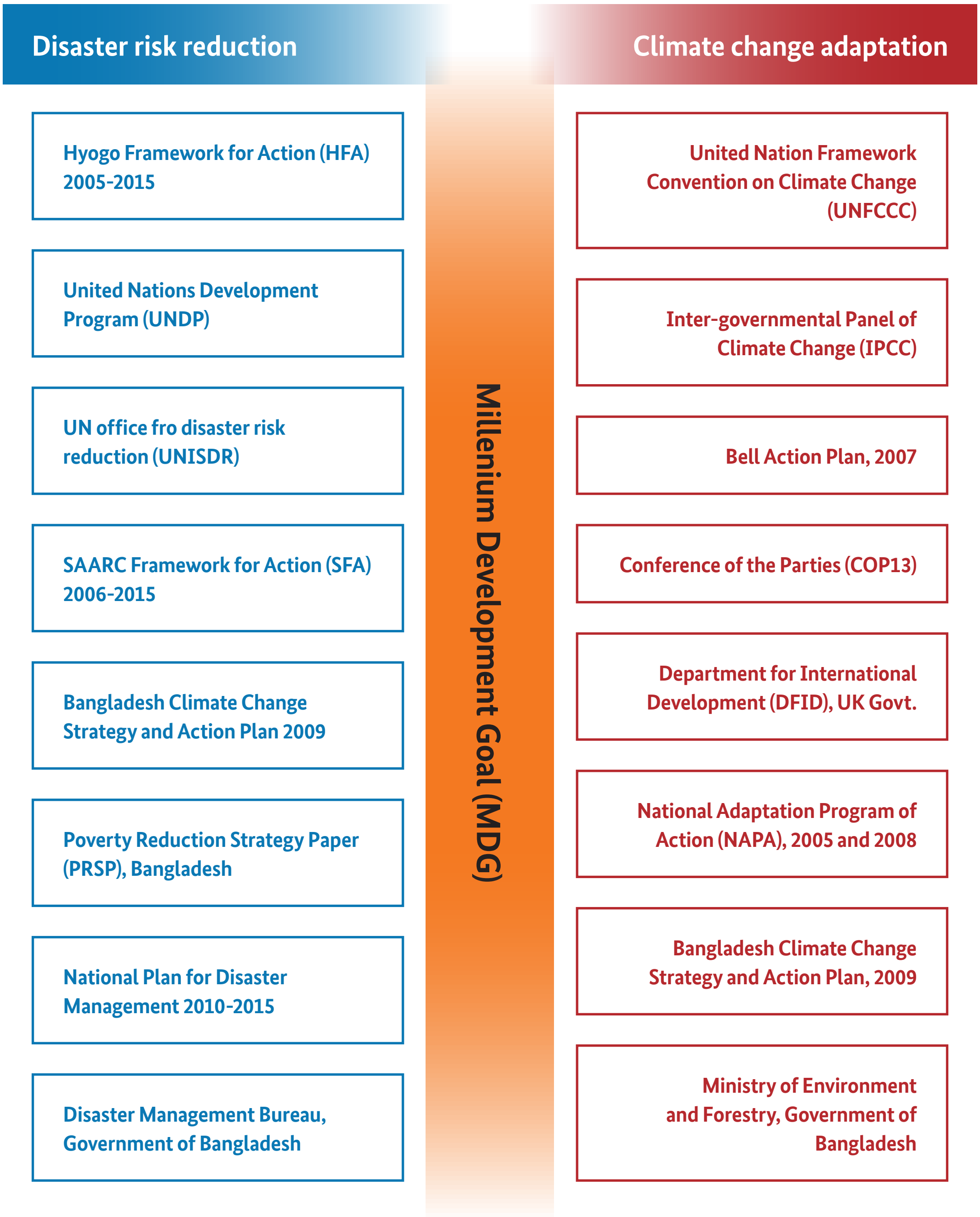

Figure 6.2: Global to national drivers for the DRR and CCA policy frameworks (source: Hasan et al., 2013)

Challenges in integrating CCA and DRR

Section 4

6.10 Key challenges in CCA and DRR integration

Although some policy documents recognize the need for integration, CCA and DRR continue to operate in silos. Indeed, the latest NPDM (2021–2025) does not address CCA and DRR integration, and its implementation strategy does not mention the UNFCCC, the Paris Agreement, or CCA. There is no dedicated section on integration, as evident in its table of contents. Even in its Summary Action Statement, which speaks about DRR governance and investing in DRR, there is no mention of CCA. The following discussion explores some of the challenges that stand in the way of integration.

6.10.1 Scope of work

There are differences in the nature and scope of the work of DRR and CCA in Bangladesh. At the national and regional levels, CCA mainly focuses on issues related to climatic events, whereas DRR focuses on any kind of anthropogenic or natural disasters. Moreover, climate change information and projects have developed at a global scale, whereas the disaster management approach is mainly based on disasters that happen locally, regionally, and nationally. One of the key differences is that DRR focuses on emergency management and recovery along with long-term sustainable development, whereas CCA mainly focuses on long-term sustainability.

6.10.2 Policy and administrative challenges

In Bangladesh, multiple administrative bodies with different values and principles are responsible for disaster risk management and climate change adaptation projects. Consequently, management approaches vary in line with these different values and principles. Although some areas of DRR and CCA work are complementary, these different administrative and management approaches may lead to contradicting strategies when it comes to implementing projects at the field level. For example, CCA goals mainly focus on long-term adaptation, whereas quick recovery from disaster is vital for DRR.

6.10.. Institutional arrangements for DRR

Bangladesh has long experience of disaster response and recovery, and the country's institutional arrangements for disaster management are fairly well organized. With the support of government, NGOs, and donor agencies, a good number of disaster management projects have been successfully developed and implemented at the regional and community levels. Even though DRR may be operating satisfactorily in Bangladesh, its integration with CCA requires work. While the concept and institutional arrangements for climate change adaptation in Bangladesh are relatively new, interactions between the ministries responsible for climate change adaptation and disaster management in Bangladesh remain limited.

6.10.4 Incoherent policy approach

An obstacle to integrating DRR and CCA can be seen in the fragmentation of policy development from the global to national level. The institutional frameworks and policy development for DRR and CCA are mostly worked on by different institutions with different values. Consequently, when projects and policies are developed following the guidelines and policies of these different institutions and legislative bodies, the integration of DRR and CCA becomes more difficult.

6.10.5 Funding sources

In terms of funding sources, different bodies finance different projects related to DRR and CCA in Bangladesh. CCA adaptation projects are highly influenced by their donors, and the World Bank plays a critical role in the disbursement and approval of these projects. On the other hand, DRR projects are mainly approved by the Government of the People's Republic of Bangladesh at the national level, under the MoDMR, and are funded by the national government and international agencies such as the World Bank, Asian Development Bank, etc. Hence, at present the funding agencies for DRR and CCA in Bangladesh are once again different and thus again have different norms and values. The institutional arrangements at the international and national levels for the funding of both DRR and CCA projects need to be rearranged to achieve further coordination and integration.

Box 6.2 Critical elements of gender mainstreaming in CCA and DRR

Common elements

- Include gender perspectives in adaptation and disaster reduction efforts at the national, regional, and international levels – including in policies, strategies, action plans, and programs.
- Build the capacities of national and local women's groups, and provide them with a platform to be heard and to lead.
- Include gender-specific indicators and data disaggregated by sex and age to monitor and track progress on gender-equality targets.
- Ensure that climate finance is responsive to climate change and disaster risk and to vulnerability dynamics, especially within marginalized groups of society, including poor women and men. To this end, undertake a gender analysis of applicable budget lines and financial instruments to determine the differentiated impacts on women and men. More broadly, engage with existing climate finance frameworks, networks, and instruments at all levels to ensure more meaningful integration of gender perspectives in disaster risk reduction and adaptation efforts.
- Consider the reallocation of resources, if relevant, to achieve gender-equality outcomes from the actions planned.
- Include women's traditional knowledge and perceptions in the analysis and evaluation of adaptation, disaster risks, and coping strategies and solutions.
- Analyze climate change data (e.g., on desertification, floods, drought, deforestation) with a gender-sensitive perspective and collect sex-disaggregated data.
- Increase women's participation and representation in all levels of decision-making processes.

Elements specific to disaster risk reduction

- Take gender-aware steps to reduce the negative impacts of disasters on women, particularly in relation to their critical roles in rural areas in the provision of water, food, and energy (i.e., provide support, health services, information, and technology).
- Ensure that women are being visibly engaged as agents of change at all levels of disaster preparedness, including in early warning systems, education, communication, information, and networking opportunities.
- Consider the level of women's access to technology and finances, health care, support services, shelter, and security in times of disaster.
- Elements specific to adaptation
- Address gender differences in capabilities to cope with climate change adaptation. Specifically, make women's equal access to information, credit, and other productive and reproductive resources a priority.
- Develop and apply gender-sensitive criteria and indicators for monitoring and evaluating the results of ongoing adaptation actions.

Women's empowerment improves adaptation to climate and disaster risk

With the new 2030 Roadmap and SDGs adopted by the global community, not only is gender-equality reaffirmed as a matter of human rights and dignity (SDG 5); it is also recognized as central to all of the SDGs. Appreciating, engaging, and promoting women's unique capacities in adaptation and DRR would allow decision-makers to pursue policies that build resilience in communities while also remedying gender injustice.

For more information, please visit: https://www.undp.org/publications/gender-adaptation-and-disaster-risk-reduction

Box 6.3 Theory into Practice

Implementation of Learning

This module provides learners with a better understanding of the ideas and intersections of climate change and disaster risk reduction, as well as the techniques, methods, and instruments that may be utilized to better incorporate climate change into disaster risk reduction. With the knowledge gained in this module, participants will be able to combine disaster risk reduction and climate change adaptation more effectively in the context of development and poverty reduction. Also, participants completing this module will be able to develop a work plan that demonstrates how they can influence their organization to effectively integrate disaster risk reduction and climate change adaptation.

For further guidance, please read the following documents and see the attached video.

Documents

Mainstreaming DRR and CCA across sectors and actors in Bangladesh:
https://www.unescap.org/sites/default/files/Mainstreaming%20DRR%20%26%20CCA%20in%20Bangladesh%20by%20Qayyum.pdf

Challenges in integrating disaster risk reduction and climate change adaptation – Exploring the Bangladesh case:
https://www.researchgate.net/publication/339481171_Challenges_in_integrating_disaster_risk_reduction_and_climate_change_adaptation_Exploring_the_Bangladesh_case

Disaster risk reduction including climate change adaptation over South Asia – Challenges and ways forward:
https://link.springer.com/article/10.1007/s13753-018-0210-9

Climate change adaptation in Bangladesh – Current practices, challenges, and the way forward:
https://www.sciencedirect.com/science/article/pii/S266727822100105X

Video

Climate change adaptation and disaster risk reduction, Bangladesh:
https://www.youtube.com/watch?v=nkb2mw6FzQM

Disaster risk reduction in Bangladesh:
https://www.youtube.com/watch?v=McVzcb6nhQ8

Working Group

Bangladesh Disaster Risk and Climate Resilience Program:
https://www.worldbank.org/en/country/bangladesh/brief/bangladesh-disaster-risk-climate-change-program

Exercise ······ Section 5

6.11 Group work

Divide into two groups and, in your breakout room, complete and discuss the following tasks and questions:

a. Give some examples of a potential adaptation action at each of these scales:

- household
- district
- sub-district
- country
- region

Next, answer these questions:

1. Can you define for each example whether it is anticipatory or reactive, autonomous or planned?
2. What are the main factors that you think are necessary to ensure each action is successful? Think about technology, skills, who needs to be involved, coordination, and resources.

b. Are there any similarities and differences between DRR and CCA that have not been identified in this module? What are they?

c. What methods can you suggest for integrating DRR and CCA in your own work?

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Notes

MODULE 7

Analysis and prioritisation of adaptation options based on diverse metrics

Overview of the training module

7.1 Brief introduction to the module

Subject

Analysis and prioritisation of adaptation options based on diverse metrics

Learning outcomes

This module will help learners to understand the need for the analysis and prioritization of adaptation options as a key step in the adaptation process. Learners will be introduced to the basics of decision-making theory and provided with relevant examples. They will be made familiar with the most commonly used metrics for monitoring adaptation and will learn how to implement a holistic multi-criteria (social, environmental, economic, etc.) analysis of adaptation options.

Topics

- The need for prioritization
- The need for a holistic approach vs a reductionist one
- Adaptation as a problem of decision-making
- Metrics for measuring adaptation

The problem and the need to prioritize

7.2 Defining the problem

Exercise

A community-level crisis due to climate change (e.g., increasing salinity of agricultural land) will be presented. The learners (working either in groups or individually) will be tasked with coming up with several solutions to the problem. The solutions will be discussed and the realities of implementing them (economics, time, social norms, etc.) examined. The learners will be told that, by the end of the module, they will be able to analyze the crisis presented and come up with the best solution.

Purpose of the exercise:

- To appreciate the realities of the climate-change-induced community-level crises often experienced in Bangladesh.
- To recognize the difficulty in determining optimal solutions to climate change issues.
- To highlight the need for metrics to measure the extent of the problem and serve as a basis to prioritize adaptation options.

7.3 The need for community-led solutions and prioritization

Many strategies to reduce risks and vulnerabilities related to climate change have frequently failed to produce results because of traditional top-down approaches to problem solving. This insistence on top-down planning, which lacks the participation of the local community, has failed to bring sustainable economic growth and poverty reduction (Kaiser, 2012). Increasing community intervention and co-creating knowledge between diverse stakeholders can contribute to remedying social and environmental injustices (Ferrari et al., 2021). Several studies underscore the need to recognize the experience of communities, particularly in relation to local involvement in project planning and implementation.

Typically, a specific problem arising due to climate change has more than one solution. In many cases, the solution needs to be specific to the community where the problem arises. Any type of adaptation policy or plan will not work without proper attention to the political structures, institutions, and social structures of the affected community (Dodman and Mitlin, 2013). In such a multidimensional solution to a particular crisis, the need for prioritization becomes acute. Prioritization may be based not only on economic cost–benefit analyses, but also on environmental and social indicators. There are various monetary and non-monetary indicators that influence adaptation decisions. A framework is therefore needed for rationally deciding which parameter is important. There can be several feasible options for solutions to a problem, but a rational and practical approach requires analyzing and selecting the correct options. Some approaches will be better suited to reducing the risks associated with the implementation of the adaptation plan in the face of uncertainties. Identifying adaptation measures includes acknowledging that there are different options present, and different risks associated with implementation in spite of the uncertainties. The options are normally referred to as no-regrets, low regrets, win–win, and flexible/adaptive management (Dodman and Mitlin, 2013).

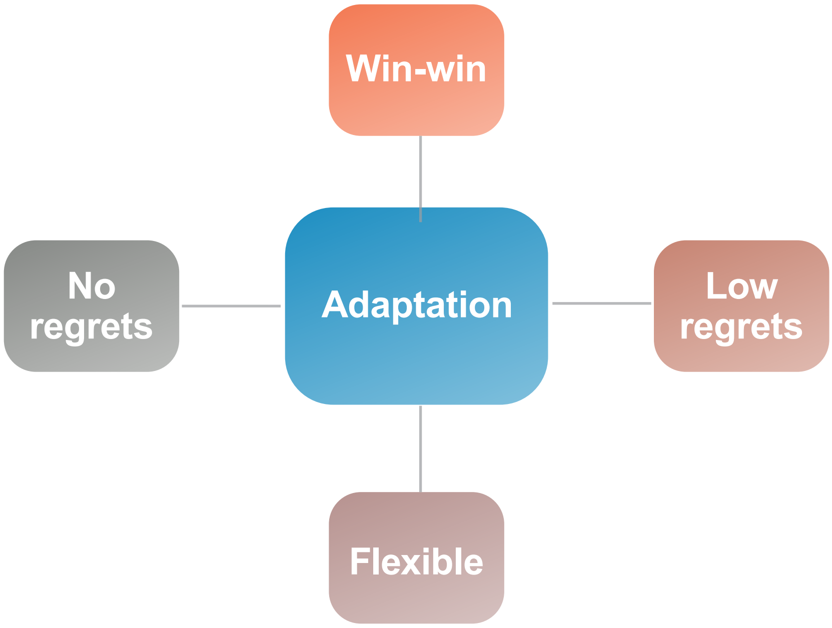

Figure 7.1: Options for prioritization in adaptation measures (source: author's own work)

- **No-regrets option:** These are measures that deliver net benefits whatever the extent of future climate change. This option includes cost-effective measures under current climate conditions and is useful in the short-term. This option has a high likelihood of being implemented and can also provide experience that can help to tackle future climate risks and design adaptation measures.
- **Low-regrets option:** These are measures where the costs are relatively low, but the rewards or benefits are high. The benefits are realized through projected future climate change and may not be appropriate for the actual scenario in the future.
- **Win–win option:** These are measures that address climate impacts but also have positive social, environmental, or economic benefits. These types of measures include those that are introduced primarily for reasons other than addressing climate risks but that also deliver the desired climate change adaptation benefits.
- Flexible or adaptive management options: These are measures that involve incremental adaptation options, rather than large-scale, one-time approaches to adaptation. This way, there is less risk should the measures taken be wrong, and options remain open in terms of utilizing the best technology, experience, and current knowledge.

7.4 Reductionist problem-solving

To solve a problem, most scientists like to break it down into its components. The underlying thought process is that by understanding the parts, we can understand the whole – the sum of all parts equals the whole. Reductionism involves reducing every problem into explanations of separate components. A reductionist approach answers the immediate direct cause and the how of the problem.

This reductionist philosophy has been very successful in science and has led to great advances in the physical sciences including biology, medical sciences, astronomy, and studies on the environment. Even when studying complex ecosystems like the marine habitat, the approach has been to look at individual components and try to link the components like a web to get an understanding of the whole system. A forest is an entire ecosystem, functional in its entirety due to the interactions and interdependencies among trees, the soil, the environment, and the animals that live above and beneath the soil, working in perfect harmony. The more complex a system is, the more dependencies and interactions are likely to be at work. Reductionist approaches to solving problems, while very successful in the natural and social sciences, do not work very well when looking at issues related to climate change.

7.5 Holistic problem-solving

A holistic approach looks at the whole problem and the multiple dimensions that the solution influences. The holistic approach provides the answers to why something happened within the context of the greater whole. An example of a holistic approach to problem-solving includes looking at how the environment influences the health of an individual. The health of a person is not only related to their physical ailments but could also be a function of their psychological make-up, external environmental influences, and the society in which they are brought up. Knowing the interactions of a person in society helps in treating individuals because they address the problem as part of an interdependent system rather than as an independent part of a system.

Holism considers the whole as more than the sum of its parts. A holistic approach to a problem posits that a process cannot be regarded in a strictly mechanistic perspective of small parts but should be viewed as a complex system with many interactions. A holistic approach not only studies the individual characteristics of all parts, but also their interdependencies and interactions. A process under study should also be viewed as a part of wider systems such as an organization, society, or the supply chain systems of business management.

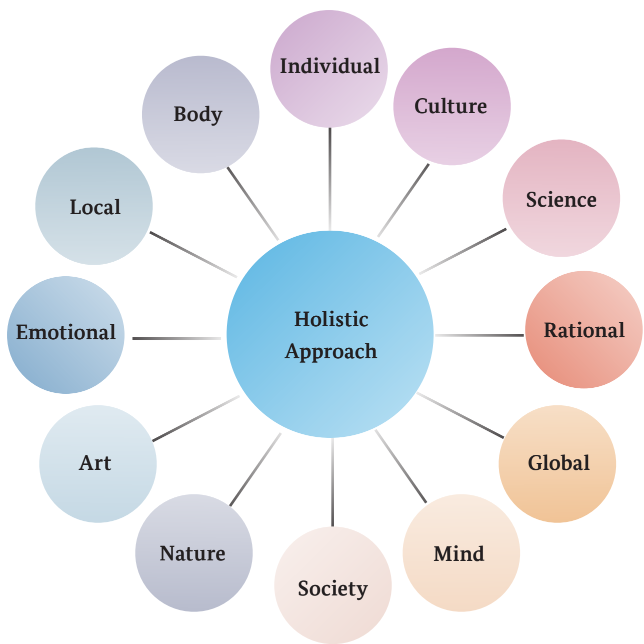

Figure 7.2: Options for prioritization through holistic problem-solving, adapted from Lehtonen et al. (2019)

Box 7.1 Gender-responsive holistic approach to climate change and its benefits for vulnerable people

The impacts of climate change do not affect all members of society in the same ways – some are more vulnerable than others. For example, in a typical rural Bangladeshi household, men are responsible for farming crops for commercial purposes – they provide the main income of the household. Women are also involved in farming crops, but these are used to feed the family (vegetables, fruits, etc.). Any negative effects on agriculture due to climate change will mean that men will need to adapt to a loss of income, while women will face household food insecurity. Any adaptation plan for agriculture will therefore need to address the different genders, backgrounds, and economic status of affected people in a holistic manner. To find out more about why gender matters for effective adaptation to climate change, please watch this NAP Global Network video:

Available at https://www.youtube.com/watch?v=luO8phhdfsA

7.6 Adaptation challenges

Decision-making theory is a theory of how rational individuals should behave under risk and uncertainty. It is defined as "a process or sequence of activities involving stages of problem recognition, search for information, definition of alternatives and the selection of an actor of one from two or more alternatives consistent with the ranked preferences" (Simon, 1979). The theory uses a set of axioms about how rational individuals behave that has been widely challenged on both empirical and theoretical grounds. Decision-making involves the adoption and application of rational choice for the management of organization in an efficient manner (Yalcin et al., 2022).

Decision-making theory first appeared in the renowned book Administrative Behavior, by the Nobel-Prize-winning economist Herbert A. Simon. Simon is best known for his work on corporate decision-making. He suggested that decisions are critical because decisions that are not taken on time will negatively impact an organization's objectives. Previously, it was thought that decisions are based on making a simple choice between alternative courses of action. However, Simon suggested that there is never one best course of action because there can never be complete information about something and, therefore, there will always be a better course of action. Also, Simon's decision-making theory was the first to consider the psychological aspects of decision-making, something that classical economists had previously overlooked. This therefore represents the first instance of bringing a holistic approach into corporate decision-making. According to Simon, there are three stages involved in the decision-making process (Simon, 1979):

1. Intelligence Activity Stage – At this stage, people identify the problems in an organization and the upper management analyzes the organizational environment to work toward a solution.
2. Design Activity Stage – In order to identify possible solutions to problems, the upper management looks for suitable strategies. They further analyze the merits and demerits to select a particular course of action.
3. Choice Activity Stage – After making a list of alternatives, the choice activity stage begins. The various consequences of all the alternatives are critically examined and evaluated, and the most suitable course of action is selected. This stage requires creativity, judgment, and quantitative analysis skills.

Since Simon's groundbreaking work on decision-making, there have been many theories and revolutions in the discipline of decision-making. Business analytics is now a well-established discipline that is used by organizations to improve decision-making processes and support strategic planning. Sophisticated methods are being employed by companies for better performance (Yalcin et al., 2022). Decision-making theories have been adopted not only in business management but also in psychology, environmental science, and in the military. There are many decision-making approaches that have been developed over the years. These include consensus decision-making, voting-based methods, the Delphi method, decision engineering, expected-value optimization, decision-support systems, etc. In fact, automated algorithmic software for decision-making are now commercially available. A description of some of the more useful decision-making approaches relevant to climate change adaptation are described below:

(a) Nominal group technique

The nominal group technique (Delbecq et al., 1971) is a group process that involves three steps: problem identification, solution generation, and decision-making. It is suitable for groups of many sizes and those who want to make their decision quickly. This is usually done by taking a vote once everyone's opinions have been taken into account. There is also a difference in the method of tallying. Every member of a group gives their view of the solution, with a short explanation. Then, duplicate solutions are eliminated from the list of all solutions, and the members proceed to rank the solutions. In the basic method, the numbers each solution receives are totaled, and the solution with the highest (i.e., the most favored) total ranking is selected as the final decision.

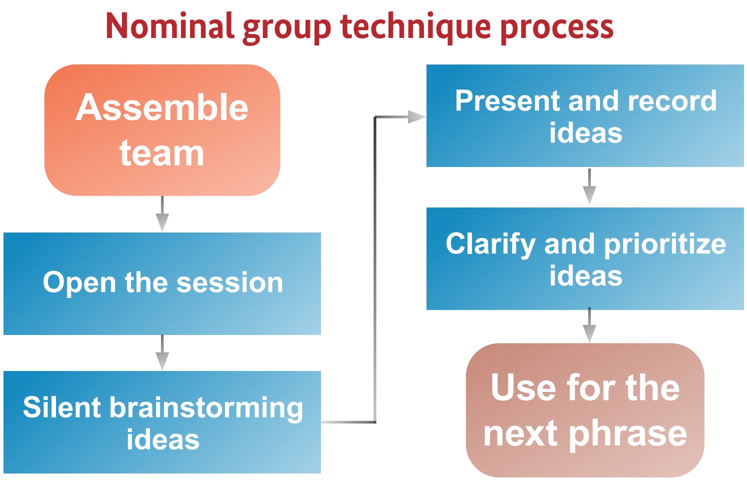

Table 7.3: Nominal group technique (source: Kumar, 2021)

(b) Criteria weighting

The weighted criteria matrix is a valuable decision-making tool that is used to evaluate program alternatives based on specific evaluation criteria weighted by importance. A little more involved than the other non-mathematical methods, this method comprises evaluating the alternatives based on their performance with respect to individual criteria. In this way, a value for the alternative can be identified. The values for each alternative can then be compared to create a rank order of their performance related to the criteria as a whole. This tool is important because it treats the criteria independently, helping to avoid the over-influence or emphasis of specific individual criteria.

(c) Cost–benefit analysis

Cost–benefit analysis is a well-known systematic approach for determining the strengths and weaknesses of alternative options. This is a very common tool used in business management, but it can also be used in choosing climate change adaptation options. Cost–benefit analysis is used to determine options that provide the best approach to achieving benefits while preserving savings. The analysis can therefore be used to compare completed or potential courses of action and to estimate or evaluate the value against the cost of a decision. Cost–benefit analysis is applied to determine whether a decision is sound and whether and by how much the benefits outweigh the costs.

Box 7.2 Case study: Cost–benefit analysis of restoring Buriganga River, Bangladesh

Overview

The Buriganga River, one of the most important rivers in Bangladesh, forms the western and southern boundaries of Dhaka City, the economic and political capital of Bangladesh. It is one of the most polluted rivers in the world, which is alarming because the Buriganga is a source of water to millions of people living along its banks. A cost–benefit analysis to determine the economic efficiency of restoring the polluted river was carried out. The benefits of the restoration were determined using market data and employing benefit transfer and contingent valuation techniques. The values generated by this approach were then integrated into the framework of a cost–benefit analysis, which revealed a benefit–cost ratio of 4.35. This demonstrates that the restoration of dying rivers in developing countries is not only an environmental imperative; it is also socially and economically justifiable.

Methods used

Cost–benefit analysis was used to quantify and value the cost and benefit of an intervention at different times using a common yardstick (e.g., net present value). The contingent valuation method was used to estimate the non-market benefits of the restoration program. The conventional contingent valuation method was extended to include respondents' preferences in terms of time for the restoration of a vulnerable river, irrespective of their decision to contribute money. The benefits were estimated as a total economic value that incorporates both use and non-use benefits.

Conclusion

In the case of the Buriganga River, about two-thirds of the expected benefits of the restoration program are derived from market benefits. The large share of market benefits is primarily due to the high land value in the study area. The whole range of benefits, both market and non-market, was relevant to the economic analysis, and the direct benefits alone made the intervention worthwhile. The benefits of any ecosystem restoration should be measured as the sum of all the components of the total economic value. Public sector investment in developing countries such as Bangladesh needs redirection to respond to emerging environmental problems such as degraded ecosystems.

7.7 Why metrics are needed for measuring adaptation

Multiple sectors and sectoral adaptations have been highlighted in previous climate change plans, policies, and strategies. The majority of these policies, including the national development policies, emphasized adaptation in the areas of water resources, agricultural and food security, coastal zone and urban transition, and disaster management. This and the next section (4.5 and 4.6) provide synopses of the sectoral strategies contained in the latest climate change policies such as the BCCSAP (MoEF, 2009), the Roadmap and Action Plan for Implementing Bangladesh NDC (MoEFCC, 2018a), the Third National Communication to the UNFCCC (MoEFCC, 2018b), and the Nationally Determined Contribution (MoEFCC, 2021). For example, the 2018 Third National Communication (TNC) provides a short inventory of adaptation approaches based on the temporal aspects and impacts of climate change where anticipatory and reactive actions mean measures taken to adapt to future and present climate change impacts respectively.

7.8 Metrics for measuring adaptation

Quantitative metrics are those that you can measure with a number. They may involve the use of a formula or certain mathematical operators to come up with a number that can be applied in decision-making. Economic cost analysis inevitably uses numbers, and it gives you precise data. Quantitative methods that emphasize statistical or numerical models are very useful in climate change studies and social sciences. The arrival of digital technologies and social media has delivered a transformational impact in that we have larger volumes of numerical information than ever before. This so-called big data research is having a huge effect on the current research on climate change and social sciences (González-Bailón, 2013).

Qualitative methods usually involve collecting information through interviews and participant observation or from archival text. While these methods are sometimes more subjective and opinion-based, they are often more useful than quantitative ones. Qualitative methods focus on unique cases and mechanisms, and they are particularly useful when investigating underlying causes and data that are hard to measure or are scarce. Quantitative metrics rely on numbers but, in the real world, evidence is often stored as descriptive language. Qualitative text analysis is essential to understand how climate social policies are designed or implemented. Field work and case studies have irreplaceable roles in investigating local conditions and criteria that may be missed from a purely quantitative analysis.

It is important to understand that no metric is superior to another. In many cases, a mixed-metrics strategy of quantitative and qualitative measurements is necessary to answer the complex questions related to climate change. The key is to be open-minded to different approaches and focus on the questions that need to be answered.

Spot the difference

It is important to note the difference between the terms "indicator" and "index" when it comes to adaptation metrics. Indicators usually consist of a single factor or variable. For example, changes in soil moisture is an example of an indicator. An index is made up of multiple indicators, which it combines into a single number. For example, a fire weather index (FWI) is used to assess fire danger in a harmonized way. The FWI uses information about fuel moisture and weather conditions to determine fire behavior (Leiter et al., 2019).

In certain cases, it might be necessary to use proxy data when real data are not forthcoming. Proxy data are very useful when looking at vulnerability analysis to measure exposure and sensitivity to climate impacts across sectors. Some indicators can be adopted as a proxy to measure components of local vulnerability. For example, location-specific temperature could be used as a proxy for the health risks from increasing heatwaves, or the per-capita income of coastal communities could be used as a proxy for coastal protection levels. These proxy measurements are useful as a metric for decision analysis.

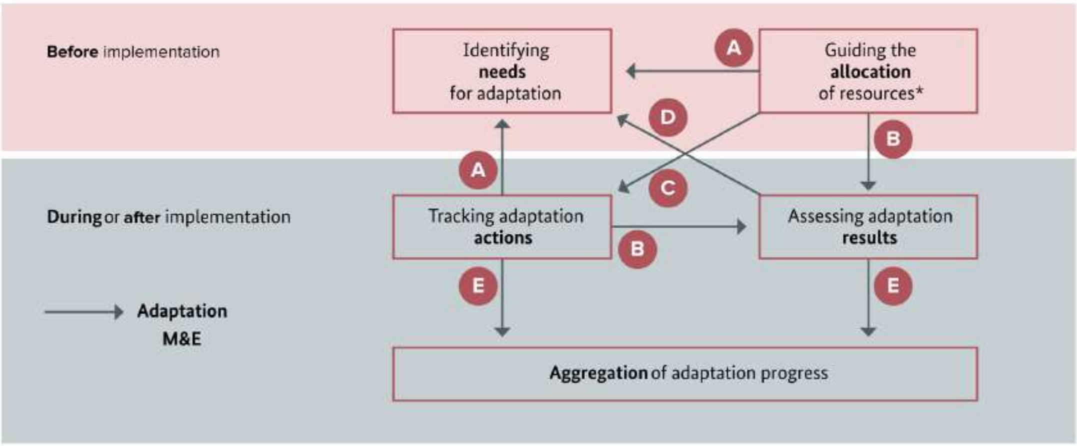

Figure 7.4. Common uses of adaptation metrics and their interrelation (Christiansen et al., 2018)

a. A: Do allocation and actions respond to needs?
b. B: Are allocation and actions result-oriented?
c. C: Does implementation take place – i.e., does the allocation translate into action?
d. D: Are actions (represented by their results) effective in addressing the needs?
e. E: What collective progress is being made through actions and their results?

*Resources include human resources (know-how, time) and financial resources.

7.9 Examples of identifying adaptation options and ranking them in terms of priority or capability

Several worked examples of how to use the decision-making tools and different metrics described above will be provided to clarify the concepts presented in this module. Also, small case studies and examples will be provided to illustrate the challenges and advantages of the different methods, setting the stage for the final section of the module.

Box 7.3 Theory into practice

Implementation of learning

The content of this module has illustrated the advantages and challenges of the various methods discussed. Several worked examples of how to use the decision-making tools and different adaptation metrics described above will be provided to clarify the concepts presented in this module. Also, small case studies and examples will be provided to illustrate the challenges and advantages of the different methods.

For further guidance, please read or watch the following:

Documents

Adaptation metrics – perspectives on measuring, aggregating, and comparing adaptation results:
Available at https://resilientcities2018.iclei.org/wp-content/uploads/UDP_Perspectives-Adaptation-Metrics-WEB.pdf

Standardizing methods for prioritizing adaption options – toolbox:
Available at https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5bc825a1a&appId=PPGMS

Application of multi-criteria analysis on climate adaptation assessment in the context of Least Developed Countries:
Available at https://www.researchgate.net/publication/305216484_Application_of_Multi-Criteria_Analysis_on_Climate_Adaptation_Assessment_in_the_Context_of_Least_Developed_Countries

Projects of the Inter-American Development Bank:
Available at https://www.iadb.org/en/projects

Videos

Adaptation metrics:
Available at https://www.youtube.com/watch?v=TBvxI7jWfvU

Exercise

7.10 Group work

The problem introduced at the beginning of the module will be analyzed based on the above discussion and information and then the adaptation options will be prioritized.

A full MCDA of the Dhaka Integrated Flood Control Embankment cum Eastern Bypass Road Multipurpose Project can be found at https://www.academia.edu/43723487/Application_of_Multi_Criteria_Analysis_on_Climate_Adaptation_Assessment_in_the_Context_of_Least_Developed_Countries

7.11 Case study exercise

Instructions

- Break out into two groups.
- In each group, analyze and prioritize adaptation options for the following scenarios:

  a. A recent news report stated that the groundwater level in Keraniganj has dropped due to the effects of climate change. The thousands of people who rely on the tube wells that access this groundwater are now facing immense hardship in gathering potable water for their daily activities. How will you go about analyzing and prioritizing the adaptation options in this scenario?

  b. Farmers in Shyamnagar, Satkhira district, are losing farmland due to saltwater intrusion. It is thought that this saltwater intrusion is because of sea level rise, which is a direct consequence of global warming. How will you go about analyzing and prioritizing the adaptation options in this scenario?

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Notes

MODULE 8

Participatory development and locally led adaptation

Overview of the training module

8.1 Brief introduction to the module

Subject

Participatory development and locally led adaptation

Learning outcomes

This module will help trainees to develop an understanding of the existing culture and practices of climate change planning and implementation in Bangladesh. Based on this understanding, trainees will learn about a different conceptual paradigm of policymaking and program design for inclusive, participatory, and locally led adaptation. Finally, trainees will develop an understanding of how to implement this new paradigm considering the pros and cons of locally led adaptation.

Topics

- Existing practices for designing and implementing adaptation projects – participatory exclusion
- Conceptualizing participatory and locally led adaptation
- Different types of participation
- Ideal conditions for citizen or community participation

Understanding climate impacts from a community perspective

8.2 Climate impacts through the community lens

The vulnerability of a country and specific segments in a society is influenced by their geographical location, physical exposure, development path, distribution of resources, access to services like education and health, prior stresses, and social and government institutions. Adaptation to climate change takes place through adjustments to reduce vulnerability or enhance resilience in response to observed or expected changes in climate and associated extreme weather events. Adaptation occurs in physical, ecological, and human systems. It involves changes in social and environmental processes, perceptions of climate risk, practices, and functions in order to reduce potential damages or realize new opportunities. Adaptations to climate change include anticipatory actions and private and public initiatives, and they relate to projected changes in temperature and current climate variations and extremes that may be altered with climate change. In practice, adaptations tend to be an ongoing process, reflecting many factors or stresses, rather than discrete measures to address climate change specifically.

We need to have an understanding of the vulnerabilities of communities living in impact hotspots and to gain this understanding by applying a human ecology lens. Through this lens, we can consider events in human contexts from the perspective of human beings in their many relational aspects. Human ecology looks at communities as full participants in ecosystems and, therefore, holds any dichotomy between culture and nature to be false. A human ecological lens is developed through participatory research with communities on human ecological relations, context, and practical wisdom or phronesis.

From this perspective, poor people's lives and livelihoods depend on their ability to adapt and make a living from nature. Although "climate change" may be a new term to these people, they have for a long time been living with and trying to cope with the problems it creates. While they may not have an explanation for the global causes of climate change, they can explain many of the changes from a local perspective, drawing on local knowledge and experience.

Livelihood is the main concern of poor people in rural Bangladesh. We might want to talk about climate change, but they want to talk about livelihoods. We might want to talk about adaptation for the future, but they want to talk about changes that are happening right now, such as those that are affecting their ability to farm. All over rural Bangladesh, seasons are changing, temperatures are rising, and rainfall patterns have become unpredictable. Villagers report that they can no longer differentiate between one season and the next. Farmers can no longer count on the monsoon rain coming at the regular time, making it difficult to know when to plant crops. The unpredictability of rainfall and fluctuating temperatures are causing massive problems for farmers, whose main crop, rice, needs large amounts of water and the right temperature to thrive.

Coastal areas are also experiencing drought during the dry months. Aside from reducing crop production, these changes are affecting domestic water supply and sanitation, creating a greater risk of waterborne diseases. In some regions the problem is too much water. Changing monsoon patterns have been causing severe floods and river erosion in Sirajganj, and farmers in Patuakhali are struggling with increased salinity caused by tidal surges, sea level rises, and erosion of the coastline.

However, climate change is just one factor among many in the lives of poor communities. The members of these communities live in a world shaped by social, cultural, environmental, and economic factors. Climate change is therefore just one of many things people have to manage simultaneously with other problems, risks, and vulnerabilities. That is why climate change is never the only explanation for local problems.

Problems are caused by a combination of climate change, environmental degradation, overpopulation, and poor governance of resources. Local and regional deforestation is a contributing factor to changes in rainfall patterns. Mismanagement of ponds, canals, and tube wells contributes to water scarcity problems. Overconsumption is contributing to decreasing groundwater levels and water scarcity in the Barind area, and the lack of fish in coastal areas might be related to overfishing. The increased salinity of fresh water is also related to the mismanagement of sluice gates separating the rivers from the canals. Increased agricultural difficulties can also be explained by soil and fertility degradation due to modernization and the increased use of fertilizers and pesticides. The increased unpredictability of floods in Sirajganj might be related to both local and upstream river management. Problems with erosion and tidal surges might also be related to the way riverbanks and the coastline have been managed.

Existing practices of adaptation projects

8.3 Existing adaptation planning practices in Bangladesh

There is significant heterogeneity in adaptation planning due to the context-specific nature of adaptation (differences in resources, values, needs, and perceptions among and within societies). This heterogeneity also results from different approaches among the countries, multilateral development agencies, and international organizations that promote and fund adaptation, and from differences in knowledge, information, and awareness about adaptation alternatives across societies. Although climate change impacts and disaster risk management are key areas addressed in adaptation, they appear to have a more prominent role in the early stages of planning and implementation. The importance of climate adaptation is also influenced by how the issue is framed. For example, to the extent that adaptation is viewed as a development issue (current development stressors and challenges; existing policy and existing agendas; and knowledge, risks, and issues communities already face), it may have greater resonance within local government (Mimura et al., 2014).

The movement to introduce adaptation into national policies has accelerated in both developed and developing countries. The diversity in national adaptation initiatives reflects the characteristics of the domestic political structures, socio-economic conditions, values, and perceptions, as well as development stresses and opportunities. National governments are assuming a coordinating role in adaptation actions at the sub-national and local levels of government. To strengthen the actions of local governments, national-level coordination includes the provision of information about potential risks. These activities provide policy frameworks that guide decisions at sub-national levels to spur and coordinate the creation of legal frameworks, to direct action in sectors and resources for national development (agriculture, fisheries, health, ecosystem protection, among others), to protect vulnerable groups, and to provide financial support to other levels of government (Mimura et al., 2014).

Based on the discussion above, and with reference to the culture of governance and administration in Bangladesh, we can say that the process as well as the top-down approach are still overly centralized. There is not much local government autonomy in the decision-making process. This is evident from the budgetary allocations of their expenditures. The Bangladesh government has introduced a budget line in its Annual Development Plan. Currently 25 ministries are implicated in climate investments. For the fiscal year (FY) 2020–21, the allocation to the 25 ministries/ accounts for 56.69% of the national budget. Of that, 7.52% is climate relevant. Currently 25 ministries are implicated in climate investments and Annual Development Plan-based funds. Among the six thematic areas of the Bangladesh Climate Change Strategy and Action Plan (BCCSAP), climate-relevant allocation for FY 2020–21 was highest for the area of food security, social protection, and health, which accounted for 41.2%, followed by the area of infrastructure (26%), as shown in Figure 8.1 below (Ministry of Finance, 2021). However, the moot point is that in all these allocations, there is not much input from communities.

Community inputs were, however, part of the process to prepare the National Adaptation Plan (NAP), which is currently being finalized. These inputs were gathered in stakeholder consultations held in Dhaka and certain other regions. However, the design of these consultations meant that genuine understandings of poor communities' perceptions were not obtained. Held as town hall meetings, the consultations gathered together all stakeholders – the rich and poor, the powerful and powerless. As a result, little insight was gained on the perspectives of the poor and powerless because, despite their participation, their voices were not heard. There are a number of reasons why these consultations did not work: the selection of participants resulted in meeting cohorts that inhibited contributions from marginalized participants; the consultation methods used did not encourage the participation of the poor; the rich and powerful participants' were more confident in expressing their views; prevailing cultural conventions require the marginalized to remain silent; and the organizers' and marginalized stakeholders' lacked the capacity to ensure equitable participation. These causes betray the link between marginality and participatory exclusion.

The key to understanding how participatory approaches can be employed as active tools of exclusion is marginality. The term "marginality" connotes something at the edge, something insignificant and inferior. The use of the term in vulnerability studies is rooted in the environmental justice movement and echoes explicit ethical terrains in locating environmental problems across the globe, such as the lack of entitlements, or the political economy of soil erosion and land degradation. Those at risk become marginalized along at least four pathways: geographically – they live in marginal, hazard-prone areas; socially – they are poor and discriminated against in terms of class, ethnicity, age, kinship, and network; economically – they lack access to resources; and politically – their voice is not heard and is excluded from political processes. So, when marginalized people take part in town hall meetings that are implemented in the way described above, we see a typical case of participatory exclusion in action.

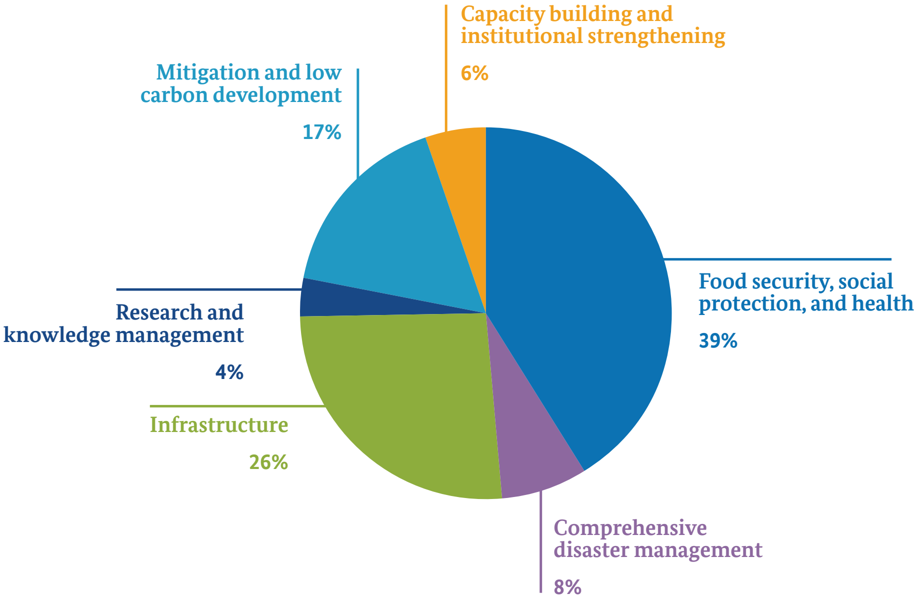

Figure 8.1: Distribution of allocations (Percentage) in FY 2020–21, broken down by BCCSAP thematic area, to the 25 selected ministries (source: Ministry of Finance, 2021)

Another instance of a top-down approach is the Bangladesh government's allocation of some USD 450 million of funding through the Bangladesh Climate Change Trust Fund (BCCTF) (Irfanullah, 2021). BCCTF received a total allocation of BDT 3,800 crore (BDT 38 billion) up to FY 2019–20. Note that, while 66% of the BCCTF money is invested, 34% is put in an interest-bearing account, which serves as a contingency fund. BCCTF has implemented a total of 727 projects through government ministries and NGOs. Among the various ministries and divisions, it is the Local Government Division that received the highest allocation from BCCTF, amounting to BDT 1,312.96 crore (just under BDT 13.13 billion), followed by the Ministry of Water Resources and Ministry of Environment, Forest and Climate Change (MoEFCC), which received allocations of BDT 1,043.8 crore (just under BDT 10.44 billion) and BDT 415.1 crore (just over BDT 4.15 billion) respectively (Ministry of Finance, 2021). In terms of BCCTF's six thematic areas, the highest allocation was for infrastructure, accounting for 61% with 395 projects. The two areas of mitigation and low-carbon development, and food security, social protection, and health received 18% and 11% shares of the overall allocation respectively, as shown in Table 8.1 below.

Thematic area	Number of projects	Total allocation (in BDT crore*)	% allocation
Food security, social protection, and health	103	385.80	10.78
Comprehensive disaster management	12	158.80	4.80
Infrastructure	395	2,025.95	60.91
Research and knowledge management	35	131.56	3.95
Mitigation and low-carbon development	173	608.62	18.30
Capacity building and institutional strengthening	9	42.01	1.26
Total	**727**	**3,325.75**	–

*** 100 crore is 1 billion.**

Table 8.1: BCCTF allocations for projects in 2020, broken down by BCCSAP thematic area (source: Ministry of Finance, 2021)

Table 8.1 also shows that funding for capacity building and institutional strengthening and for comprehensive disaster management is quite poor. Furthermore, the highest number of beneficiary projects were located in Barishal Division, followed by Chattogram and Dhaka. This reflects political bias in the allocation of BCCTF funds, as the allocations for the country's real vulnerability hotspots, such as Bangladesh's north-east, north-west, south-west, south-east, and southern regions, are insignificant by comparison

Additionally, it is interesting to note that not a single national document – including the Eighth Five-Year Plan 2021–2025, the Inception Report on the Formulation and Advancement of NAP, the Mujib Climate Prosperity Plan 2021–2030, and the updated Nationally Determined Contributions 2021 – contains the expression "just transition" in its text. These documents do, however, contain other expressions relating to climate change and social inclusion. This shows that the Government or those writing these policy documents are likely unaware of this emerging concept that requires fairness and equity in structural changes to the economy.

Overview of participatory and locally led adaptation

8.4 The evolution of community participation towards locally led adaption

The concept of participatory development came into vogue in the 1970s, led by the development agencies. The reason for its popularity was that the models of development applied in the then emerging developing countries – growth-focused trickle-down in the 1950s and growth with equity in the 1960s – were not working as expected. Then along came the model of participatory development (Wilson, 2020).

By the mid-1980s, the participatory development model was subsumed under the framework of sustainable development, espoused by the World Commission on Environment and Development, otherwise known as the Brundtland Commission. This Commission's flagship report Our Common Future remained the go-to framework of development for some time/for the rest of that decade/ throughout the 80s and 90s/for several decades. (Butlin, 1987). However, sustainable development is a very capacious framework, with its definition of a development that meets the needs of the present without compromising the needs of future generations. This has proved challenging to operationalize because the needs of the current, living generations differ greatly from one individual to the next and one country to the next and, at the same time, the needs of the future generations are unknown and there are no consumer advocates to reveal their preferences.

Attempts have been made to operationalize sustainable development through its three dimensions: (1) economic – the system must function productively; (2) environmental – the system must not allow degradation and depletion of the resource base; and (3) social, which directs us to take care of the social aspects of development, such as citizens' participation in development, community-based resource management, and the use of other social instruments like moral incentives and public censure (Mensah, 2019). The latter dimension can be summed up as participatory development. However, the ubiquitous yet amorphous concept of participation has resulted in much critical debate on its impact and outcomes at both the micro (project) and macro (policy) levels.

The rapid rise in the popularity of participatory development among policymakers and practitioners has been accompanied by a critical debate on its merits and drawbacks. This discussion has helped lift some of the conceptual haze surrounding this ambiguous 'buzzword' (Cornwall, 2008), highlighting, on the one hand, its power to radically transform political/power relations within nations, and on the other, its potential for exploitation, marginalization, and social control. Some are strident in their criticism, notably the contributors to the provocatively titled book *Participation: The New Tyranny?* (Cooke and Kothari, 2001). Focusing largely on micro-level participatory rural appraisals, these contributors argue that so-called participatory approaches often fail to engage with the issues of power and politics, in the process depoliticizing local development processes. Others, however, through their useful typologies or ladders of participation (Chambers, 1997), highlight the multiple contested meanings of the concept and draw attention to the consequent range of outcomes possible. Thus, for some, participation may indeed serve to legitimize decisions already made – as many of the contributors to *Participation: The New Tyranny?* assert. For others, it may serve a purely instrumental function, making projects and activities more cost-effective by drawing on communities' own resources. For others again, it may aim at empowerment.

More specifically, in contexts characterized by high levels of distributional inequality, many experts argue that community participation through elected or traditional authorities resembles a modern version of colonial indirect rule – effective as a means of managing labor and resources, but ultimately avoiding the politics at the heart of community development. This group argues that traditional or current institutions are not necessarily representative of or accountable to the populations over which they preside and that additional mechanisms that open the space for citizen participation are necessary. Taken together, these contributions (and many others) highlight the intensely political nature of participatory processes, which have the potential to either transform or consolidate existing political relations. Clearly, there is nothing simple about participation, and for those engaged in or supporting participatory processes, there is much to consider. The cardinal question is: To what extent have these insights and contributions informed policy and practice on the ground, most particularly within agencies and among practitioners supporting so-called participatory initiatives? This all depends on what kind of participation we are talking about.

8.4.1 Types of participation

Participation or community involvement can be viewed from different perspectives. Participation approaches can therefore be classified into several categories, including (Nair, 2011):

- **Passive participation** – People participate by being told what is going to happen or has already happened through unilateral announcement by administration.
- **Participation in information sharing** – People participate by answering questions posted by extractive researchers using questionnaire surveys or similar approaches and do not have the opportunity to influence results/outcomes.
- **Participation by consultation** – People participate by being consulted, and external agents listen to views and may make modifications in the light of people's responses but do not involve the consultees in decision-making.
- **Participation for material incentives** – People participate by providing resources (e.g., labor) in return for food, cash, or other material incentives, yet people have no stake in sustaining activities when the incentives are gone.
- **Functional participation** – People participate by forming groups to meet predetermined objectives related to the project after major decisions have been made.
- **Interactive participation** – People participate in joint analysis, the development of action plans, and the formation or strengthening of local institutions.
- **Self-mobilization** – People participate by taking initiatives independent of external institutions to change systems. They develop contacts with external institutions for resources and the technical advice they need but retain control over how resources are used. This can also take the form of social movements that seek to bring about social change. In many cases, it is when communities have worked through a series of participatory processes and practices that this approach may be adopted, as they turn to themselves to act as change agents.

8.4.2 Ideal conditions for citizen or community participation

The literature on this topic provides a comprehensive array of strategies to employ in constructing effective participatory practices in environmental management. Commonly cited strategies are the careful selection of a representative group of stakeholders; a transparent decision-making process to build trust among the participants; clear authority in decision-making; competent and unbiased group facilitators; regular meetings; and adequate financial resources to support the group process through the potentially long learning and decision-making process it involves. However, even if the above strategies are employed, the success of the initiative in achieving significant outcomes may depend strongly on the local context and culture (Irvin and Stansbury, 2004).

8.4.3 Locally led adaptation

The experience gained globally over the past two decades in conducting a largely centralized approach to adaptation policy design and its implementation shows that this approach has not delivered the expected results. In response, the now-defunct Global Commission on Adaptation, led by Ban Ki Moon and Bill Gates, introduced the locally led adaptation (LLA) track in 2020. Since then, LLA has rapidly become the new mantra of adaptation, championing the bottom-up model over the centralized or top-down approach. Climate adaptation is context dependent. It is uniquely linked to specific locations, making it predominantly a local-government and community-level action. Therefore, in conceptualizing and practicing LLA, we must address the questions of who initiated and managed what processes and how. Here the relevance of political ecology is important, because it questions the existing power structures at the local, national, and global levels.

Humans and other organisms perceive the world around them by recognizing difference. Since differentiation enables perception, and without perception there is no knowledge, diversity is the source of knowledge. The loss of diversity threatens the essence of our humanity. Multiple ways of perceiving and knowing the world are therefore the indispensable assets of human communities at all scales. Basically, human ecological relations are informed and sustained through active engagement with one's ecology, both directly with humans, other animals, plants, and inanimate and spiritual entities, and indirectly, through reflecting the complex connectivity inherent in sociocultural-ecological systems (Kassam et al., 2011).

On the other hand, local leadership is vital to the success of LLA. These leaders have a better knowledge and understanding of the local dynamics, trends in local climate over time, and effective adaptation practices than do outsiders, including central government bureaucrats and scientists. However, to better understand the dynamic process of climate science and its impacts, an integration of local, indigenous knowledge with modern, IPCC-based scientific knowledge is necessary. Hence, local adaptation plans must be aligned with national and global efforts. In any case, despite climate change impacts being largely absorbed by localities, less than 10% of total climate finance reaches the community level (IIED, 2017).

Locally led adaptation is quickly gaining traction. The 2021 Climate Adaptation Summit endorsed the eight principles of LLA, as have some 50 governments and more than 100 major NGOs and corporations worldwide. The eight principles are:

1. **Devolving decision-making to the lowest appropriate level**
   Giving local institutions and communities more direct access to finance and decision-making power over how adaptation actions are defined, prioritized, designed, and implemented; how progress is monitored; and how success is evaluated. [1]

2. **Addressing structural inequalities faced by women, youth, children, people with disability, displaced people, Indigenous Peoples, and marginalized ethnic groups**
   Integrating gender-based, economic, and political inequalities that are root causes of vulnerability into the core of adaptation action and encouraging vulnerable and marginalized individuals to meaningfully participate in and lead adaptation decisions.

3. **Providing patient and predictable funding that can be accessed more easily**
   Supporting the long-term development of local governance processes, capacity, and institutions through simpler access modalities and longer-term and more predictable funding horizons, to ensure that communities can effectively implement adaptation actions.

4. **Investing in local capabilities to leave an institutional legacy**
   Improving the capabilities of local institutions to ensure they can understand climate risks and uncertainties, generate solutions, and facilitate and manage adaptation initiatives over the long term without being dependent on project-based donor funding.

5. **Building a robust understanding of climate risk and uncertainty**
   Informing adaptation decisions through a combination of local, traditional, Indigenous, generational, and scientific knowledge that can enable resilience under a range of future climate scenarios.

6. **Flexible programming and learning**
   Enabling adaptive management to address the inherent uncertainty in adaptation, especially through robust monitoring and learning systems, flexible finance, and flexible programming.

7. **Ensuring transparency and accountability**
   Making the processes of financing, designing, and delivering programs more transparent and accountable downward to local stakeholders.

8. **Collaborative action and investment**
   Collaboration across sectors, initiatives, and levels to ensure that different initiatives and different sources of funding (humanitarian assistance, development, disaster risk reduction, green recovery funds, etc.) support each other, and their activities avoid duplication, to enhance efficiencies and good practice.

1 It should be noted, however, that Danielle Falzon, a Ph.D. student at Brown University in the USA, has argued that “devolving decision-making to the lowest appropriate level” contains a derogative tone of “devolving,” and that the “appropriate level” of decision-making can be used to justify keeping decision-making power away from local communities” (Falzon, 2021).

Box 8.1 Case Study 1

Joint forest management in Arabari, West Bengal, India

The Arabari experiment in the joint protection and management of natural forests has now become well-known in India and abroad. Dr. Ajit Banerjee, the Divisional Forest Officer (DFO) of West Bengal in 1971–72, began the experiment in the Arabari Forest Range, which is located in East Midnapore Forest Division, about 200 km west of Kolkata. Banerjee realized that it was difficult to regenerate and protect the sal (Shorea robusta) forest without the cooperation of the local people who depended on the forest for fuelwood, fodder, wood, grazing of animals, minor forest produce, and even cash income from the sale of fuelwood. Consequently, he started meeting people (such as political activists) in the neighboring villages and informally discussing with them the need for forest protection and regeneration.

The DFO, with the consent and assurance of the local people, demarcated 1,272 ha of degraded forestland for plantation and protection by the people. The plantation work, which guaranteed all local people equal employment opportunities, reached full capacity only in the lean periods. Some 1,200 families living in the surrounding villages were asked to form a Forest Protection Committee (FPC) for managing and protecting the plantation. The FPC guaranteed work under various ongoing rural employment schemes and awarded exclusive rights to all non-wood forest products, free of cost. Locals' immediate needs for fuel and fodder were also taken care of.

The Arabari experience demonstrated that local people will effectively protect degraded forest if their basic needs for fuelwood, fodder, and small wood are fulfilled, if they are provided with exclusive rights to non-wood forest products and wage-based employment, and if they are assured of substantial cash benefits from the final harvest.

The success of the Arabari experiment is attributed mainly to: the State Government of West Bengal's political commitment to improve forest management and deliver substantial and immediate benefits to participants in the form of wages and forest produce; the well-defined policy for sharing the benefits derived from the forest; the protection of the forest with the participation of local people; the dynamic leadership and commitment of senior forest officers to the joint forest management approach; and local people's willing participation in the program.

Encouraged by West Bengal's success in joint forest management, in June 1990 India's Ministry of Environment and Forests issued guidelines to all the country's States and Union Territories on the involvement of village communities and voluntary agencies in the regeneration and protection of forestlands. According to these guidelines, access to forestland and its usufruct benefits are limited to those eligible local people who organize in village institutions specially for forest protection and regeneration, with no restriction on membership.

This model of joint forest management showed that, even when there is heavy biotic pressure on natural resources, real and genuine community participation can bring benefits both for the government, society, and for the communities themselves. In the early 1980s, when Arabari was turned into a forest greenbelt, the World Bank invited Dr. Banerjee to serve as a senior forestry specialist in its Natural Resources Division, based at its headquarters in the US capital. Dr. Banerjee was also a member of the Ph.D. Dissertation Committee that guided Prof. Mizan R. Khan in his research on social forestry in Bangladesh and India.

Source: Mondal (2011)

Box 8.2 Case Study 2

Improved adaptive capacity to climate change for sustainable livelihoods in the agriculture sector under the Comprehensive Disaster Management Programme

Due to its geophysical position and socio-economic context, Bangladesh is highly prone to natural hazards and the impacts of climate change. In 2005 the Food and Agriculture Organization of the United Nations (FAO) initiated a project at the behest of the Government of the People's Republic of Bangladesh (GoB) that was designed to improve the adaptive capacities of rural populations and their resilience to drought and other climate change impacts. Another of the project's aims was to share its lessons learned and findings with service providers and policymakers in order to improve support for future adaptation processes.

The project was implemented under the Comprehensive Disaster Management Programme by Bangladesh's Department of Agricultural Extension, working in concert with the departments in charge of fisheries, livestock, and forestry and with national research institutes such as the Bangladesh Rice Research Institute and Bangladesh Agricultural Research Institute. . The community-based actions started with the characterization of livelihood systems, the profiling of vulnerable groups, the assessment of past and current climate impacts, and work to understand local perceptions of climate impacts, local coping capacities, and existing adaptation strategies. Based on the findings from these activities, the project next worked with key agencies and farmer associations/groups to promote institutional and technical capacity-building on the demand-responsive services that farmers need to improve their adaptive capacity. The project has developed over time, offering a constantly updated menu of diversified good-practice adaptation options that have been used to guide the field-testing of locally prioritized adaptation practices. Participatory extension is key and includes demonstrations, orientation meetings, field days, farmer field schools, and community rallies. This project has gathered lessons learned from its implementation process and identified good practice options for drought risk management in the context of climate change.

Although this project was funded by the FAO and jointly implemented by several GoB Source: Ali, Quayyum and Islam (2007)

Box 8.3 Theory into Practice

Implementation of Learning

This module on locally led adaptation provides participants with an understanding of how local communities benefit from having more direct financial access and decision-making power over the identification, prioritization, creation, and implementation of adaptation initiatives.; how progress is tracked; and how success is measured. Based on this learning, participants will be able to support the long-term development of local governance processes, capacity, and institutions through promoting easier access mechanisms and more predictable funding horizons. They will be able to ensure that adaptation actions can be implemented effectively by communities. In addition, by understanding climate risks and uncertainties, they will be able to coordinate and manage adaptation programs over the long term without relying on project-based donor funding.

For further guidance, please read the following documents and see the attached video.

Documents

Principles for locally led adaptation – a call to action:
https://pubs.iied.org/sites/default/files/pdfs/2021-01/10211IIED.pdf

Locally led adaptation: drivers for appropriate grassroots initiatives:
https://www.icccad.net/wp-content/uploads/2021/02/Locally-led-adaptation-drivers-for-appropriate-grassroots-initiatives.pdf

Video

Championing locally led adaptation – IIED annual review 2021:
https://www.youtube.com/watch?v=pbj2l1I0HMc

Locally led adaptation in Nepal:
https://www.youtube.com/watch?v=3Hg6E_PS88E

Working Group

Bangladesh Disaster Risk and Climate Resilience Program:
https://www.worldbank.org/en/country/bangladesh/brief/bangladesh-disaster-risk-climate-change-program

8.5 The way forward

The above discussion shows that, while existing practices – particularly in Bangladesh – still remain top-down affairs, to make projects and programs sustainable it is essential that approaches ensure the participation of communities. In the current scheme of things, communities are seen as beneficiaries of actions, not as agents in their design and implementation. The culture can therefore be said to be one of participatory exclusion. A case in point is the implementation of projects under the BCCTF, which lacked any consultation of local communities and, moreover, underwent a form of elite capture by sectoral leaders whose preferences were toward infrastructure development projects. This runs contrary to the vision and dream of Bangladesh's Father of the Nation, Sheikh Mujibur Rahman.

In the present era of anticipatory adaptation to climate change, if we really mean business and really wish to strengthen the adaptive capacity of local people across Bangladesh, then there can be no more centralized working. Instead, action should largely comprise decentralized LLA options. Local governments have a big part to play in achieving this, serving as facilitators that create the space for local political, civil society, and community leaders to assume real roles in the process. However, LLA must remain aligned to national and global adaptation policies if it is to achieve scale. To this end, there is a strong need to build the capacity of all those involved in adaptation actions.

Although the Bangladesh government's policies and plans provide for participatory development, it is not being delivered on the ground. Therefore, the specific aim of adapting to climate change through an inclusive process should be confirmed and strongly reflected in national policy and its implementation detailed in a roadmap. In addition, proper governance and budget allocation should be ensured. Finally, Bangladesh's government officials at all levels, and particularly at the local government level, need to be provided with a large-scale program of socialization that brings them together with local civil society organizations and community leaders, the aim being to reinforce over time these officials' understanding that they are the servants of the people.

8.6 Group work

a. The participants are divided into two groups, with each group selecting a hotspot. In a breakout session, the group members then complete the following tasks:

1. List the climate hazards present in the five climate hotspots mentioned in the table below .
2. Identify locally led adaptation practices in these climate hotspots
3. Enumerate the challenges and ways forward.

Climate hotspots	Name of hazards	Locally led adaptation practices	Challenges	Ways forward
North-east				
North-west				
South-west				
South-east				
Southern region				

b. Participants are requested to answer the following questions:

1. In what ways do you think communities should have been consulted on BCCTF projects? What do you think about community consultation for BCCTF projects?
2. How should communities be consulted on these projects?

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Notes

MODULE 09

Monitoring and evaluation (M&E): fiduciary management and project implementation

Overview of the training module

9.1 Brief introduction to the module

Subject

Monitoring and evaluation: fiduciary management and project implementation

Learning outcomes

This module will help learners to track the performance of activities undertaken during the development of an adaptation plan (e.g., stakeholder engagement activities). It will provide an understanding of pre-identified risk thresholds/trigger levels in the implementation of climate adaptation measures. Learners will be able to evaluate the achievement of outputs and outcomes based on implemented adaptation measures. They will also learn about decision-making through relevant examples and about the metrics most commonly used to monitor adaptation.

Topics

- Overview of monitoring and evaluation (M&E) in project management
- General M&E system and framework
- Understanding the interlinkages and dependencies between planning, monitoring, and evaluation
- Understanding indicators
- The M&E approach for climate change adaptation
- Tools for the monitoring and evaluation of climate change adaptation project implementation
- Developing a theory of change for climate change adaptation projects
- Fiduciary management
- Quality assurance and ensuring transparency in the project implementation process

9.2 Overview of monitoring and evaluation in project management

A well-functioning monitoring and evaluation (M&E) system is a critical part of good project and program management and accountability. It is important to conduct regular M&E as you implement the activities in your workplan in order to capture reliable information. This information can then be used to:

- support project/program implementation with accurate, evidence-based reporting that informs management and decision-making and, in so doing, guides and improves project/program performance;
- contribute to organizational learning and knowledge-sharing by enabling reflection on and the sharing of experiences and lessons learned so that the project/program team can draw maximum benefit from what it does and how it does it;
- uphold accountability and compliance by demonstrating whether or not work has been carried out as agreed and in compliance with established standards and any other donor requirements;
- provide opportunities for feedback from stakeholders, especially beneficiaries, who can provide their inputs on and perceptions of the work, in this way setting an example of management that is open to criticism and willing to learn from experiences and adapt to changing needs; and
- promote and celebrate project/program work by highlighting accomplishments and achievements, thus building morale and contributing to resource mobilization

	Monitoring	Evaluation
Definition	Monitoring is a continuous or periodic process in which data on specific indicators are systematically collected to provide information about the performance of a project.	Evaluation is systematic and objective feedback on a completed or ongoing action, aimed at providing information about design, implementation, and performance.
Why?	• Check progress • Inform decisions and remedial action • Update project plans • Support accountability	• Assess progress and worthwhileness Identify lessons and recommendations for longer-term planning and organizational learning • Provide accountability
When?	Ongoing during project/program	Periodic and after project/ program
Who?	Internal, but also possibly involving project/program implementers and local community members	Can be internal or external to the organization
Link to logical hierarchy	Focus on inputs, activities, outputs, and shorter-term outcomes	Focus on outcomes and overall goal

Table 9.1: The basics of M&E

9.3 General M&E system and framework

M&E needs to be understood as an integrated reflection and communication system within the project that must be planned, managed, resourced, and utilized. A well-functioning M&E system helps guide the intervention strategy and ensure effective operations for all key stakeholders. It is one part of the overall management of the project. Each stage of the project cycle requires certain key M&E tasks to be carried out by specific stakeholders. A detailed M&E plan is developed during project start-up and needs to be documented clearly and shared with those who are to implement it. In climate change adaptation projects, the M&E system will itself need to be monitored and updated regularly during the lifetime of the project.

9.4 Understanding the interlinkages and dependencies between planning and M&E

The following points are the interlinkages between planning, monitoring, and evaluation (UNDG, 2011):

- Without proper planning and clear articulation of intended results, it is not clear what should be monitored and how; hence monitoring cannot be done well.
- Without effective planning (clear results frameworks), the basis for evaluation is weak; hence evaluation cannot be done well.
- Without careful monitoring, the necessary data is not collected; hence evaluation cannot be done well.
- Monitoring is necessary, but not sufficient, for evaluation.
- Monitoring facilitates evaluation, but evaluation uses additional new data collection and different frameworks for analysis.
- The monitoring and evaluation of a program will often lead to changes in program plans. This may mean further changes or modifications in the data collection for monitoring purposes

Another source of climate data is radiation measurements, which are used for the following purposes: (i) to study the transformation of energy within the Earth-atmosphere system and its variation in time and space, (ii) to analyze the properties and distribution of the atmosphere with regard to its constituents, such as aerosols, water vapor, ozone, and so on, (iii) to study the distribution and variations of incoming, outgoing, and net radiation, (iv) to satisfy the needs of biological, medical, agricultural, architectural, and industrial activities with respect to radiation, and (v) to verify satellite radiation measurements and algorithms.

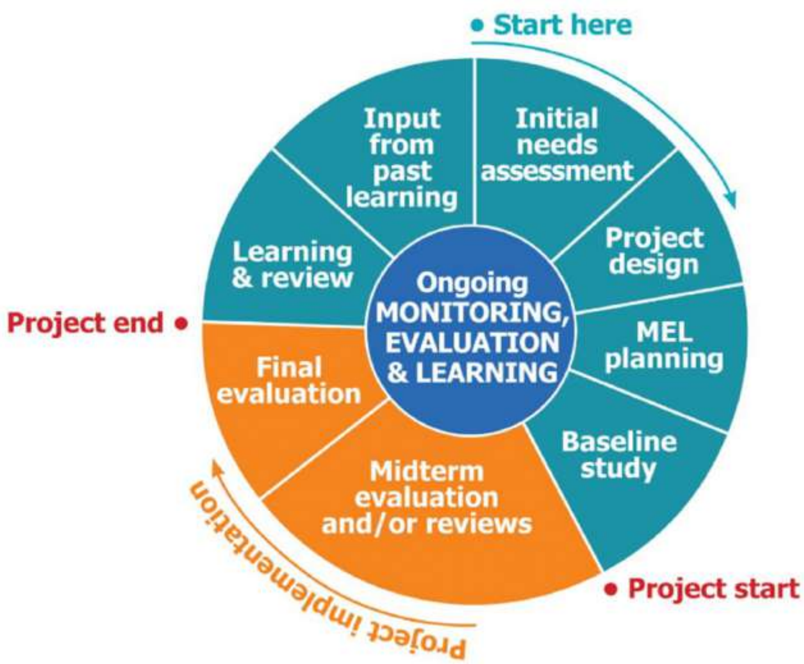


Figure 9.1: Comprehensive view of the M&E system (source: FAO, 2019)

For more ideas, check out this suggested tool for the monitoring, evaluation, and learning (MEL) framework:
https://www.fao.org/fileadmin/user_upload/cap-dev/docs/Suggested_tool_M_E_Framework.pdf

9.5 Putting planning and M&E together: results-based management

Planning, monitoring, and evaluation come together as results-based management (RBM) (Tools4Dev, 2019). RBM is defined as "a broad management strategy aimed at achieving improved performance and demonstrable results, and has been adopted by many multilateral development organizations, bilateral development agencies and public administrations throughout the world."

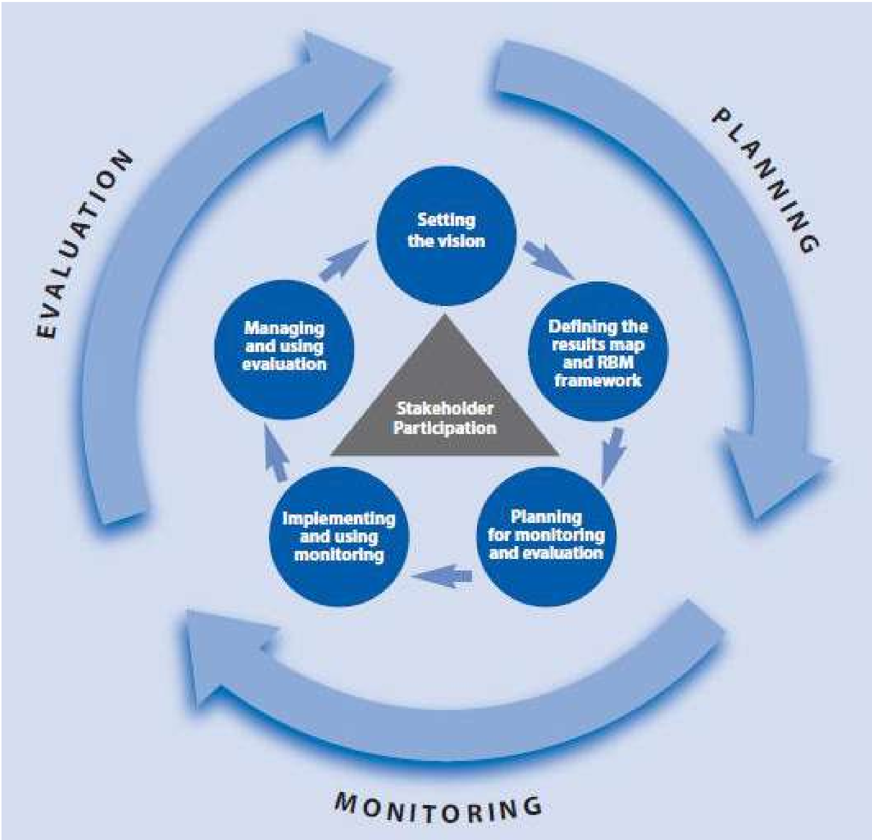


Figure 9.2: The RBM life-cycle approach (source: Mihić and Obradović, 2012)

9.6 Understanding indicators

Indicators are a measure of progress or lack of progress used to assess progress towards meeting stated objectives. An indicator should provide, where possible, a clearly defined unit of measurement and a target detailing the quantity, quality, and timing of the expected results (AusAID, 2005).

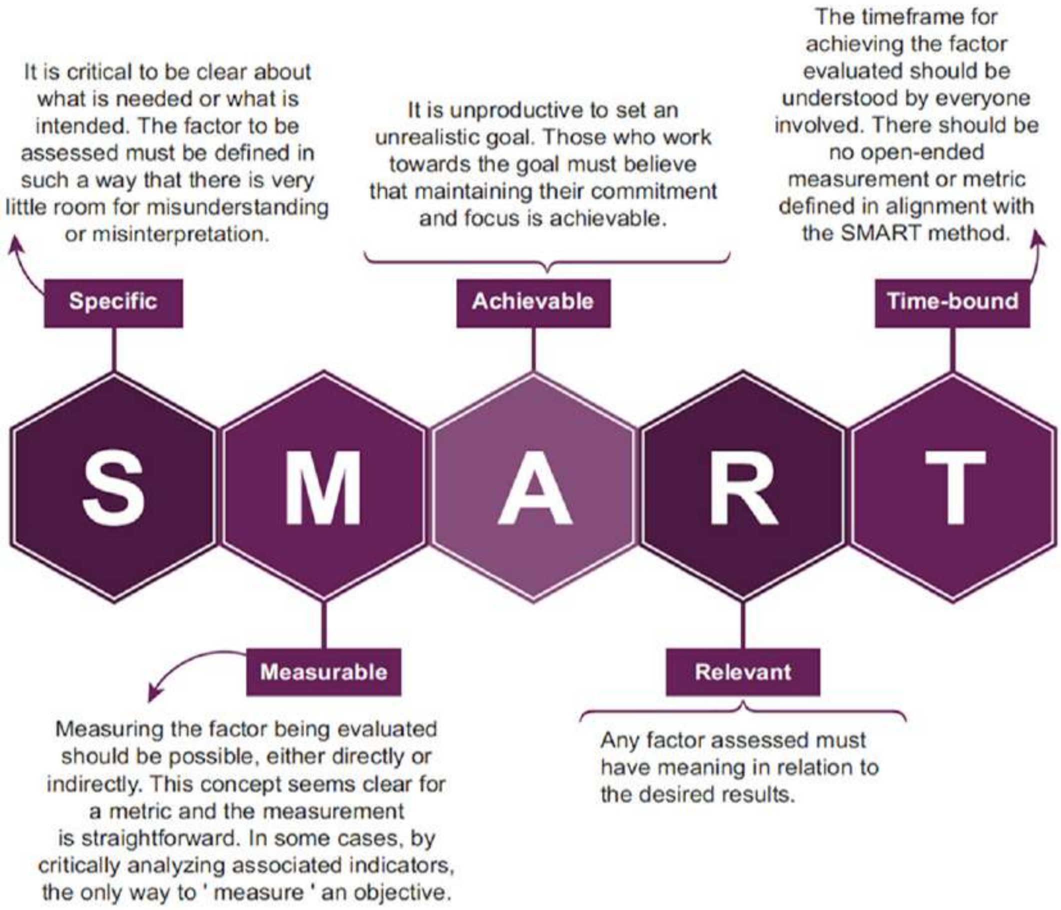


Figure 9.3: SMART indicators (source: AusAID, 2005)

9.7 The M&E approach for climate change adaptation

Achieving the Sustainable Development Goals (SDGs) intensifies the demand for robust and effective M&E frameworks that measure outcomes in relation to these commitments. Climate change commitments fall into two fundamental response strategies: climate change adaptation (CCA) and climate change mitigation.

CCA focuses on anticipating the risks and adverse impacts of a changing climate, taking appropriate action to prevent or minimize the damage, and seizing on potential opportunities that may arise. Creating adaptation pathways may include fashioning programs, projects, and policies that try to minimize the impacts of climate change. Interventions can take the form of activities in livelihood security, disaster risk reduction, and national policy development to promote resilience and capacities to respond to, cope with, and prepare communities for climate variability.

The critical questions that inform the role of M&E in CCA are listed below:

- How do we know when successful adaptation has been achieved?
- How can we monitor whether interventions are on track and delivering results?
- What does successful adaptation look like?
- How can we extract lessons from past and current activities to help shape the future direction of adaptation interventions?

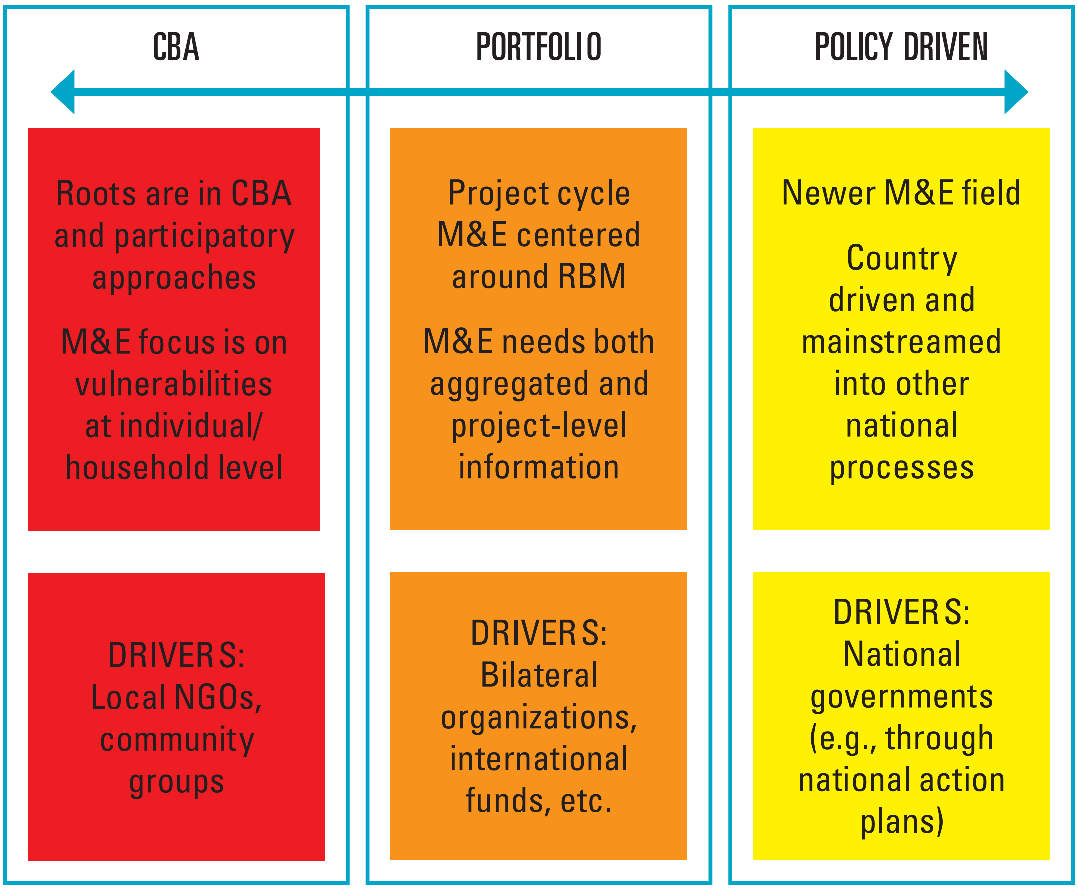


Figure 9.4: M&E focal areas (source: Spearman and McGray, 2011)

*CBA: community-based adaptation

9.8 Basic components of M&E in CCA

M&E is used extensively by international and national development agencies and financial institutions to assess the progress and effectiveness of many diverse investment projects and programs. As CCA funding scales up in the near future, it is more critical than ever to ensure the effectiveness, equity, and efficiency of CCA interventions (Lamhauge et al., 2013) and to ensure they are readily adopted. While there are no universally set definitions for M&E terms and concepts, there are four typical M&E components, briefly described here

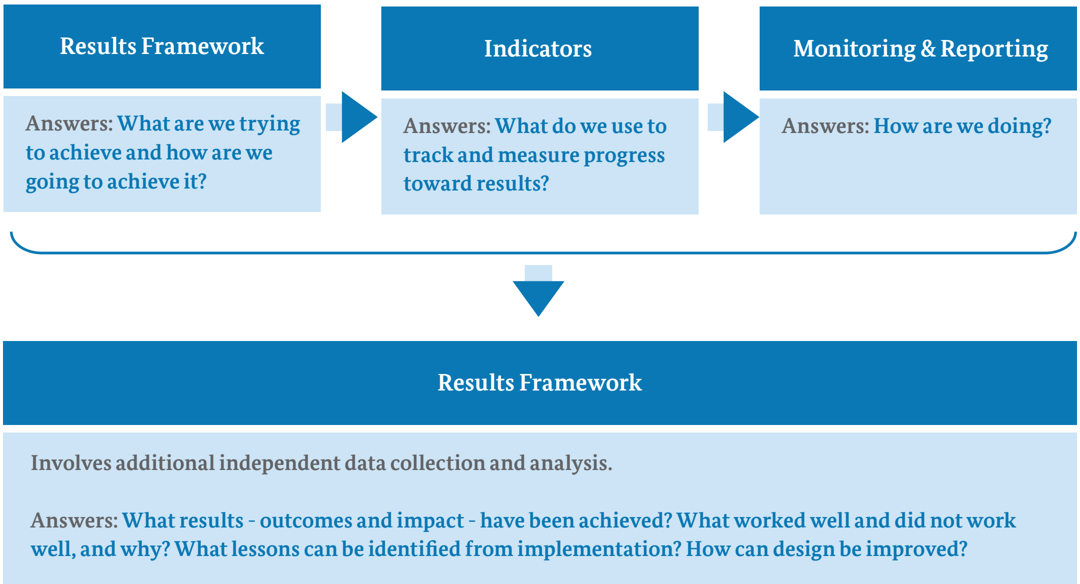


Figure 9.5: Basic components of an M&E system (source: Lamhauge et al., 2013)

9.9 Tools for the M&E of climate change adaptation project implementation

9.9.1 UNDP's M&E framework for CCA

The United Nations Development Programme (UNDP) developed an M&E framework for CCA (Leagnavar, 2015) to fulfill the mandates of the LDCF and SCCF, two adaptation-focused climate funding windows mandated by the UNFCCC. The LDCF is designed to address the special needs of least developed countries in financing the preparation and implementation of national adaptation programs of action. The SCCF supports both long- and short-term adaptation activities that increase the resilience of national development sectors to the impacts of climate change.

The framework is organized according to six thematic areas as key climate-sensitive development priorities. It is designed to aggregate indicator data from the project to the portfolio level and encourages the use of consistent units of measurement for this purpose. The framework differentiates between, on the one hand, a core set of standard indicators at the project and portfolio levels, applicable across all thematic areas, and on the other hand, supplementary indicators, which are defined specifically for each thematic area (see Figure 9.6).

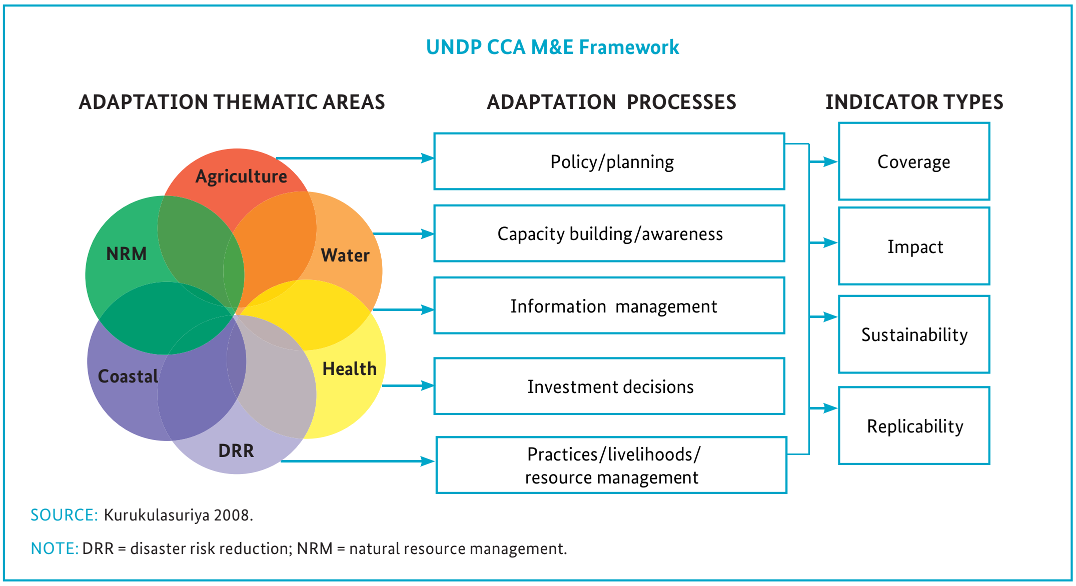


Figure 9.6: UNDP's CCA M&E framework (source: Leagnavar, 2015)
Key: NRM – Natural Resource Management; DRR – Disaster Risk Reduction

The UNDP framework remains a good example of an M&E approach that links and aggregates standard indicators within key sectors, and it has informed and shaped some of the newer approaches that have since been developed by others.

9.9.2 Pilot Program for Climate Resilience's monitoring and reporting toolkit

The Climate Investment Funds' *Pilot Program for Climate Resilience (PPCR) Monitoring and Reporting Toolkit* is another example of a result measurement system. The PPCR Toolkit has five core (required) indicators. Of these, two are monitored at the national (pilot country) level, and the remaining three are based on information gathered from PPCR projects that is aggregated and monitored at the program level for each PPCR pilot country (CIF, 2018).

The five core indicators are: (1) degree of integration of climate change into national, including sector, planning; (2) evidence of strengthened government capacity and coordination mechanism to mainstream climate resilience; (3) quality and the extent to which climate-responsive instruments/investment models are developed and tested; (4) extent to which vulnerable households, communities, businesses, and public sector services use improved PPCR-supported tools, instruments, strategies, and activities to respond to climate variability and climate change; and (5) number of people supported by PPCR to cope with the effects of climate change.

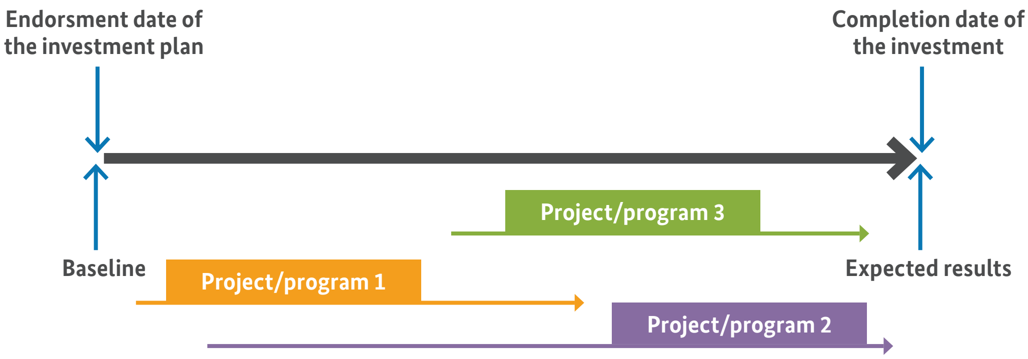


Figure 9.7: Life-cycle diagram of the PPCR investment plan (CIF, 2018)

9.9.3 Tracking Adaptation and Measuring Development

Tracking Adaptation and Measuring Development (TAMD) is a framework for evaluating adaptation and adaptation-relevant development initiatives across scales (Brooks et al., 2014). TAMD is a "twin-track framework that evaluates adaptation success as a combination of how widely and how well countries or institutions manage climate risks (Track 1 for climate risk management) and how successful adaptation interventions are in reducing climate vulnerability and in keeping development on course (Track 2 for development performance)" (see Figure 9.8 below).

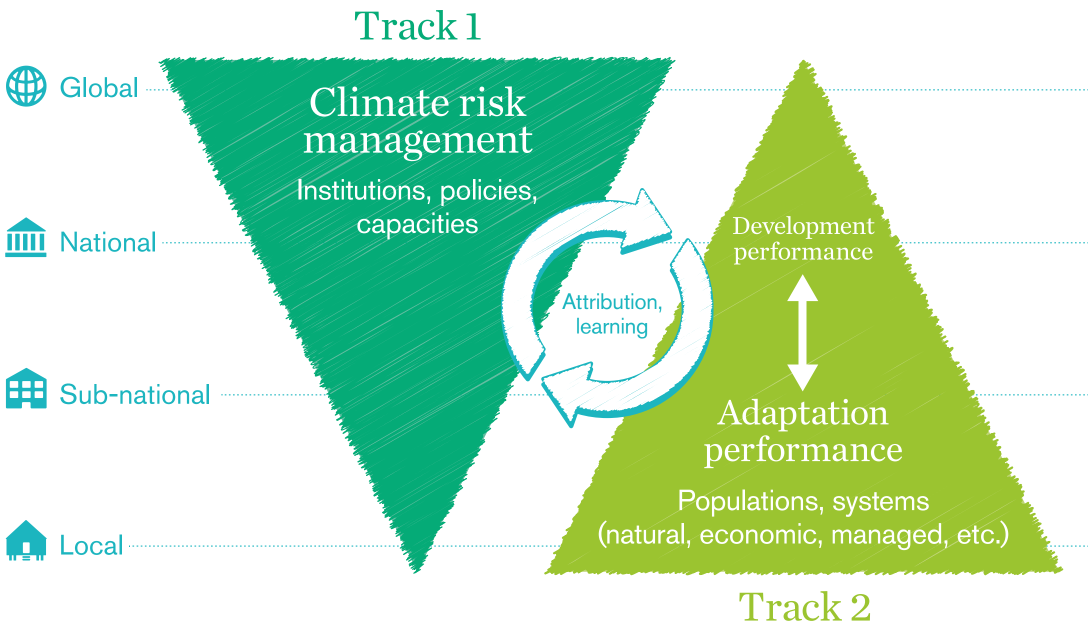


Figure 9.8: The TAMD framework, illustrating the two climate risk management and development performance tracks (source: Brooks et al., 2014)

TAMD seeks to assess the adaptation process at scales from global to local by evaluating the outputs, outcomes, and impacts of adaptation and adaptation-relevant development interventions within and across the two tracks, and by considering how outputs are linked to outcomes and impacts. To address the challenge of attributing adaptation outcomes and impacts to specific interventions, TAMD proposes a quasi-experimental approach that estimates indicators for vulnerability and capacity to adapt to particular climate risks, and more usual development indicators for populations before, during, and after interventions.

9.9.4 Logical framework approach

Logical frameworks, also known as logframes, involve the regular evaluation of goals, objectives, intermediate results, and all the project outcomes. The goal is the long-term, widespread improvement in society that is beyond the life of the project. Keep in mind that the project intervention may be only one of the factors contributing toward the achievement of the overall goals. For example, reaching the goal of increasing the representative nature of parliament will require more than just one short-term project.

The objective is the effect of intermediate results on the target or beneficiaries that you expect to see by the end of the project. Intermediate results are benefits – i.e., the intermediate effects of outputs on your target or beneficiaries. Intermediate results are those that are necessary to achieve the program objectives. There are likely to be any number of intermediate results that contribute to a given objective. Focus on those that you feel are most relevant.

Outputs are deliverables, products, and/or services that are generated by the activities. Outputs should contribute to the achievement of the intermediate results. Activities are services, the tasks that are needed to turn inputs into outputs. Monitoring of activities is necessary to assess whether they are efficient and

Outcomes	Evaluate	**Goal (impacts)**	Long-term, widespread, beyond the life of the project
		Objective	**Change**: effect of intermediate results on the target or beneficiaries by the end of the project
		Intermediate results	**Benefits:** intermediate effects of outputs on the target or beneficiaries
Processes	Monitor	**Outputs**	**Deliverables:** products/services produced
		Activities	**Services:** tasks needed to reach outputs.
		Inputs	**Resources:** financial, human, and material

Table 9.2: Components of a logframe

relevant and whether they contribute to the objectives of the program. Inputs are the financial, human, and material resources that are required for your activities. Outputs, activities, and inputs are all processes that should be monitored on an ongoing basis.

9.10 Selecting indicators for climate change adaptation programming

Indicators for particular CCA projects, programs, policies, and portfolios may not necessarily look much different from those for other development programs. It is not the CCA indicators themselves that are unique, but whether the ones that are chosen combine into a suite that appropriately frames and assesses adaptation progress and resilience to climate change over time. Moreover, the complexities and uncertainties inherent in climate change are better served with a broader selection of indicators than is usually called for in more straightforward development interventions. Finallys, there should be an appropriate qualitative, quantitative, and binary indicator (Lamhauge et al., 2013). In addition, once outcomes are agreed upon, stakeholders should develop a "long list" of potential indicators by asking key questions including:

- How would we know that change has happened in this outcome?
- How will we know success when we see it?
- What would be the evidence of this change?

9.11 Gender dimension of M&E

Gender-sensitive M&E is used to reveal whether a program addresses the different priorities and needs of women and men, to assess if it has an impact on gender relations, and to determine gender aspects that need to be integrated into M&E systems. The inclusion of explicit gender equality objectives and indicators at the planning stage also strengthens accountability in terms of the progress made on gender equality issues.The following table provides more information on the roles and services of Bangladesh's national agencies with Effective gender-responsive monitoring and evaluation needs to include both qualitative and quantitative data that measure the impact on gender relations. Without sufficient data, a meaningful analysis of the impact on gender equality is very difficult. This also implies that, as a minimum, all data should be collected, presented, and analyzed in a sex-disaggregated manner.

The efforts made by organizations and projects toward structuring gender-focused M&E systems have faced considerable distortions and theoretical and methodological obstacles.

Box 9.1 Limitations of integrating gender in M&E systems

The limitations of integrating gender in M&E systems include the following:

- The misconception that gender-focused evaluations are complex and should be conducted by specialists, that it is hard to make approximations, and that it is impossible to change the existing power relationships.
- Qualitative aspects are somewhat unscientific and hard to measure, for which reason it is not possible to design adequate tools.
- The absence of indicators to measure changes related to identities, gender roles, or relationships makes it more difficult to measure such changes, and usually end up being considered as groundless
- Obstacles when implementing M&E systems for an institution or project that has not defined a gender-equity policy and, therefore, has not incorporated gender into its vision.
- The emphasis on improving women's conditions but that neglects changes to their strategic position within public and private environments.
- The lack of metrics on men's positive or negative changes.
- Perceptions that it threatens the culture and customs of a given area or community, disregarding the fact that every project offers options for attitude changes.

Further reading:

RESPECT Framework Monitoring and Evaluation Guidance (UNWOMEN, 2020): https://www.unwomen.org/sites/default/files/Headquarters/Attachments/Sections/Library/Publications/2020/RESPECT-implementation-guide-Monitoring-and-evaluation-guidance-en.pdf

Monitoring and evaluation framework for gender-inclusive recruitment and selection (USAID, 2019):

https://www.climatelinks.org/sites/default/files/asset/document/2019_USAID-RALI-Project_Gender-Measurement-and-Evaluation-Framework.pdf

9.12 Planning and implementing M&E in a CCA project

In addition to a focus on the traditional objective of accountability, there should be a greater emphasis on learning when choosing the methods and design of an M&E framework for project management related to climate change adaptation. This greater emphasis on learning, especially when applied from the outset of M&E framework development, can enhance flexibility and the continuous improvement of climate risk management interventions over time. Apart from the objective of learning, other policy objectives can also affect how the methods and design of an M&E framework for climate risk management should be selected.

The development of M&E frameworks can draw on existing M&E frameworks, such as those for disaster risk reduction or for long-term ecosystem or biodiversity conservation. In this way, instead of creating entirely new frameworks, the practical first step to designing the components of an M&E framework for climate risk management could be broadening the scope of these existing M&E frameworks.

M&E frameworks for climate change adaptation project management also focus on the evolving nature and ongoing processes of interventions, aiming to facilitate the improvement of these interventions over the course of their implementation. Certain types of evaluation have been developed to promote "developmental evaluation" that aims to conceptualize, design, and test new approaches while the intervention is in progress (also known as formative evaluation). In developmental evaluation, the evaluators accompany the intervention team and assist in assessing and adapting interventions. Quinn Patton (2010) argues that developmental evaluation is required for complex problems in rapidly changing systems where constant feedback and adjustment are needed. This applies to the long time-horizon of climate risk management interventions and their outcomes.

9.13 Participatory approaches that promote learning for CCA and increase the M&E framework's accuracy and validity

Using a participatory design increases the acceptance by involved stakeholders of the outcomes of the M&E process and its recommendations (Zall et al., 2004; OECD DAC, 2019). Moreover, participation and transparency together constitute one of the six adaptation principles embodied in Article 7 of the Paris Agreement (UNFCCC, 2015). Involving relevant actors at the design stage of M&E frameworks is conducive to enhancing stakeholder participation and improving consultation throughout the M&E process. In the field of evaluation, participation can be supported using explicit participatory approaches such as empowerment evaluation, human-rights-based evaluation, and indigenous evaluation, which are often based on formative M&E perspectives (CARE, 2014).

Since M&E frameworks for climate risk management interventions are characterized by a diversity of actors, each with different interests, needs, and perspectives, the consideration of participation is especially relevant. The diversity of members within an M&E team can widen the scope of its analysis, shape a common understanding of complex interventions and their outcomes, and balance the perspectives. This can, in turn, bring about a broader acceptance of the recommendations from the M&E among different social groups. This potential is currently often overlooked when designing climate risk management interventions and the associated M&E framework. Beneficiaries of the climate risk management intervention and the implementation team become jointly responsible for the M&E design and the use of the results for strengthened local resilience.

9.14 Capturing the lessons learned

Monitoring and evaluation for learning are the pillars of an interdependent and integrated framework (OECD, 2020), which highlights the integrated nature of M&E as a prerequisite for effective national reporting systems and policymaking processes for climate change adaptation and disaster risk reduction. A flexible approach to M&E is also key given the various uncertainties of the response of the climate system to greenhouse gas emissions, theirits impacts, and social and technological contexts (Kunreuther et al., 2014). These uncertainties also highlight the importance of continuous learning and adaptive management.

Climate change adaptation in project interventions often includes activities at the local, sub-national, and national levels that are also embedded in policies at the regional or global level. This calls for an M&E framework that covers interventions across levels of governance (a multi-level M&E framework). For instance, many existing M&E frameworks refer to the assessment of a national strategy on climate adaptation and risk management, but they often do not adequately consider sub-national-level activities that contribute to the overall outcome of the strategy (Leiter, 2015). Monitoring and evaluating interventions across different levels also entails a series of challenges. One example is stakeholder coordination, especially when making an agreement on overarching conclusions among actors at different levels of governance.

Multi-level climate adaptation interventions require one comprehensive multi-level M&E framework, or several frameworks interrelated with each other. An M&E framework sets standards and guides monitoring, evaluation, and learning for an intervention. An effective M&E framework is adjusted to national and sub-national needs and refers to international agreements and agendas, while being in line with relevant M&E standards, principles, and criteria.

Box 9.2 Six steps for developing an M&E plan

Steps for developing an M&E plan:

- Identify program goals and objectives
- Define indicators
- Define data collection methods and timeline
- Identify M&E roles and responsibilities
- Create an analysis plan and reporting templates
- Plan for dissemination and donor reporting

9.15 Developing a theory of change for climate change adaptation projects

“Theory of change” has become a buzzword in climate adaptation circles in recent years. A theory of change is essentially an illustration of how and why a desired change is expected to happen in the context of a project/program. It provides the basis for identifying what type of activity or intervention will lead to the outcomes identified as preconditions for achieving the proposal’s long-term goals. It is focused on mapping out what has been described as the “missing middle” between the intended interventions and the desired goals. The theory of change facilitates better planning, in that activities are linked to a detailed understanding of how change happens. It also leads to better evaluation, as it is possible to measure progress toward the achievement of long-term goals that goes beyond the identification of intended outcomes.

The development of a theory of change requires a series of iterations before it is finalized. Once the initial draft of the theory of change has been formulated, it is important to review and, if necessary, realign the linkages between the project results, outcomes, and the final goal to ensure that all linkages have been captured, and that the theory of change presents in a logical manner how the goal cascades back to the outcomes and results. In this process, for example, some outputs may be removed or replaced and linkages changed to establish a clear logical pathway. The process of fine-tuning the theory of change may be repeated several times. The theory of change is innovative in that it makes the distinction between desired and actual outcomes and it requires stakeholders to model their desired outcomes before they decide on forms of intervention to achieve those outcomes. The development of the theory of change should comprise an inclusive process, involving stakeholders with diverse perspectives in achieving solutions. The ultimate success of any theory of change lies in its ability to demonstrate how proposed activities will achieve the desired outcomes. The added value of a theory of change lies in its outlining of a conceptual model that demonstrates the causal connections between conditions that need to change in order to meet the proposal's ultimate goals. On the downside, with a growing number of donors and financing entities now requiring theories of change, it can feel like yet another hoop to jump through, especially for Small Island Developing States where resources are limited and staff are often overstretched.

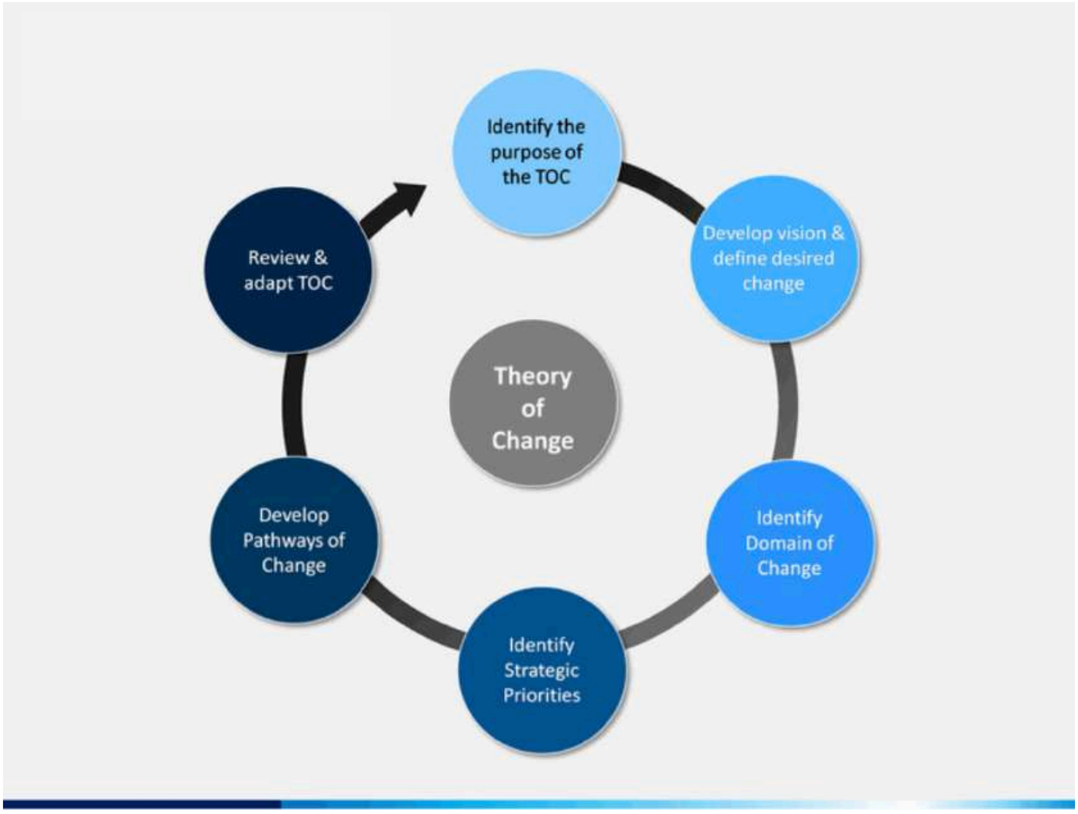
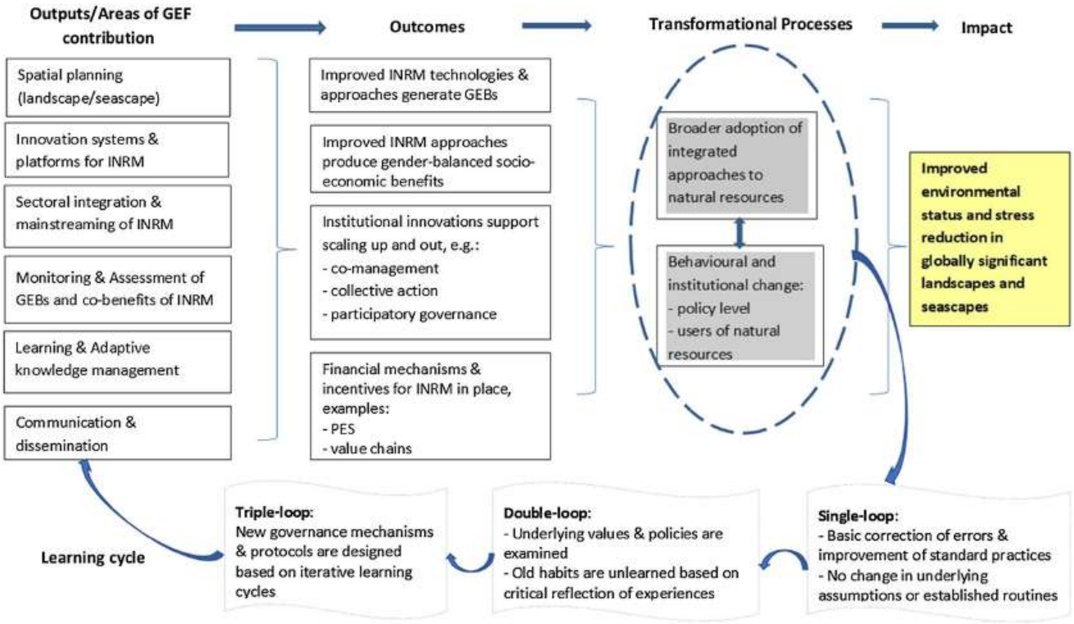


Figure 9.9: Theory of change Template (Source: Sketchbubble, 2022)



Key: EbA – ecosystem-based adaptation; HH – household

Case Study 1. Theory of change for integrated natural resources management (source: Tengberg and Valencia, 2018): Key: GEB = global environmental benefit; GEF = Global Environment Facility; INRM = integrated natural resources management; PES = payment for ecosystem services

9.16 Fiduciary management

Fiduciary management includes the coordination, supervision, and management of fiduciary services for projects funded by donors/development partners. Its aim is to achieve the projects' development objectives consistent with government priorities and in line with donor procedures. The main pillars of fiduciary management are the following:

- Credible financial management systems and arrangements that ensure efficient and transparent utilization of funds in support of projects/programs.
- A robust and efficient procurement management system based on required guidelines, procedures, and controls to ensure value for money.
- The improvement and strengthening of project performance.
- Quality coordination and supervision of projects in order to track progress toward the achievement of project development objectives.
- An effective channel of communication and collaboration between government and donors on project development and implementation.

Initial basic fiduciary standards include administrative capabilities, financial capacities, transparency, and accountability. Transparency and accountability are to be demonstrated through an effective combination of fully functional policies, procedures, systems, and approaches. Some of the basic fiduciary standards are as follows:

- Financial inputs and outputs are properly accounted for, reported, and administered transparently in accordance with pertinent regulations and laws, and with due accountability.
- Information relating to the overall administration and management of the entity is available, consistent, reliable, complete, and relevant to the required fiduciary standards.
- Operations of the entity show a track record of effectiveness and efficiency.
- Commitment to protect against mismanagement and fraudulent, corrupt, and wasteful practices.

- Disclosure of any form of conflict of interest (actual, potential, or perceived).
- A code of ethics, policies, and a culture that drive and promote full transparency and accountability.
- Project-at-risk systems and related project risk management capabilities.
- Public access to information on beneficiaries and results.

9.17 Quality assurance and ensuring transparency in the project implementation process

A quality system is defined as the organizational structure, responsibilities, processes, procedures and resources for implementing quality management. Quality management includes those aspects of the overall management function that determine and implement the Company quality policy and quality objectives. Both quality control and quality assurance are parts of quality management.

On the other hand, transparency isn't something project managers talk about often. In fact, it might even be a topic they avoid discussing. Transparency promotes responsibility by making it clear to the entire team what needs to be accomplished. If a team doesn't have a clear understanding of the problem, they won't be able to come up with a solution. Also, Transparency helps managers and team members understand the functions of the entire team and the relationship between various tasks. This understanding improves communication, commitment, and accountability of the team. The function of the quality assurance and transparency in project implementation process is provided below:

a) Ensure a focus on results

- Elaborate projects and programs based on intended outcomes.
- Establish what evidence is being sought, what variations can be anticipated, and what should be done if such variations occur (i.e., what will constitute supportive or contrary evidence for any given project or program).
- Define, for each staff level and partners, the purpose of generating knowledge or decision-making information and its scope.
- Define monitoring priorities oriented to outputs and outcomes and have reference points or standards against which judgments can be made about feedback.
- Select knowledge and information indicators based on organisational priorities, use, and users.
- Be cost-effective with regard to the level of resources applied and identify key evaluation resource requirements in future programming.
- Incorporate a timescale covering future changes in programming.
- Agree on the system for collecting and analyzing data and allocate responsibility and costs.
- Scan qualitative information to improve the application of certain M&E techniques such as the field-checking of assumptions, better framing of questions or issues, and more astute choice of assessment areas.
- Monitor learning processes, including the use of feedback and knowledge products.

b) Ask questions

- Constantly inquire, through feedback mechanisms, about why events appear to have happened or to be happening in projects and programs.
- Identify the extent of the effect that projects or programs are having as compared to other factors influencing a development situation.
- Make use of knowledge and learning: use evaluative evidence.
- Specify where, when, and how information will be interpreted, communicated, and disseminated, including consultations as inputs to routine processes.

c) Share knowledge

- Document, analyze, and review comparative experiences in program design, partnerships, and M&E activities.
- Operate at different organizational levels (operational activities, strategic choices, corporate vision/priority) consistent with UNDP's knowledge-management strategy.
- Share knowledge and learning with communities of practice, using the global knowledge networks.
- Determine knowledge and information sources, including the type of evaluative evidence they provide and the frequency of their availability.

Box 9.3 Theory into practice

Implementation of learning

This module helps to identify a number of methodological challenges and difficulties for M&E, starting with the difficulty of defining "success" in CCA. The long-term nature of climate change makes the success of adaptation efforts only apparent over time and in retrospect, which creates difficulties for current and near-term assessments of progress. Furthermore, adaptation interventions occur against the background of evolving climate, environmental, and developmental baselines, which poses challenges for attribution and evaluation – including the relative lack of counterfactual examples for comparative purposes.

This module also explores a number of potentially promising ways in which more effective M&E may strengthen CCA in the Department of Environment, Department of Agricultural Extension, and other government departments:

- Orienting M&E and adaptation interventions to support learning.
- Monitoring the progress of CCA approaches and evaluating the impacts of the CCA intervention over the long term.
- Adopting indicators that reflect the adaptation processes at different scales and provide contextual richness, while allowing for some degree of comparability and aggregation.
- Creating environments that enable learning and knowledge management.
- For further guidance, please consult the following:

Further reading

Guidance note – Strengthening M&E for adaptation planning in the agriculture sector:
https://www.fao.org/in-action/naps/resources/learning/monitoring-and-evaluation-guide/en/

Participatory M&E for natural resource management and research – socio-economic methodologies for natural resources research:
https://www.participatorymethods.org/resource/participatory-monitoring-and-evaluation-natural-resource-management-and-research-socio

M&E of climate change adaptation in Nepal – A review of national systems:
https://www.oecd.org/env/cc/National%20level%20ME%20in%20Nepal.pdf

Videos

M&E in the National Adaptation Plan (NAP) process:
https://www.youtube.com/watch?v=GIqbygK6obE

DIY toolkit – theory of change:
https://www.youtube.com/watch?v=6zRre_gB6A4

Lecture

M&E of agricultural projects – understanding agriculture monitoring:
https://www.youtube.com/watch?v=H8gdxfbsu0M

9.18 Group work

Learners are provided with a case study on **enhancing safe drinking water security and climate resilience through rainwater harvesting.** Using this case study, learners are then requested to answer or complete the following questions or tasks

1. Logframe exercise

Identify the possible inputs, activities, outputs, outcome, and impact for the project detailed in the case study, writing them up in the table below. **Enhancing safe drinking water security and climate resilience through rainwater harvesting.**

Input	Activities	Output	Outcome	Impact
___	___	___		
___	___	___		
___	___	___		
___	___	___		
___	___	___		
___	___	___	___	___

2. Identify possible risks and assumptions.

3. Develop a theory of change.

4. Identify approaches for data collection, verification, dissemination, etc.

5. Conduct a post-test of terminologies and M&E.

NB: Comparing pre- and post-test results would be an indicator of how many participants have learned from the training.

References and selected readings

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Notes

MODULE 10

Climate change negotiations under the UN Framework Convention on Climate Change (UNFCCC)

Overview of the training module

10.1 Brief introduction to the module

Subject

Climate change negotiations under the UN Framework Convention on Climate Change (UNFCCC)

Learning outcomes

This module will provide learners with a basic understanding and knowledge of human-induced climate change and its impacts on human society (and on Bangladesh in particular), and of the politics around the UNFCCC negotiations and how Bangladesh plans to address the issues. Learners will develop their analytical skills by examining how politics is conducted in the multi-track, multi-stakeholder UNFCCC negotiation process and also in the domestic policy process. They will also develop cosmopolitan values for living in harmony with a stable climate system.

This module will begin with brief discussions on climate change negotiations and the politicization of climate science. It will then focus on the United Nations Framework Convention on Climate Change (UNFCCC) negotiation process, covering the basic provisions of the regime, the institutional architecture, the main agendas, political groupings, the most intractable issues, etc. Next, the module will focus on Bangladesh's strategy in the negotiations and the way forward.

Throughout this process, we will tease out how the increasing number of negotiating blocs and non-state stakeholders play their roles. In the discussion, focus will be given to the negotiation strategies of the particularly vulnerable countries (PVCs), which include the Least Developed Countries (LDCs) and Small Island Developing States (SIDS).

10.2 Climate change negotiations: a brief history

We already live in a world altered by human-induced climate change, and the issue of our changing climate is now top of the global agenda. In 2019 the United Kingdom's House of Commons declared a "climate emergency" and, that same year, the Bangladesh Parliament adopted a declaration of planetary emergency. To understand how we got here, following is a very brief history of climate science and the UNFCCC process.

At the first international environmental summit held in 1972 in Stockholm, Sweden, climate change was just a footnote to the proceedings, with the issue viewed solely as a scientific concern. However, between 1972 and the late 1980s, scientists increasingly issued warnings about the risks posed by increased greenhouse gas (GHG) emissions, thus bringing the issue to the attention of politicians. At the first World Climate Conference in 1979 and, later on, at the Toronto Conference on the Changing Climate in 1988, GHGs' role in global warming was formally recognized.

In 1988 the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP), which had been established at the aforementioned Stockholm summit, jointly set up the Intergovernmental Panel on Climate Change (IPCC) as a group of global scientists dedicated to assessing the science, impacts, and response options of climate change. Since 1990 the IPCC has produced six assessment reports. However, the Panel has its critics, with some describing it as "too cautious" and others as "too political and alarmist." Even so, the IPCC's reports have been widely accepted as the authoritative source of scientific information on climate change, and in 2007 the Panel was awarded the Nobel Peace Prize.

10.2.1 Adoption of the UNFCCC

In 1990 the IPCC published its *First Assessment Report*, which warned that emissions resulting from human activities are substantially increasing atmospheric concentrations of GHGs. Building on the momentum generated by the IPCC report, the UN General Assembly launched negotiations leading to the adoption on 9 May 1992 of the UNFCCC. The Convention opened for signatures a month later at the UN Conference on Environment and Development (the Earth Summit) in Rio de Janeiro, Brazil. The Convention has near universal membership with 197 Parties. Its objective is to "stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (Article 2).

The Convention acknowledges the existence of human-induced climate change, and it divides countries into four main groups:

- Annex I parties are industrialized countries (43 countries in total) and have been given the largest share of the responsibility for combating climate change, but on a voluntary basis.
- Annex II parties (24 countries) are the long-industrialized, developed countries that are the main donors.
- Least Developed Countries (49 countries) have a special status due to their limited capacity to adapt to the effects of climate change.
- Non-Annex I parties are mostly low-income developing countries.

Since 1995 an annual Conference of the Parties (COP) has been held, with the most recent one (COP 26) taking place in November 2021 in Glasgow, UK. The COP is the decision-making body of the UNFCCC.

10.2.2 The Kyoto Protocol

Given the voluntary nature of the UNFCCC commitments, the negotiations at COP 1 in 1995 began with proposals to strengthen these commitments. With no substantive action being taken to reduce emissions, there was a pressing need for "legally binding" actions. The result was the adoption of the Kyoto Protocol in 1997, which entered into force in 2005. This was the first time binding GHG reduction targets were set for industrialized countries. In subsequent years, 192 of the UNFCCC parties ratified the Protocol, but it remained somewhat ineffective because the USA – as one of the world's largest emitters – did not ratify it. Moreover, major developing countries like China and India were exempted from binding reductions. The Doha Amendment at COP 18 in 2012 extended the Kyoto commitments until 2020, a move that laid the ground for the Paris Agreement in 2015.

10.2.3 COP 21 and the Paris Agreement: commitments for all

Negotiations on what should follow the Kyoto Protocol from 2020 onwards began at COP 13 in 2007. The failure to reach any agreement in 2009 at COP 15 in Copenhagen (dubbed "Brokenhagen") forced country-parties to negotiate a new agreement by 2015. Following five years of arduous negotiations, agreement was finally reached at COP 21 in the form of the Paris Agreement. Unlike the Kyoto Protocol, which has a top-down compliance mechanism, the Paris Agreement's is bottom-up, in the sense that it is universal in terms of responsibility and that parties will periodically submit their emission reduction plans, known as Nationally Determined Contributions (NDCs). While the provision on NDCs is obligatory, the PVCs are allowed some flexibility. The Paris Agreement sets an ambitious goal to keep temperatures "well below 2°C" and to "pursue efforts to limit the temperature increase to 1.5°C."

The Paris Agreement set a deadline of 2018 for countries to develop and agree guidelines – the Rulebook – for bringing the agreement fully to life ahead of it coming into effect in 2020. In 2021 this Rulebook was finally adopted in full at COP 26, paving the way for its implementation.

Timeline of the key dates in global climate change negotiations, 1988–2022

1988: IPCC established jointly by WMO and UNEP

1990: IPCC's First Assessment Report published

1992: UNFCCC adopted at the Rio Summit

1995: IPCC's Second Assessment Report published

1995: First meeting of the UNFCCC Conference of the Parties (COP 1) takes place in Berlin, Germany

1997: Following two years of formal negotiations, the Kyoto Protocol is agreed at COP 3 in Kyoto, Japan

2001: IPCC's Third Assessment Report published

2005: Kyoto Protocol enters into force

2007: IPCC's Fourth Assessment Report published

2009: Parties fail to reach agreement on a successor to the Kyoto Protocol at COP 15 in Copenhagen, Denmark

2014–15: IPCC's Fifth Assessment Report published

2015: A successor agreement to the Kyoto Protocol – the Paris Agreement – is reached at COP 21 in Paris, France

2020: Paris Agreement takes legal effect (no COP held because of COVID-19)

2021: Previously postponed COP 26 held in Glasgow, Scotland

2022: COP 27 to be held in Sharm el-Sheikh, Egypt.

10.3 Basic provisions of the UNFCCC, Kyoto Protocol, and Paris Agreement

10.3.1 UNFCCC

The basic goal of the UNFCCC is to stabilize GHG concentrations in the atmosphere at a level suitable to avoid "dangerous" interference both to human and ecological systems (Article 2). However, the required GHG emission reductions are left to voluntary initiatives by Parties. Article 4 requires that Annex I countries act first (4.2), and it also prescribes adaptation as a climate change initiative.

The guiding principles include, among others, the principles of equity and of common but differentiated responsibility based on respective capability, which give special consideration to LDCs and SIDS, the precautionary principle, cost-effectiveness, and the promotion of an open economic system and sustainable development.

Furthermore, Annex I countries are required to assist Non-Annex I countries (especially the vulnerable developing and Least Developed Countries) in meeting the costs of mitigation, adaptation, and technical needs. This should take the form of funding that is "new" and "additional" to official development assistance (ODA) (Articles 4.3, 4.4, 4.7, 4.8, and 4.9 of the UNFCCC).

10.3.2 Kyoto Protocol

The Kyoto Protocol committed most of the Annex I signatories to the UNFCCC[1] to mandatory emission reduction targets, which varied depending on the unique circumstances of each country. Other signatories to the UNFCCC and the Protocol, consisting mostly of developing countries, were not required to restrict their emissions.

The Protocol entered into force in February 2005, 90 days after being ratified by at least 55 Annex I signatories that together accounted for at least 55% of total carbon dioxide emissions in 1990. The Protocol provided several means for countries to reach their targets. One approach was to make use of natural processes, called "sinks," that remove GHGs from the atmosphere. The planting of trees, which take up carbon dioxide from the air, would be an example. Another approach was the international program called the Clean Development Mechanism (CDM), which encouraged developed countries to invest in technology and infrastructure in less-developed countries where there were often significant opportunities to reduce emissions. Under the CDM, the investing country could claim the effective reduction in emissions as a credit toward meeting its obligations under the Protocol. An example would be an investment in a clean-burning natural gas power plant to replace a proposed coal-fired plant. A third approach was emissions trading, which allowed participating countries to buy and sell emissions rights and thereby placed an economic value on GHG emissions. European countries initiated an emissions-trading market as a mechanism to work toward meeting their commitments under the Kyoto Protocol. Countries that failed to meet their emissions targets would be required to make up the difference between their targeted and actual emissions, plus a penalty amount of 30%, in the subsequent commitment period, beginning in 2012. They would also be prevented from engaging in emissions trading until they were judged to be in compliance with the Protocol. The emission targets for commitment periods after 2012 were to be established in future protocols.

10.3.3 The Paris Agreement

In the effort to combat climate change and its negative impacts, world leaders at COP 21 in Paris achieved a breakthrough on 12 December 2015: the historic Paris Agreement. The Agreement entered into force on 4 November 2016. Today, 193 Parties (192 countries plus the European Union) have signed up to this legally binding international treaty. The Paris Agreement includes commitments from all countries to reduce their emissions and work together to adapt to the impacts of climate change, and it calls on countries to strengthen their commitments over time. The Agreement provides a pathway for developed nations to assist developing

1 The Annex I signatories comprise the member countries of the Organization for Economic Co-operation and Development (OECD) and several countries with "economies in transition".

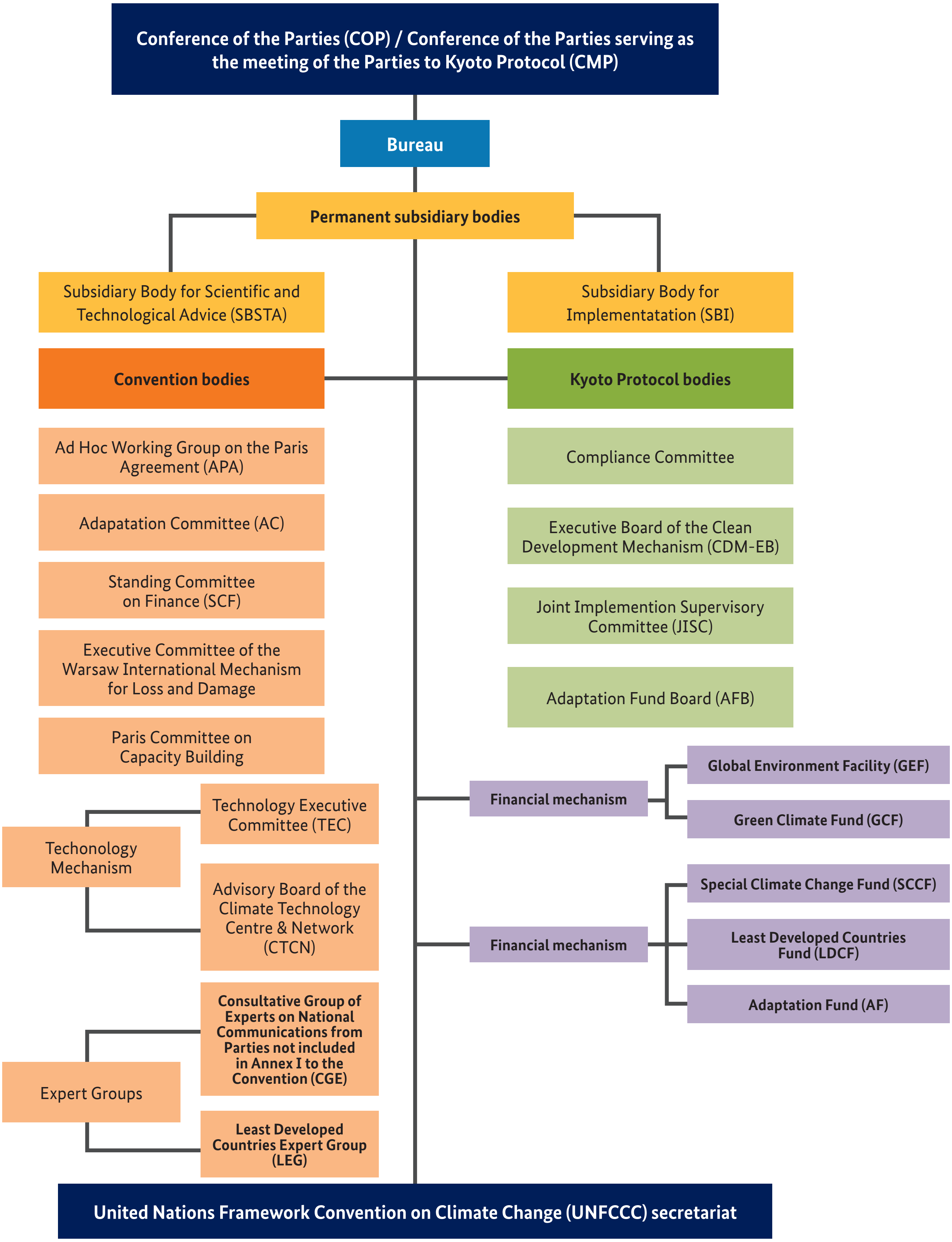

Figure 10.1: Institutional architecture of the UNFCCC process (Rambelli et al., 2017)

nations in their climate mitigation and adaptation efforts, while creating a framework for the transparent monitoring and reporting of countries' climate goals. The Paris Agreement provides a durable framework to guide global efforts for decades to come and marks the beginning of a shift toward a net-zero-emissions world. Implementation of the Paris Agreement is also essential for the achievement of the United Nations' Sustainable Development Goals.

The strategies for addressing climate change and the means of implementation fall within three categories:

- **Mitigation:** A human intervention to reduce the sources or enhance the sinks of GHGs.
- **Adaptation:** The process of adjustment to actual or expected impacts of climate change.
- **Loss and damage:** Covered in Article 8 of the Paris Agreement, this is the residual damage that cannot be adapted to – it is beyond adaptation. This includes, for example, the watery demise of some of the SIDS because of sea level rise or human casualties, which are irreparable. Also, there is non-economic loss and damage, such as biodiversity loss and loss of cultural values or identity.

10.4 Institutional architecture of the climate regime

Since 1992 the UNFCCC regime has developed an institutional structure for managing climate negotiations and the implementation of decisions adopted at the COPs. As previously mentioned, the **Conference of the Parties** (COP) is the supreme decision-making body and is attended by all the signatory and ratifying countries. Alongside this there is the **Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol** (CMP), which cannot be attended by the USA as it is a non-ratifying country, and the **Conference of the Parties serving as the meeting of the Parties to the Paris Agreement** (CMA). All states that are parties to the CMA attend its meetings, while states that are not parties participate as observers. The CMA oversees the implementation of the Paris Agreement and takes decisions to promote its effective implementation.

The **Bureau** supports

- the COP, CMP, and CMA through the provision of advice and guidance on the ongoing work under the UNFCCC, the Kyoto Protocol, and the Paris Agreement;
- the organization of their sessions; and
- the operation of the Secretariat, especially at times when the COP, CMP, and CMA are not in session.

The Bureau is elected from among representatives of the Parties, who are nominated by each of the five United Nations regional groups and the Small Island Developing States. The two main bodies, the Subsidiary Body for Implementation and the Subsidiary Body for Scientific and Technological Advice, also have their own bureaus.

As shown in Figure 10.1, the UNFCCC structure includes a number of funds, expert groups, compliance committees, the IPCC, etc., and also its Bonn-based Secretariat, which carries out the day-to-day functions of the UNFCCC process. Alongside this formal structure, informal processes also exist and can be initiated by the COP Presidency.

Each Party to the UNFCCC process is represented at sessions by a national delegation empowered to represent and negotiate on behalf of its government. Based on the tradition of the United Nations, Parties are organized into five regional groups, mainly for the purposes of electing the Bureau: African States, Asian States, Eastern European States, Latin American and the Caribbean States, and the Western European and Other States. Note that the latter group's "Other States" include Australia, Canada, Iceland, New Zealand, Norway, Switzerland, and the United States of America (but not Japan, which is in the Asian States group). These five regional groups are not, however, usually used to present the substantive interests of Parties; several other groupings, described below, are more important for climate negotiations.

Developing-country Parties generally work through the **Group of 77 (G-77)** to establish common negotiating positions. The G-77 was founded in 1964 in the context of the UN Conference on Trade and Development (UNCTAD) and now functions throughout the UN system. Despite its name, there are now about 134 members in the G 77. The Party holding the Chair of the G 77 in New York (which rotates every year) often speaks for the G 77 and China as a whole (China is an associate member – so the group is also referred to as G 77 and China). However, because the G 77 and China is a diverse group with differing interests on climate change issues, individual developing-country Parties also intervene in debates, as do groups within the G 77, such as the African Group, the Small Island Developing States, and the group of Least Developed Countries.

The **African Group of Negotiators** (AGN) was established in 1995, at COP 1 in Berlin, Germany, as an alliance of African Member States that represents the interests of the region in the international climate change negotiations, providing a common and unified voice. The AGN, which comprises 54 Parties, is active in and supportive of all aspects of the climate change negotiation process (e.g., in the areas of vulnerability, mitigation, and adaptation to climate change).

The **Arab States** comprises 22 Member States, namely Algeria, Bahrain, the Comoros, Djibouti, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, the Palestinian territories, Qatar, Saudi Arabia, Somalia, Sudan, Syria, Tunisia, the United Arab Emirates, and Yemen.

The **Environmental Integrity Group**, formed in 2000, comprises Georgia, Liechtenstein, Mexico, Monaco, the Republic of Korea, and Switzerland. It serves as a kind of bridge-builder between developed and developing countries.

The 27 Member States of the **European Union** (now excluding the UK) negotiate to agree on common positions. The Party that holds the EU Presidency – a position that rotates every six months – then speaks for the European Union and its 27 Member States. As a regional economic integration organization, the European Union itself can be, and is, a Party to the Convention. However, it does not have a separate vote from its members. Croatia is the latest country to join the European Union in 2013.

The 46 Parties defined by the UN as **Least Developed Countries** regularly work together in the wider UN system. They have become increasingly active in the climate change process, often working together to defend their particular interests – e.g., with regard to vulnerability and adaptation to climate change. Six countries have so far graduated from LDC status: Botswana in 1994, Cape Verde in 2007, Maldives in 2011, Samoa in 2014, Equatorial Guinea in 2017, and Vanuatu in 2020.

The **Small Island Developing States (SIDS)** is a coalition of some 40 low-lying islands (most of which are members of the G 77) that are particularly vulnerable to sea level rise. The SIDS grouping is called the Alliance of Small Island States (AOSIS), which is, in fact, the oldest of these groups, formed back in 1991. The AOSIS countries, which are united by the threat that climate change poses to their physical survival, frequently adopt a common stance in negotiations. The group was the first to propose a draft text during the Kyoto Protocol negotiations calling for cuts in carbon dioxide emissions of 20% from 1990 levels by 2005.

The **Umbrella Group** is a coalition of Parties that formed following the adoption of the Kyoto Protocol. Today, the Umbrella Group comprises the non-EU developed countries of Australia, Belarus, Canada, Iceland, Israel, Japan, Kazakhstan, New Zealand, Norway, the Russian Federation, Ukraine, the United Kingdom, and the United States of America.

Several other groups also work together in the climate change process, including countries from the Organization of Petroleum Exporting Countries (OPEC), the Group of Latin American and Caribbean Countries (GRULAC), the Cartagena Dialogue, the Independent Association of Latin America and the Caribbean (AILAC), the BASIC Group (Brazil, South Africa, India and China), the Like-Minded Group of Developing Countries (LMDC), the Central American Integration System (SICA), the Coalition for Rainforest Nations, and the Bolivarian Alliance for the Peoples of Our America (ALBA in Spanish).

10.5 The most intractable issues in the negotiations

Of the agendas of accountability, adaptation, capacity building, climate finance, global stocktake, loss and damage, mitigation, technology transfer, and transparency, it is mitigation and climate finance that remain the most intractable agendas to reach agreement on. And of these two, it is climate finance that takes up most of the time and causes most overruns of the two-week COP meetings, given the difficulties that often arise in reaching a consensus on climate finance issues. In the rest of this section, we will look at the obstacles to consensus in mitigation and climate finance more closely.

Mitigation

Mitigation means the reduction of GHG emissions. Anthropogenic climate change is a product of the age of industry, in which the atmospheric concentration of carbon dioxide equivalent (CO2e) greenhouse gas has increased from 280 parts per million (ppm) at the start of the Industrial Revolution to its current concentration of 415 ppm. Annual global emissions need to be 55% lower or dropped from 53.3 billion tonnes to around 24 billion tonnes compared to 2018 by 2030 (Royal Society, 2018), then to net zero by 2050, to limit temperature rise to 1.5°C compared to pre-industrial levels. However, GHG emissions have risen at a rate of 1.5% per year over the last decade. G20 members account for 78% of global GHG emissions (including land use), and they largely determine global emission trends and the extent to which the 2030 emissions gap will be closed. From a share of 70% by the Global North in 1992, now the Global South emits about 65% of all GHGs. Even so, the North's contribution is still historically more than three-quarters, with the USA being the largest emitter. Even with 100% compliance of the submitted NDCs, global temperature will rise by more than 3°C compared to pre-industrial levels, far from the Paris Agreement goal of 1.5°C (OECD, 2021).

It may be recalled that the Kyoto Protocol could not succeed because of the non-participation of the then largest emitter, the USA. While the EU complied with their commitments in reducing their emissions, the Umbrella Group members did not comply with theirs. Under the Protocol's successor, the Paris Agreement, the bottom-up approach involving NDC submissions and their five-yearly reviews and stocktake based on naming and shaming is not likely to work. COP 26 also failed to extract ambitious commitments from the major emitters. While many countries have committed to reach net-zero emissions by 2050, China and India are likely to reach that target by 2070. The warnings of the IPCC Working Group 1 of a runaway climate change are, it seems, falling on deaf ears.

Climate finance

With regard to climate finance, it may be recalled that the developed countries assumed an obligatory responsibility to support developing countries in their adaptation and mitigation actions. Accordingly, in 2010 they committed to contribute USD 100 billion a year by 2020. However, this goal is far from being met. While an OECD report (2020) stated that USD 78.9 billion was mobilized in 2018, Oxfam's calculations indicate that a much-reduced figure of around USD 19–22 billion was in fact mobilized. In the OECD's calculations, ODA is repackaged, resulting in the double or triple counting of the same money. The main problem is that there is still no agreed definition of climate finance. Furthermore, the mitigation vs adaptation ratio stands at around 80:20 against the repeated pledges of 50:50. These days, more ODA goes toward mitigation actions in the South, which is not a priority for most developing countries.

In addition, the loan vs grant ratio stands at 80:20 and, while climate finance has risen a little over the last few years at the cost of ODA, there has been a downward trend in ODA overall. At COP 26, there was some progress on securing adaptation financing for the PVCs, but the target of reaching USD 100 billion a year may not be realized before 2025. This year is scheduled to have a new quantified goal in climate finance, keeping USD 100 billion as the floor. But everything hangs in the balance.

In this regard, it is interesting to consider some statements that Winston Churchill, a former UK Prime Minister, made to that country's House of Commons on 12 November 1936. Although referring to the threat posed by Nazism in Europe, it is equally valid for today's intractable climate negotiations:

> [The Government] go on in strange paradox, decided only to be undecided, resolved to be irresolute, adamant for drift, solid for fluidity, all-powerful to be impotent [...] Owing to past neglect, in the face of the plainest warnings, we have entered upon a period of danger… The era of procrastination, of half measures, of soothing and baffling expedience, of delays, is coming to a close. In its place we are entering a period of consequences… We cannot avoid this period; we are in it now." (Ratcliffe, 2016; Juniper, 2014)

10.6 Obligations of developing countries, and Bangladesh's position in climate change negotiations

Becoming a party to any international agreement or treaty entails the responsibility to comply with its provisions through adjusting domestic actions in line with the agreement and also the need to submit periodic country reports. For example, under Article 4 of the UNFCCC, all countries agree, on a voluntary basis, to periodically submit the inventory of their national-level GHG emissions. The Paris Agreement goes further, with its Article 4 requiring that all countries periodically prepare their Nationally Determined Contributions (NDCs) for submission to the UNFCCC Secretariat every five years. Rather than being voluntary, this is an obligation for all Parties, although the LDCs and SIDS have some flexibility in this regard. The Paris Agreement's Article 7 requires that all developing countries formulate National Adaptation Plans (NAPs), for which funding will be made available, particularly for those of the PVCs. In addition, its Article 7.10 indicates that Parties should prepare adaptation communications.

To ensure accountability through transparency, Article 13 of the Paris Agreement requires that all countries prepare and submit reports on their actions – the so-called biennial update reports (BURs) – from 2024 onwards. Here again, the LDCs and SIDS have flexibility in meeting this obligation.

In the last two decades, Bangladesh has prepared three National Communications and a National Programme of Action (NAPA). Back in 2008–2009 the country initiated the Bangladesh Climate Change Strategy and Action Plan (BCCSAP). Work to update the BCCSAP got under way in 2020, and the new version will be launched by the Government of the People's Republic of Bangladesh soon. The country also submitted its first NDC in 2016 and has now submitted its updated NDC in advance of COP 27. Currently, Bangladesh is finalizing its National Adaptation Plan (NAP) for submission to the UNFCCC Secretariat.

Bangladesh also established its own fund for the implementation of the BCCSAP, the Bangladesh Climate Change Trust Fund (BCCTF). Over the last decade, the BCCTF has disbursed a total of USD 500 million of funding for some 800 projects. In addition, Bangladesh has already created a budget line to fund climate actions that amounts to around 6–7% of the annual development plan. In absolute terms, this represents close to USD 3 billion a year (Ministry of Finance, 2020).

10.7 International support

Over the last decade in particular, Bangladesh has received international support for climate action, particularly for adaptation. The Global Environment Facility (GEF) has so far funded 43 projects through grants, amounting to a total of USD 160 million along with USD 1,037 million received as additional co-financing. To date, Bangladesh has received USD 94.7 million in the form of grants from the Green Climate Fund and USD 72.6 million in the form of government co-financing for implementing four projects (The Climate Resilient Infrastructure Mainstreaming, Enhancing Adaptive Capacities of Coastal Communities, especially Women, to Cope with Climate Change Induced Salinity, Global Clean Cooking Programme-Bangladesh and Extended Community Climate Change Project-Flood (ECCP-Flood).. Bangladesh received a total of USD 110 million in grants from the Climate Investment Funds to support the Pilot Program for Climate Resilience (PPCR) (Ministry of Finance, 2020).

In recent years, multilateral disbursement to Bangladesh has continued to increase. To date, the country has received funding amounting to USD 634 million.. The PPCR has approved 11 projects in Bangladesh so far, totaling USD 176.66 million of funding and USD 1,049.01 million of co-financing. The PPCR's role in improving climate-resilient agriculture and food security; increasing the reliability of freshwater supply, sanitation, and infrastructure; and enhancing the resilience of coastal communities in Bangladesh has been effective in creating other co-benefits. For its part, the GEF, which has funded 43 projects in Bangladesh, has provided a grant totaling USD 160 million, and this has generated an additional USD 1,037 million of co-financing from other sources including from Bangladesh (Sirazoom et al., 2021).

The domestic government and numerous international development actors have been providing funds to implement adaptation projects in Bangladesh. Overall, 61% of funds (approximately US$3687) were sourced from the domestic government (i.e., BCCTF and ADP-based funds), and the remaining 39% (approximately US$2385) was channelled through foreign donor agencies. This foreign donor-based funding is also included in the ADP. That means, BCCTF is solely domestic sourced fund. However, ADP is a programmatic documentation consisting of both donor-sourced and domestic sourced funds in the public sector, based on which projects of different sectors are implemented in a single fiscal year. As soon as the agreement is signed between foreign donors and government, and respective project documents are approved in the government system, the project funding being included as an ADP project. Both bilateral and multilateral donors fund are considered for including in the ADP document. Regarding donor-funded ADP projects, a mixed approach of implementation modalities is followed, wherein concerned development actors from donors, government and NGOs (if applicable) act and control over the project resources as per the agreed/approved project documents. However, project document analysis reveals that bilateral foreign donors, who provide grants, have more control and authority over project resources and implementation. Besides, multilateral donors (mostly banks), who provide loans, have less control over implementation means, but they tend to put emphasize on monitoring and compliance mechanism (Rahman et al., 2020).

among the foreign donors, a few multilateral banks, and bilateral and multilateral agencies have been engaged in adaptation tasks. Among them, the World Bank was the highest contributor (i.e., 20% of the total funds); however, the Asian Development Bank supplied 4% of the total funds. Among international multilateral organizations, the International Fund for Agricultural Development, World Food Programme, and GEF funded 2%, 2%, and 1%, respectively. In addition, of the bilateral donors, Japan was the leader (i.e., 4%) and channelled this aid through the Japan International Cooperation Agency, Japan International Cooperation System, and Japan Debt Cancellation Fund. Moreover, bilateral donors, such as the Department for International Development-UK, the United States Agency for International Development, the European Union, and Germany (GIZ, KFW), each participated slightly by supplying 2%, 1%, 1%, and less than 1%, respectively, of the total funds. Similarly, Norway, Australia, Switzerland, Sweden, Denmark, the Netherlands, the Spanish Trust, China, and the United Nations Development Program collectively contributed 2% of the total aid in implementing climate adaptation activities in Bangladesh (Rahman et al. 2020).

Recently, five CSA Investment Packages have been identified by the World Bank's Bangladesh Climate Change Action Plan with a total volume of US$809 million (US$2 billion, PPP). They are informed by stakeholder input and extensive quantitative modeling, robust to uncertainty and primed for financing by leveraging the World Bank Group's framework for maximizing finance for development and climate finance sources (World Bank, 2019).

Bangladesh first submitted its emission reduction plan in 2015. With respect to Bangladesh's contribution to global efforts to counter climate change, this INDC sets out a number of mitigation actions that will help limit the country's GHG emissions. These mitigation actions will play a key role in realising the move to a low-carbon, climate-resilient economy and to becoming a middle-income country by 2021 whilst ensuring that it will not cross the average per capita emissions of the developing world. The INDC includes both unconditional and conditional emissions reduction goals for the power, transport, and industry sectors, alongside further mitigation actions in other sectors, which Bangladesh intends to carry out. Bangladesh intends to implement its conditional emissions reduction goal subject to appropriate international support in the form of finance, investment, technology development and transfer, and capacity building.

Sector	Base Year (2011) ($MtCO_2e$)	Bau Scenario (2030) ($MtCO_2e$)	BAU change from 2011 to 2030	Unconditional contribution scenario (2030) ($MtCO_2e$)	Change vs BAU	Conditional contribution scenario (2030) ($MtCO_2e$)	Change vs BAU
Power	21	91	336%	86	-5%	75	-18%
Transport	17	37	118%	33	-9%	28	-24%
Industry (Energy)	26	106	300%	102	-4%	95	-10%
Total	64	234	264%	222	-5%	198	-15%

Table 10.1: Projected emissions reductions in the power, transport and industry (energy) by 2030 (Source: MoEF, 2015)

10.8 National communications to the UNFCCC

All countries which are signatories to the United Nations Framework Convention on Climate Change (UNFCCC), taking into account their common but differentiated responsibilities and their specific national and regional development priorities, objectives and circumstances, are required to periodically submit a National Communication to the Convention. Towards the fulfillment of its obligation under the Convention, Bangladesh submitted its Initial National Communication (INC) to the UNFCCC Secretariat in 2002 and the Second National Communication (SNC) in 2012. This Third National Communication reflects the firm commitment of the Government of Bangladesh to the Convention, its principles and ultimate objective.

Bangladesh's Third National Communication provides an overview of climate change issues in the country and their implications for the key stakeholders at local, national, regional and global levels. It explains national circumstances, details greenhouse gas (GHG) inventory, and highlights programs of measures for adaptation to climate change and mitigation actions.

Bangladesh's Third National Communication Project, the preparation of which has been funded by the Global Environment Facility (GEF) through UNDP Bangladesh, has been able to create a solid foundation for further work on scientific and policy issues. It has also been able to clearly define the concerns relevant within the national context and has identified potential areas for further action. This document alerts policy makers and other key stakeholders of the urgency of mainstream climate issues in the national development policy and agenda as well as within a legal framework. The process of its preparation has helped enhance the capacity of the scientific and research communities of Bangladesh for formulating and planning adaptation and mitigation policies and options. It highlights the need for a more concerted effort to spread awareness among all stakeholders including the research community, decision-makers and those involved in implementation activities, and the need to strengthen the coordination, networking and information flows between ministries, different levels of government and civil society to have a more efficient integration of climate change issues into poverty reduction and development strategies.

According to Bangladesh's Third National Communication (MoEFCC, 2018):

- The total emissions from Bangladesh's agriculture sector were 45.88 $MtCO_2e$, which corresponds to 30.19% of the country's total GHG emissions.
- The waste sector was responsible for 23.78 $MtCO_2e$ or 15.63% of Bangladesh's total GHG emissions.
- If we include these two sectors in Bangladesh's updated NDC, this will make up 45.82% of Bangladesh's national emissions.
- The emissions coverage under the updated NDC will be the present 48.14% plus agriculture and waste's combined total of 45.82%, making 93.96% of Bangladesh's national emissions.

Box 10.1 Theory into Practice

Implementation of Learning

Equipped with this knowledge of the UNFCCC negotiation process, the politics around the UNFCCC negotiations, and Bangladesh's position in the climate negotiations, officials will be better placed to help the government design its climate change policies and maintain its diplomatic position within UNFCCC, and to support the government in the decision-making process.

For further guidance, please read the following:

Pocket Guide to Climate Science and the UNFCCC:
https://ecbi.org/sites/default/files/Pocket%20Guide%20to%20Science_0.pdf

Pocket Guide to Architecture and Processes of the UNFCCC:
https://ecbi.org/sites/default/files/UNFCCC%20Architecture%20and%20Processes%20 2020_0_1.pdf

Pocket Guide to the Paris Agreement:
https://ecbi.org/sites/default/files/PocketGuide-Digital.pdf

10.9 Role of Bangladesh in the climate change negotiations

As no country negotiates in the UNFCCC as a single country, but rather within negotiating groups, Bangladesh negotiates as a member of the LDC group. Bangladesh was at one time the chair of the group, but it now remains in the senior group of LDC negotiators. Given their expertise on different topics, a number of experienced negotiators from Bangladesh have been selected by the LDC group to represent the LDCs in dealings on their areas of expertise, which include locally led adaptation, loss and damage, climate finance, etc.

Bangladesh has also been selected to be a member of a number of important bodies set up by the UNFCCC over the years, such as the Adaptation Fund Board, the Green Climate Fund Board, and the Executive Committee of the Warsaw International Mechanism on Loss and Damage. This is further recognition of Bangladesh's acknowledged expertise and importance in this area. Recently, on March 15, 2022, Bangladesh made its submission to the UNFCCC on the Operationalization of the Santiago Network on Loss and Damage. The Santiago Network will connect vulnerable developing countries with the providers of technical assistance, knowledge, and resources needed to address climate risks comprehensively in the context of averting, minimizing, and addressing loss and damage.

The annual COPs are not just attended by government officials; there are many NGOs in attendance, which hold side events on different topics, and also a number of reporters from Bangladesh's television and print media, who report back to their news outlets every day. Furthermore, a number of Bangladeshi experts participate in these programs on behalf of other institutions, including UN agencies. As we can see, Bangladesh is certainly recognized in the UNFCCC talks as an important country, due as much to its actions at home as to its strong contingent of COP negotiators and other representatives.

Exercise

10.10 Group work

a. Divide the cohort into two groups.
b. Each group is then tasked with brainstorming:

   1. the key agendas that need to be discussed at COP 27, and
   2. the possible challenges in and ways forward for implementing those agendas.

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Notes

MODULE 11

Introduction to climate finance

Overview of the training module

11.1 Brief introduction to the module

Subject

Introduction to climate finance

Learning outcomes

This module will provide learners with an understanding of the legal and institutional framework of climate finance, covering the UNFCCC as well as other bilateral and multilateral funds. Trainees will gain an insight into the political realities around climate finance and into the process of submitting funding proposals to the Green Climate Fund (GCF). Finally, a brainstorming exercise will be conducted with trainees to draw out their ideas for developing proposals to the GCF and other funding bodies.

The module will begin by setting out the legal and institutional framework of climate finance under the UNFCCC. This will also include discussion of many of the other funds available outside of the UNFCCC financial mechanisms, such as bilateral and multilateral climate funds. The material will then delve into the political realities of climate finance, such as the demand/need, supply, and governance of climate finance. Many different issues will be addressed from the perspective of developing countries, particularly of the Least Developed Countries (LDCs). The module will then focus in detail on the procedural aspects of the submission of funding proposals to the Green Climate Fund (GCF) as the biggest funder of climate finance.

11.2 Legal framework of climate finance

The UNFCCC's Article 3 lays down the basic principles of economics and financing for addressing the problem of climate change. The five basic principles are (a) equity, (b) consideration of the specific needs and special circumstances of developing countries, especially those that are particularly vulnerable to climate impacts, (c) the precautionary principle, cost-effectiveness, and ensuring global benefits from adopted measures, (d) recognition of the right to promote development and sustainable development by Parties as an essential condition for addressing climate change, and (e) cooperation to promote a supportive and open international economic system.

The Convention also includes several other provisions on climate finance. Financial commitments under the climate regime involve two categories of responsibilities on the part of wealthy industrial countries: (a) financial assistance under Article 4.3 and (b) assistance aimed specifically at adaptation (Article 4.4). Article 4.3 requires that "new and additional" financial resources meet the "agreed full costs" (under Convention Article 12.1, which is on preparing National Communications) or "agreed incremental costs" (under Article 4.1, meant for both mitigation and adaptation measures) incurred by developing country Parties in meeting their commitments and needs.

It can be argued that the second sentence of Article 4.3 provides a basis for claiming funds for both indirect and direct damage-prevention measures in developing countries; the activities to be undertaken with "new and additional" financial resources include programs and adaptation measures under Article 4.1(b), cooperation in preparing for adaptation (4.1[e]), and measures to implement activities under Articles 4.8 and 4.9. In its third and last sentence, Article 4.3 says such implementation "shall take into account the need for adequacy and predictability in the flow of funds and the importance of appropriate burden sharing among the developed country Parties" in meeting their obligations under the Convention. Article 4.3 therefore spells out the four principles of climate finance: new, additional, adequate, and predictable. Articles 4.3 and 4.4 can be taken as prominent reflections of the common but differentiated responsibility (CBDR) principle, as can Article 4.7, which says that measures to be undertaken by the developing countries for carrying out their obligations under the Convention will depend on the transfer of finance and technology from the industrial countries.

The Paris Agreement, too, obligates the industrial countries to support developing countries ("shall provide ... support" – Article 9.1), giving preference to the particularly vulnerable countries (PVCs) under Article 9.2. Article 9 also includes a "global goal" on adaptation (9.1) and looks at adaptation as a "global challenge" to be addressed at the local, national, and international scales. Article 9.4 stipulates that a balance be achieved between adaptation and mitigation, aligning the needs of adaptation with those of mitigation.. Articles 9.5 and 9.7 require developed countries to provide ex-ante (predicted delivery for the next two years) and ex-post (delivered) information on climate finance. The Agreement's Article 2.1(c) aligns the flow of climate finance with a low-carbon and climate-resilient development, and Articles 9.6 and 14 provide for a global stocktake of climate finance support. Article 13 establishes an "enhanced transparency framework" for action and support under which both the developed and developing countries will report their actions in terms of addressing climate change, support provided, and support received.

Articles 6.2 and 6.4 of the Paris Agreement also provide for the mobilization of climate finance through emissions trading between developed and developing countries (the Kyoto Protocol provides for emissions trading under its Article 12). Lastly, Article 6.8 provides non-market approaches for mobilizing climate finance through integrated and transparent implementation of climate policies. This is particularly important for countries that do not have enough space for emissions trading, Bangladesh being one such country.

11.3 Institutional framework of climate finance

We will now briefly explore the institutional mechanism of climate finance under the UNFCCC regime. Article 11 of the UNFCCC establishes the financial mechanism:

> A mechanism for the provision of financial resources on a grant or concessional basis, including for the transfer of technology, is hereby defined. It shall function under the guidance of and be accountable to the Conference of the Parties, which shall decide on its policies, programme priorities and eligibility criteria [for funding]. Its operation shall be entrusted to one or more existing international entities.

Accordingly, UNFCCC Article 21.3 designates the Global Environment Facility (GEF) – to be co-administered by the World Bank, United Nations Development Programme (UNDP), and United Nations Environmental Programme (UNEP) – as the financial mechanism of the Convention on an interim basis. Moreover, its Article 11.2 stipulates that “The financial mechanism shall have an equitable and balanced representation of all Parties within a transparent system of governance.” Article 11.3(d) establishes the basis of “determination in a predictable and identifiable manner of the amount of funding necessary and available [...].” However, there is a catch: without having to agree by developed countries on the sources of available funding, the level of need of the climate vulnerable population can never be met. This is where the developed countries apply the concept of “constructive ambiguity” in interpreting the regime provisions subjectively, in line with their national interests.

It may be recalled that COP 7, held in 2001 in Marrakech, established three funds: the LDC fund, the Special Climate Change Fund (for all developing countries), and the Adaptation Fund under the Kyoto Protocol, the latter being funded by a 2% levy on the proceeds of emissions trading. However, emissions trading struggled to get off the ground because of the non-participation of the US in the Kyoto Protocol and design flaws in the EU trading schemes. It took almost a decade to fully operationalize these funds, which have since been transferred for management under the regime. In 2010, COP 16 in Cancun established the Green Climate Fund (GCF), which was operationalized in 2014. In 2021, COP 26 finally operationalized Article 6 of the Paris Agreement. A mechanism to contribute to the mitigation of greenhouse gas emissions and support sustainable development is hereby established under the authority and guidance of the Conference of the Parties serving as the meeting of the Parties to this Agreement for use by Parties on a voluntary basis.

Some controversy persists around the relationship between the GEF as the financial mechanism of the UNFCCC and the focus of developing country Parties on the nature and extent of the COP’s guidance to the GEF. The guidance is limited in the Convention to the “policies, programme priorities and eligibility criteria” established by the COP, so it does not extend to specific funding decisions. In 1994 the GEF was restructured to accommodate the last sentence of Article 21.3, which required that membership be opened up to all and thus to developing countries. Basically, GEF played a significant role in mobilising co-financing. Since its establishment in 1991, the GEF has been providing more than $21.1 billion in grants and mobilised an additional $114 billion in co-financing more than 5,000 projects in 170 countries. Loans from multilateral development banks continue to play a major role in co-financing GEF projects. Private sectors also co-finance in GEF projects but their interests are mostly in Non-Grant Instruments (NGIs) and Impact programmes (IPs). The GEF was disliked by developing countries because of its donor-driven culture. This created an invisible and constant tension between the industrial countries, whose preference is for the GEF to remain the funding agency, and the developing countries, whose preference is for a mechanism under the control of the COP (i.e., what is now the Green Climate Fund or GCF).

The GCF is an operating entity of the financial mechanism under UNFCCC to assist developing countries in adaptation and mitigation practices of climate change. The Fund aims for a 50:50 balance between mitigation and adaptation investments over time. But accessing climate finance from the GCF requires a complex, resource intensive and arduously lengthy process. The GCF funding proposal for "Promoting private sector investment through large-scale adoption of energy saving technologies and equipment for Textile and Readymade Garment (RMG) sectors of Bangladesh" project was a 157-page document. GCF accreditation processes are slow, resource intensive and challenging. Countries willing to access funds often face delay and struggle to fulfil the accreditation criteria (e.g. fiduciary principles and standards, environmental and social safeguards and Gender-sensitive development impact). In addition, Despite GCF's claim of significant progress in this project financing, it still took 6 months (against about 2 years taken for KfW project to help mainstream climate-resilient infrastructure in Bangladesh) in getting the Funded Activity Agreement (FAA) approved from the date of approval of the project by the GCF Board. For example, The Infrastructure Development Company Limited (IDCOL), one of the DAEs in Bangladesh, reported that accreditation had taken almost two years and involved the upload of 188 documents. Besides, Inadequate fiduciary system is another hurdle in accessing climate finance from GCF. Although public sector entities follow Generally Accepted Accounting Principles (GAAP) in maintaining their accounts, they 'do not maintain accounts of assets and liabilities at the organizational level and as such fails 'in producing Annual Financial Statements (Income Statements and Balance Sheets) at the organizational level which is 'a must for getting accreditation of GCF (Yusuf, 2022).

In 2018, GCF and GEF agreed to take joint steps to improve climate finance flows to best meet the needs of developing countries in tackling the global climate challenge. It is essential to continue to strengthen the synergies between our two funds to simplify the architecture of climate finance. This will help to ensure countries receive coordinated financial inputs that best suit their needs in driving low-emission and climate-resilient development.

11.4 Climate finance types and geographical coverage

The UNFCCC, the Kyoto Protocol, and the Paris Agreement call on Parties with more financial resources to provide financial assistance to those that are less endowed and more vulnerable. This recognizes that countries' contributions to climate change and their capacity to prevent it and cope with its consequences vary enormously. Climate finance is needed for mitigation because large-scale investments are required if emissions are to be significantly reduced. Climate finance is equally important for adaptation, as significant financial resources are needed to adapt to the adverse effects of a changing climate and to reduce its impacts.

Climate finance can come from very different sources, which can include public or private, national or international, or bilateral or multilateral sources. Box 11.1 below lists the different types of climate funds.

Box 11.1 Different types of climate funds

National climate funds, such as those of Bangladesh, Indonesia, and elsewhere.

Bilateral climate funds: Six such funds have been established by Australia, Germany, Spain, Canada, the UK, and the USA..

Regional funds: The Amazon Fund, the Congo Basin Fund, and the regional develop-ment banks.

Multilateral funds: The UNFCCC, the multilateral development banks and other UN funds, and the Global Climate Change Alliance (GCCA).

Carbon markets and public-private investment funds: Article 6 of the Paris Agreement was operationalized at COP26.

11.5 UNFCCC funds

As already mentioned, at COP 7 held in Marrakech in 2001, three funds were established:

- The **Special Climate Change Fund**, established under the UNFCCC, covers adaptation, technology transfer, energy, transport, industry, forest, and waste management and has invested some USD 355 million over the 20 years since its inception.
- The **LDC Fund** assists the LDCs to prepare for and implement immediate urgently needed adaptation measures (the National Adaptation Programme of Action or NAPA). Since 2001 it has provided USD 1.7 billion in funding.
- The **Adaptation Fund** is financed with a share of proceeds from the clean development mechanism (CDM) project activities and other sources of funding. The share of proceeds amounts to 2% of certified emission reductions (CERs) issued for a CDM project activity. The Adaptation Fund is supervised and managed by the Adaptation Fund Board (AFB). The AFB is composed of 16 members and 16 alternates and meets at least twice a year (Membership of the AFB)..

The GCF was established by 194 countries party to the UN Framework Convention on Climate Change in 2010. It is designed as an operating entity of the Convention's financial mechanism and is headquartered in the Republic of Korea. It is governed by a 24 Board member Board, representing countries, and receives guidance from the Conference of the Parties to the Convention (COP). Created by the United Nations Framework Convention on Climate Change (UNFCCC), the Fund aims to support a paradigm shift in the global response to climate change. It allocates its resources to low-emission and climate-resilient projects and programmes in developing countries. The Fund pays particular attention to the needs of societies that are highly vulnerable to the effects of climate change, in particular Least Developed Countries (LDCs), Small Island Developing States (SIDS), and African States. Recently, the GCF Board has approved four new climate projects (Relief Web, 2022) valued at USD 380.7 million in GCF funding and USD 1.0 billion with co-financing, whilst also launching the process for the Fund's replenishment for the 2024-2027 period. With the newly approved projects, GCF's portfolio now stands at 200 projects with a total value of USD 10.8 billion in GCF resources, USD 40.3 billion including co-financing.

It is also useful to break down these and other relevant funds according to the areas they focus on:

- **Mitigation:** the Clean Technology Fund, the Partnership for Market Readiness, the Scaling up Renewable Energy Program, the Global Energy Efficiency and Renewable Energy Fund.
- **Adaptation:** the LDC Fund (LDCF), the Special Climate Change Fund (SCCF), the Adaptation Fund (AF), the Secretariat of the Pacific Regional Environment Programme, the Carbon Fund, the Adaptation for Smallholder Agriculture Programme, the Pilot Program for Climate Resilience (PPCR).
- **REDD+:** the Carbon Fund, the Amazon Fund, the Forest Carbon Partnership Facility's Readiness Fund, the LDC Fund, the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation (UN REDD), the BioCarbon Fund, the Forest Investment Program, Norway's International Climate and Forest Initiative.
- **Loss and damage:** While there is no dedicated funding facility for this yet, the demand for such exists and is now being addressed in ongoing negotiations under the Glasgow Dialogue, established at COP 26.

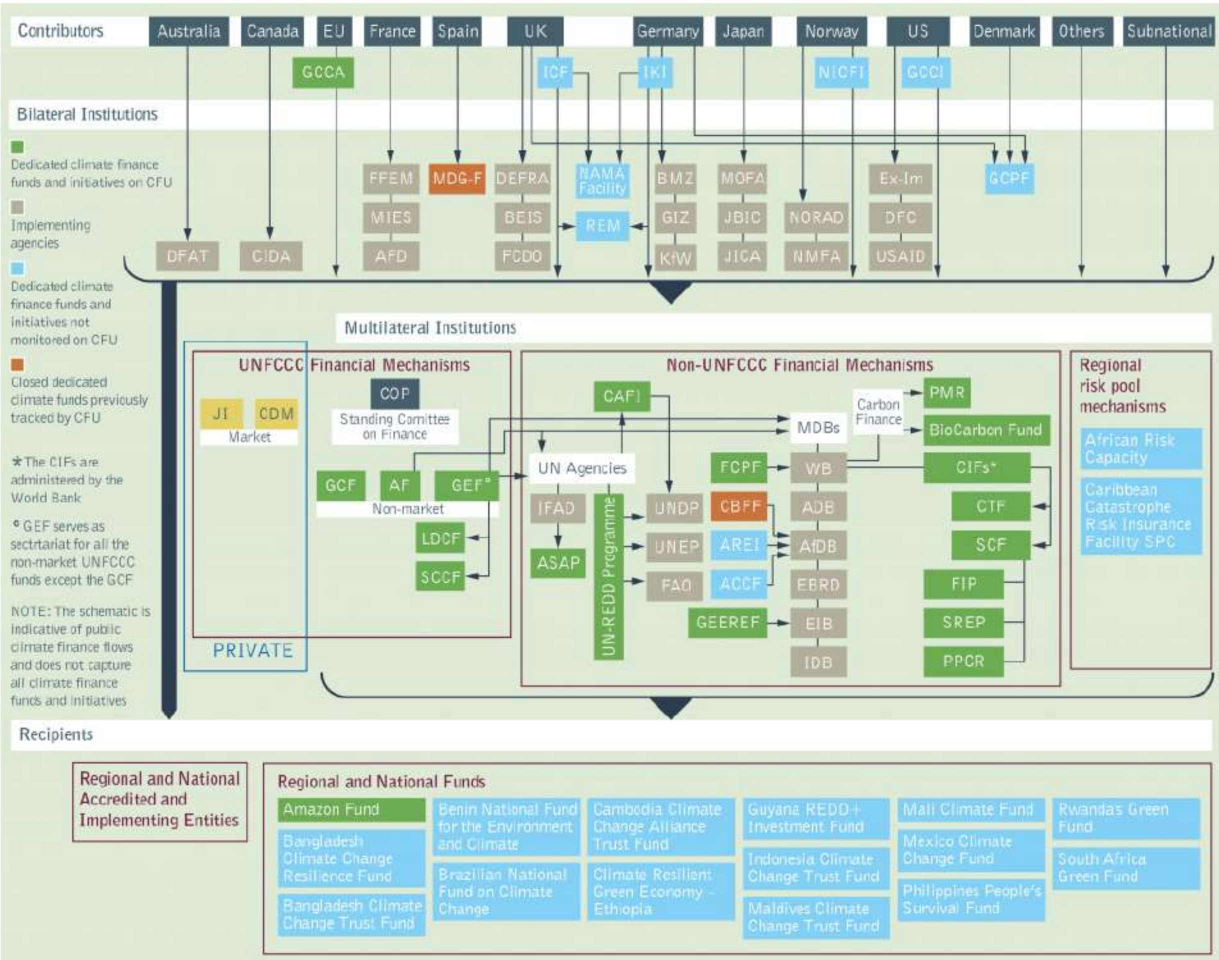

Figure 11.1: Global climate finance architecture (source: Climate Funds Update, 2022)

11.6 Demand, supply, and governance of climate funds

The architecture of climate finance is extremely fragmented and uncertain, with many multilateral and bilateral initiatives. There are three levels in climate finance and each comes with its own politics and contentions around the raising and allocation of funds and the governance of the process. Raising and allocating funds falls on the supply side of adaptation finance, and it is where we can see the gap between the promises made and what is actually delivered. The UNFCCC states that funds should be new, additional, adequate, and predictable. However, the Convention does not specify the level of financing for addressing climate change issues. Its Article 7(h) says that the COP will "Seek to mobilize financial resources in accordance with Article 4, paragraphs 3, 4 and 5, and Article 11." The Convention's Article 11.3(d) indicates striking a balance between necessity and availability, with the identification of sources and their predictability.

The debates continue around climate finance issues, including the basis of its mobilization, its sources and priority areas, and the governance process. The Group of 77[1] (G-77) and China insist on there being some assessed scale of contributions, which combines both responsibility and capability, while the Alliance of Small Island States (AOSIS) and the LDCs demand that this assessed scale be based on public-private partnerships (PPPs) that combine both historical responsibility and capability.

On climate finance, a few issues are clear: First, the developed countries largely avoid any reference to the "responsibility" part, with only the EU recognizing both the responsibility and capability parts of the governance principle. Second, some EU countries explicitly define the threshold of measuring "new and additional" funding in relation to official development assistance (ODA). Third, the developed countries demand that the newly emerging and major developing countries should also contribute to climate finance in view of their new capabilities, an approach that is opposed by this latter group of countries, particularly by China. However, the AOSIS welcomes the contributions of major developing countries for mitigation action. Fourth, there is a trend – at least in some contributor-countries' approaches – toward diluting climate finance with ODA, a move strongly opposed by the G-77. Finally, there is a consensus among the developed and major developing countries that adaptation finance is different and that the LDCs and AOSIS countries should be prioritized in the allocation of adaptation finance.

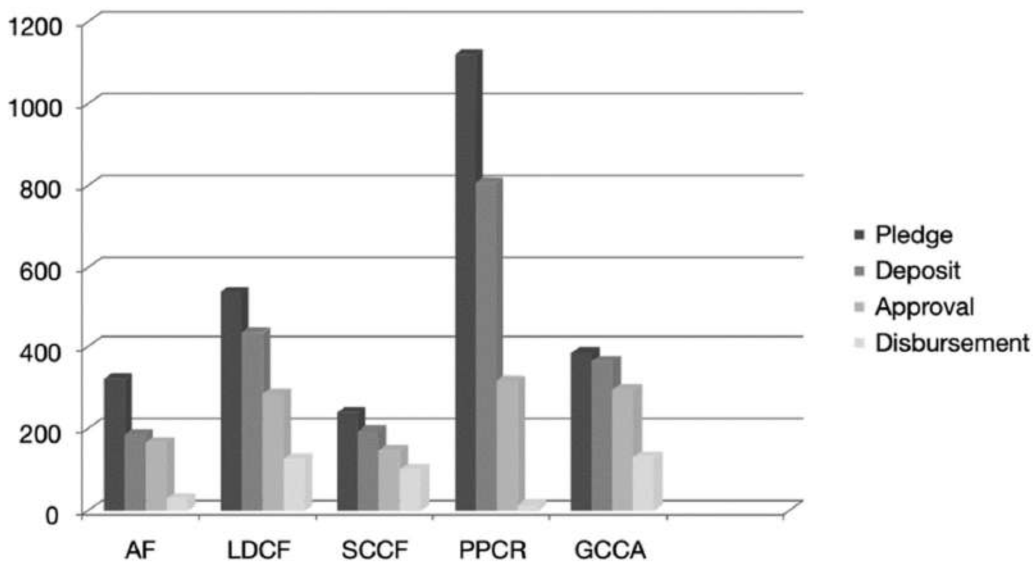

Figure 11.2: Funds primarily supporting adaptation as of October 2021 (USD million) (source: Climate Funds Update, 2022)

1 The Group of 77 at the United Nations is a coalition of 134 developing countries, designed to promote its members' collective economic interests and create an enhanced joint negotiating capacity in the United Nations.

In addition, there has been a yawning gap in the amount of adaptation funds available for developing nations compared to their assessed needs. The estimated needs for adaptation globally reach a total of almost USD 2 trillion over the decade lead-ing up to 2030.. However, for developing countries only, the need ranges from USD 24 billion to USD 100 billion a year from 2030. It is also not clear what proportion of the funding will be in the form of pure grants, partial grants, concessional loans, or purely market-rate loans. It is difficult to see how vulnerable countries could respond to the requirement to repay loans for adaptation.

While on the supply side of adaptation finance there are questions about, for example, where funds are to come from, on the demand side there are questions about, for instance, who gets access to available adaptation funds and based on what criteria. If the current pledges stand, the issue of how to divide too few funds among too many claimants may serve as a potential wedge that disrupts solidarity between developing country actors in both the mitigation and adaptation negotiations.

There is also the issue that funds may not be allocated in a way that prioritizes the most vulnerable groups. Instead, some funding allocation formulas reflect donor-country interests more than the needs of vulnerable actors. Adaptation poses distributive questions that are "not only between burden-takers (i.e., those who take adaptive or mitigating action) but also between recipients of benefits" (Jagers and Duus-Otterström, 2008). The term "vulnerability" is mentioned four times in the UNFCCC and just once in the Kyoto Protocol. The Convention's preamble (paragraph 19) mentions "low-lying and other small island countries," and while its Article 4.8 lays down nine categories of country that demand special consideration, it does not use the term "particularly vulnerable." The nine categories are (a) small-island countries, (b) countries with low-lying coastal areas, (c) countries with arid and semi-arid areas, forested areas, and areas liable to forest decay, (d) countries with areas prone to natural disasters, (e) countries with areas liable to drought and desertification, (f) countries with areas of high urban atmospheric pollution, (g) countries with areas with fragile ecosystems, including mountainous ecosystems, (h) landlocked and transit countries, and (i) countries whose economies are highly dependent on income generated from the production, processing, and export, and/or on the consumption of fossil fuels and associated energy-intensive products.

11.7 GCF's strategic areas for investment

As mentioned above, there are a plethora funds at different levels. However, this module will focus on the GCF as the main multilateral agency for funding climate actions and on its strategic areas, criteria for project selection, proposal template, and its complex submission and review process.

The GCF's programming and pipeline development are guided by three key policy frameworks: the Investment Framework (IF), the Results Management Framework (RMF), and the Performance Measurement Framework (PMF). Financial proposals must be prepared in accordance with the considerations and requirements of these key policy frameworks. The IF is the key guiding framework informing GCF programming and investment decision-making. It is supported by the GCF's investment policies and contains six investment criteria and related activity-specific sub-criteria indicators and assessment factors.

1. Not to be confused with the six investment criteria, there are six steps for moving ahead with the preparation of financial proposals for the GCF: **Check** the accreditation scope and the environmental and social safeguards category.
2. **Define** the project scope/activity.
3. **Conduct** stakeholder engagement.
4. **Obtain** a no-objection letter.
5. **Select** the executing entity.
6. **Set** the financial structure.

There are also six investment criteria such as Impact potential, Paradigm-shift potential, Sustainable Development potential, Needs of the recipient, Country Ownership and Efficiency and Effectiveness.

Accredited entities (AEs) are expected to develop their funding proposals taking due consideration of all six of the GCF investment criteria and of only those activity-specific sub-criteria and indicative assessment factors that are applicable and relevant. Note that not all of these sub-criteria and factors will be applicable or relevant to every proposal. AEs can be private or public, non-governmental, sub-national, national, regional or international, as long as they meet the standards of the Fund. AEs carry out a range of activities that usually include the development of funding proposals and the management and monitoring of projects and programmes. Countries may access GCF resources through multiple entities simultaneously.

The current RMF and PMF define the areas of action in which the GCF seeks to invest and its approach to tracking and monitoring results. The GCF invests across eight "result areas," which comprise four mitigation and four adaptation strategic impact areas. The PMF has been designed to measure the results of the many cross-cutting opportunities (for example, relief projects) with the potential to have an impact on both mitigation and adaptation. In their funding proposals to the GCF, AEs are expected to demonstrate how they will deliver on a limited set of representative indicators mirroring the Investment Framework that are relevant to their proposed project activities and result areas, and which will be tracked and monitored throughout the project implementation process. Figure 11.3 sets out the result areas in which the GCF seeks to invest.

11.8 GCF proposal template

A proposal for funding from the GCF should include the following sections along with specific details provided as sub-sections:

Section A: Project/program summary
Section B: Project/program information
Section C: Financing information
Section D: Expected performance against investment criteria
Section E: Logical framework
Section F: Risk assessment and management

Section G: GCF policies and standards
Section H: Annexes

A template for the proposal itself is available at https://www.greenclimate.fund/document/funding-proposal-template

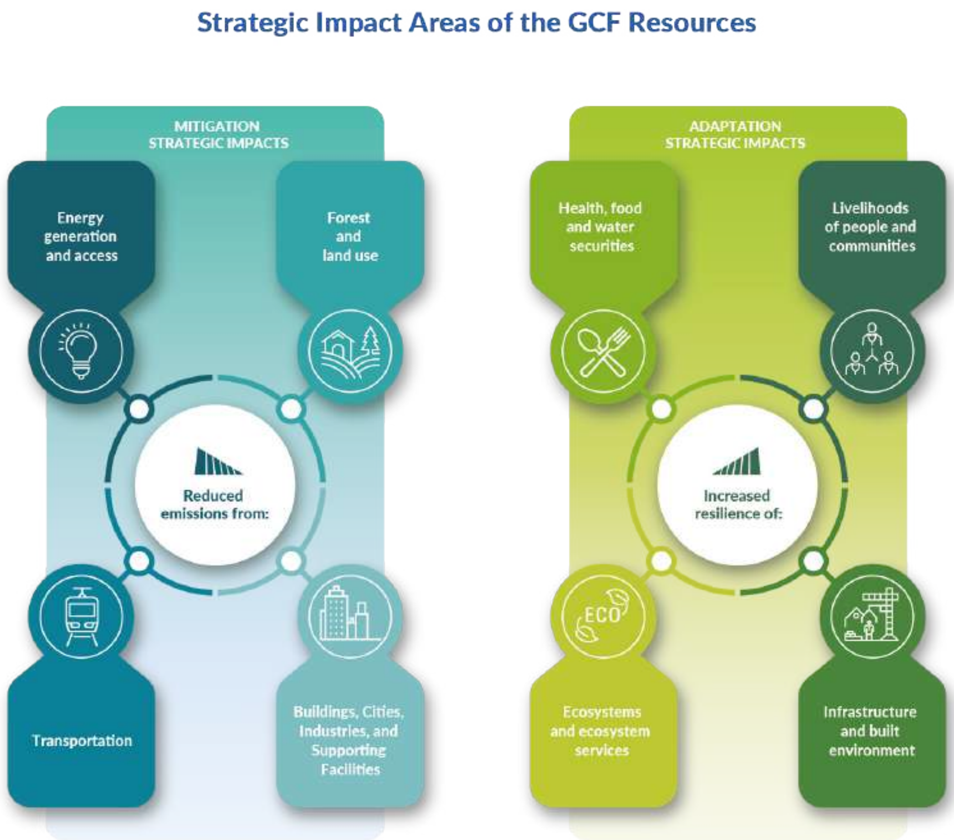

Figure 11.3: Result areas in which the GCF seeks to Invest (Source: NDA GCF, 2022)

The GCF's sectoral guidance provides additional directions on the types of initiatives that fully meet GCF investment criteria in key sectors across its eight result areas.

The selection criteria for proposals are based on the following aspects:

11.8.1 Investment framework

The GCF's Investment Framework seeks to translate the Fund's overall objectives into clear guidelines for investment decisions. The Framework is composed of policies, strategies, targets, and criteria that inform the design, assessment, and approval of funding decisions within the GCF.

11.8.2 Portfolio targets and allocation parameters

In 2020 the GCF's Board agreed updated portfolio targets and allocation parameters to guide investments for the Fund's first replenishment programming period (2020–2023). These targets and parameters strive to achieve greater impacts for developing countries, compared with the initial resource mobilization period (2015–2019), through

- maintaining the 50:50 balance of adaptation and mitigation funding over time while seeking to deliver portfolio-level mitigation and adaptation outcomes that exceed average Independent Redress Mechanism (IRM) outcomes;
- maintaining a minimum allocation floor of 50% of adaptation funding for developing countries that are particularly vulnerable to the adverse effects of climate change, including Small Island Developing States, LDCs, and African States, taking into account their urgent and immediate needs, while aiming to build on IRM outcomes;

- aiming for appropriate geographical balance;
- significantly increasing funding channeled through direct-access entities relative to the IRM;
- maximizing engagement with the private sector, including small, micro, and medium-size enterprises, by ensuring the allocation to the Private Sector Facility exceeds 20%; and
- significantly increasing mobilized private finance at the portfolio level relative to the IRM.

11.8.3 Policies for proposal development

The GCF's set of financial policies consist of investment policies and financial risk management policies and comprise the overall investment guiding principles from a financial point of view.

- **Paradigm shift:** The GCF will finance projects and programs that demonstrate the maximum potential for a paradigm shift toward low-carbon and climate-resilient sustainable development, in accordance with its agreed result areas and consistent with a country-driven approach.
- **Grant-equivalent accounting:** Funding received and extended by the GCF will be accounted for in grant-equivalent terms based on a standard methodology, to be developed by the Fund based on best international practices, in order to provide an accurate comparison of funding amounts between financial instruments.
- **Minimal concessional funding:** The GCF will provide the minimum concessional funding necessary to make a project or program viable. Concessional funding is understood as funding with below-market terms and conditions. Consistent with the Governing Instrument, the minimum amount of concessional funding needed can be up to and including the full cost of the project or program. Governing Instruments means legal documents that establish the existence of an organization and define its powers, including articles of incorporation or association, constitution, charter, by-laws, or similar documents.
- **Blending:** Financing provided by the GCF to intermediaries may be used by the latter to blend with their own financial resources in order to increase the level of concessionality[2] of the financing they extend to projects and programs.
- **Crowding out other financing sources:** The GCF will not "crowd out" potential financing from other public and private sources.
- **Revenues:** Only revenue-generating activities that are intrinsically sound from a financial point of view will be supported through loans by the Fund.

11.9 Writing concept notes

The concept note presents a summary of a proposed project/programme to the GCF in order to receive feedback from the GCF Secretariat on whether the concept is aligned with the Fund's objectives, policies and investment criteria. Such feedback will provide information to further develop and strengthen the project/programme idea.

Prior to the submission of the concept note, if applicable, but no later than submission of a funding proposal to the Secretariat, the AE shall: a. Inform the NDA or, if applicable, the focal point about the proposed activity to be implemented in their country and commence consultations with a view to confirming it is in accordance with the country's strategic framework and priorities; and b. Inform the Secretariat that it has commenced consultations with the NDA or, if applicable, the focal point.

Any feedback provided by the GCF Secretariat does not represent acceptance or commitment to provide financial resources in respect of a specific project/programme. Funding decisions can only be made by the GCF's Board. Any feedback is intended to provide non-binding guidance to enable the AE to initiate the next phase, the preparation and submission of the full funding proposal. The concept note is not mandatory but strongly encouraged to promote early feedback from the GCF Secretariat, to streamline with the Project Preparation Facility (PPF), and to allow for a faster review process.

2 Concessionality is defined as a measure of the level of benefit provided to a borrower when compared with financing available at full market rates.

11.10 Funding proposal submission and completeness Check

When a proposal has been submitted, the GCF Secretariat acknowledges the submission and assigns the relevant team to review it. Depending on the project type (public or private) and the sector, the review is led by either the Division of Adaptation and Mitigation (DMA) for public sector proposals or the Private Sector Facility (PSF) for private sector proposals. The same members involved in the origination and structuring team are assigned to the funding proposal once it has been submitted through the online submission system. Origination and structuring team enable a transparent assessment and screening of funding proposals against the six investment criteria; and is the foundation of GCF's results management frameworks to report project achievement against applicable investment criteria. For projects that are not recommended for interdivisional review, the origination and structuring team will further work with the AEs in reshaping the proposals so that they meet GCF requirements.

Figure 11.4: Key Elements for Consideration as part of the Project/Programme Review by The Origination and Structuring Team (Source: GCF, 2020)

Additionally, the task manager assigned to the project will often be the relevant sector/financial structuring specialist for the main theme of the project. The task manager will be the key GCF contact person for the AE during the review of the proposed project, the submission of the proposal to the Board, and post-approval arrangements.

The funding proposal package must include a number of supporting documents, which are detailed in the following checklist:

- No-objection letter(s)
- Feasibility study and, if applicable, market study
- Economic or/and financial analysis spreadsheet format
- Detailed budget plan
- Implementation timetable, including key project/program milestones
- Environmental and social safeguards report
- Summary of consultation and stakeholder engagement plan
- Gender assessment and project-/program-level action plan
- Legal due diligence (regulation, taxation, and insurance)
- Procurement plan
- Monitoring and evaluation plan
- Accredited-entity fee request
- Co-financing commitment letter (if applicable)
- Term sheet, including a detailed disbursement schedule and, if applicable, repayment schedule
- Evidence of internal approval
- Map(s) indicating the location of proposed interventions
- Multi-country project/program information
- Appraisal, due diligence, or evaluation report for proposals based on the scaling-up or replication of a pilot project

- Procedures for controlling procurement by any third parties or executing entities undertaking projects financed by the accredited entity
- First-level anti-money laundering (AML) and countering the financing of terrorism (CFT) assessment
- Operations manual (operation and maintenance)
- GHG emissions reduction estimates
- Other references, responses, or feedback

Upon receipt of the funding proposal, the Secretariat performs an initial review and completeness check of the required documentation. If the required information or documentation is missing or incomplete, the Secretariat informs the AE accordingly, and requests the AE to submit the missing information. This stage comprises both a check of the submission of the required documentation in an adequate format, and an initial quality assessment of the information contained in the documentation (e.g. ensuring that the funding proposal has been developed in line with guidance provided at the concept note stage). For some annexes, a prescribed template is provided, which must be used to present relevant project-specific information. Annexes that are incomplete or not submitted in the required template will not be reviewed until such annexes are revised to the satisfaction of GCF. Therefore, AEs must ensure that they provide complete information and documentation, and that all required documentation is sufficiently advanced prior to FP submission to the GCF.

Some annexes could be submitted at a later stage after the initial funding proposal submission as the review progresses; however, AEs are highly encouraged to submit all relevant annexes with the initial submission to ensure that a complete review can be undertaken by the Secretariat in a timely manner. At a minimum, a funding proposal package submitted to the GCF Secretariat as an initial submission should include, among other elements:

- A feasibility study
- A project appraisal report (if applicable)
- A detailed budget
- ESS reports
- Gender assessments and project-/programme-level action plans
- A draft term sheet
- An evaluation report of baseline projects (if applicable)
- An NOL
- Co-financing or commitment letter(s)
- A project implementation timetable
- An economic and/or financial analysis

If a funding proposal is submitted without these annexes, the Secretariat will not proceed to review the documentation until such annexes are provided by the AE. The full funding proposal package must be sent to the Secretariat no later than by the start of the technical review stage. Additional information and annexes may be requested as the technical review progresses.

11.11 Additional submission requirements for funding proposals for countries with UN sanctioned regimes

The GCF Board policy on sanctions, is to ensure compliance with UN financial sanctions, as expressed in the GCF Anti-Money Laundering and Countering the Financing of Terrorism Policy (GCF/B.18/20) and the Standards for the Implementation of the Anti-Money Laundering and Countering the Financing of Terrorism Policy (GCF/B.23/22). As such funding proposals submitted to GCF must comply with sanctions measures set out in the sanctions regimes established by the United Nations Security Council. Upon confirmation by the GCF task team (Division of Mitigation and Adaptation, the Private Sector Facility) in consultation with the Office of Risk Management and Compliance and the Independent Integrity Unit, if a proposal is submitted to GCF for funding for a country with a United Nations Security Council sanctions regime, the AE must either submit a signed letter confirming that according to its assessment of the sanctions regime, the proposed activities are not subject to, or affected by, United Nations Security Council sanctions; or, in cases where proposed activities may be subject to, or affected by, United Nations Security Council sanctions, the AE must submit, at a minimum, a preliminary clearance/exemption letter from the respective United

Nations Security Council Sanctions Committee in order for it to be considered complete. In addition, the proposal must include information from the Sanctions Committee on how frequently such exemption letters would be required with respect to funded activities that detail, for example, procedures for the procurement of goods and services and associated costs. Additional conditions may be required to be fulfilled either prior to approval or after approval, as appropriate.

11.12 Publication of the funding proposal package on the GCF website and submission to the board

Upon completion of the independent Technical Advisory Panel (TAP) assessment, the Secretariat compiles the funding proposal package, shares it with the Board and publishes it on the GCF website. 45 For public sector funding proposals, all project-related annexes are disclosed, subject to the redaction of confidential information. The AEs shall provide confirmation as to whether any such annexes (or any relevant sections therein) can be disclosed as part of the funding proposal package.

Funding proposals are put together and presented for Board consideration in the following format:

1. Funding proposal package:

   a. Funding proposal;
   b. No-objection letter;
   c. Environmental and social safeguards disclosure form;
   d. Secretariat assessment;
   e. Independent TAP assessment;
   f. AE response to independent TAP questions;
   g. Gender documents;
   h. All non-confidential annexes to the public sector funding proposal;

2. Limited distribution documents (Limited distribution documents are circulated by email to members and alternate members of the Board, as well as advisers who have signed the confidentiality agreement. These documents include: (i) a list of proposed conditions and recommendations; and (ii) term sheets.

   a. The list of conditions put forward either by the independent TAP or by the Secretariat;
   b. Term sheets; and
   c. Those annexes to the funding proposal that have been marked and/or described as confidential by the AE with reasons provided for not sharing them publicly.

The Secretariat submits the above documentation to an upcoming Board meeting for consideration no later than 21 days before the first day of the Board meeting (known as the “publication deadline”).

11.12 Recap of key points

This module has shown that, despite having an agreed legal and institutional framework in place for climate finance, little progress has been achieved in terms of the delivery of the pledged funds. The goal of USD 100 billion remains as elusive as ever, despite the fact that this figure was supposed to have been reached by 2020. Indeed, as the above-mentioned Oxfam report shows, only around a quarter of that amount has so far been made available. Adaptation funding is absolutely essential for poor countries like Bangladesh, which has seen no progress in financing for loss and damage.

The institutional fragmentation affecting the delivery of climate finance is immense, and this compromises the effectiveness of climate finance utilization at the recipients’ end. Also, transparency at the donors’ end remains problematic, given that the obligations under Article 9.5 and 9.7 of the Paris Agreement are not being complied with. Then, as set out in Section 4, there is the process of submitting a funding proposal to the GCF, which shows just how complex and time-consuming accessing climate finance can be (although expedited access to funding may be possible for LDCs).

Finally, many different bilateral and multilateral agencies have differing needs and criteria for proposal submission and selection. From my own experience, for a bid to be successful it must be based on three things: (a) an understanding of the funding agency in question's priority areas and of its selection criteria for proposals, (b) a team whose members have the right knowledge and first-class technical skills for identifying the niche in which to place the proposal, and (c) excellent English language skills for writing the different sections of the proposal and for developing the logframe to ensure effective implementation and M&E.

Box 11.2 Theory into Practice

Implementation of Learning

Having completed the training on climate finance, participants will develop their own project idea for presentation in a separate, follow-up session called the "Project Idea Workshop." In this Workshop, participants will be tasked with developing with their own project ideas, which will then be validated and prioritized according to the SMART principles (Specific, Measurable, Achievable, Relevant, and Time Bound). They will also hone and finesse their project ideas, drawing on their own experiences of and perspectives on conceptualizing and implementing ideas. Finally, under the supervision of workshop facilitators and external experts, the participants will prepare draft proposals and set up the logframe for submission.

For further guidance, please read the following:

Pocket guide to finance under the UNFCCC:
https://ecbi.org/sites/default/files/Pocket%20Guide%20to%20Finance_0.pdf

Climate financing for sustainable development:
https://mof.portal.gov.bd/sites/default/files/files/mof.portal.gov.bd/page/6e496a5b_f5c1_447b_bbb4_257a2d8a97a1/2020-2021_Climate_BR_English.pdf

Climate finance shadow report 2020:
https://www.oxfam.org/en/research/climate-finance-shadow-report-2020

11.13 Group work

1. After the climate finance training, participants will be divided into four groups.
2. Group members will work together on brainstorming and developing project ideas.
3. The experts will provide feedback, where required, on the project ideas.
4. After incorporating this feedback, each group will take part in a Project Idea Workshop where they will present their ideas to a panel of national and international climate finance experts.
5. The panel will then provide comments and suggestions on the ideas put forward by each group.

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Notes

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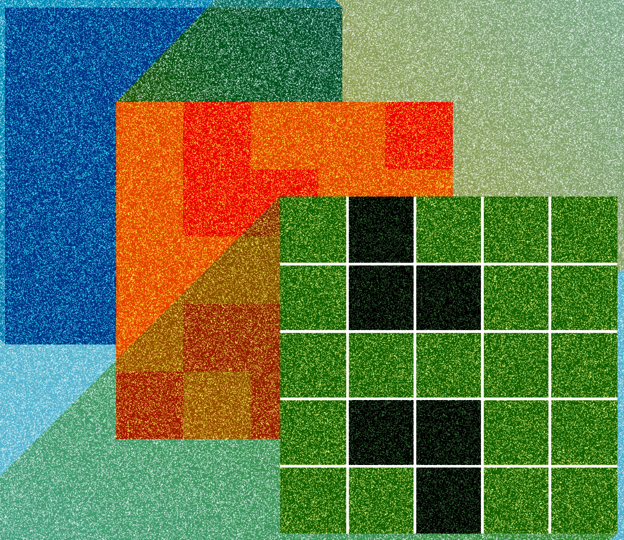

MODULE 12

Fundamentals of Geographic Information Systems (GIS)

Overview of the training module

12.1 Brief introduction to the module

Subject

Fundamentals of geographic information systems (GISs)

Learning outcomes

This module will provide learners with a basic understanding of GIS platforms, GIS databases, map projection, and spatial analysis. Learners will find out about how GIS is applied in natural resource management, geographic planning, climate mapping, and the prediction of future changes in the climate. They will also learn how to use GIS in climate risk and vulnerability assessments.

This module on the fundamentals of GIS will look at how GIS is applied to understand climate data and at the concept of spatial analysis and the basic elements of a map. Based on this learning, participants will be able to interpret a climate map or a hazard map. Climate change is a geographical issue that requires geographic solutions. A geographic information system (GIS) is a technology that can help with climate change decisions. However, the most significant difficulty that arises with regard to GIS tools is the lack of adequate data needed to get the best out of the technology. While GIS practitioners can provide meaningful analysis using the best available data, there is a demand for more refined data, particularly data that can help with project-level decisions. Securing these data will maximize our use of GIS as a tool to inform decision-making on important climate change mitigation and adaptation issues.

12.2 Geographic Information Systems

GIS is a computer-based technology that captures, integrates, stores, edits, manipulates, and analyzes geographically referenced data and produces outputs on maps and in tabular form. In fact, it is tabular information that provides the basis for GIS's geographic features. A GIS can manage different data types occupying the same geographic space. Remote sensing (RS) and the Global Positioning System (GPS) are sources of data for a GIS database.

12.2.1 GIS components

A working GIS comprises five key components: hardware, software, data, people, and methods. There are many commercial GIS software packages such as AutoCAD Map 3D, Esri ArcGIS, GeoMedia, Global Mapper, IDRISI, MapInfo Professional, etc., and there are also open-source packages for performing GIS activities such as DIVA-GIS, GRASS GIS, Manifold System, PostGIS, Quantum GIS (QGIS), and System for Automated Geoscientific Analyses (SAGA) GIS. The Environmental Systems Research Institute (Esri), which is headquartered in Redlands, California, is an international supplier of GIS software, web GIS, and geodatabase management applications. Its ArcGIS mapping software is currently the most powerful mapping and spatial data analytics software available.

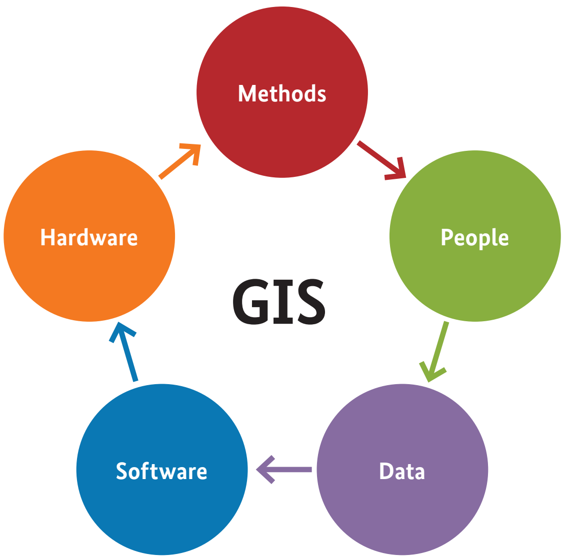

Figure 12.1: GIS components (Source: ARC Advisory Group, 2018)

12.2.2 Fundamental data types used in GIS

(a) Spatial data

Objects or elements that are present in a geographical space or horizon:

- map
- image

(b) Non-spatial data

These data do not involve space. Rather, they describe the quantitative or qualitative characteristics of spatial features – e.g., area, length, and population. Non-spatial data can be mapped and usually stored as coordinates and topology.

(c) Vector data

Vector data structures represent specific features on the Earth's surface and assign attributes to those features. There are three kinds of geographic feature type in vector data: point, line, and polygon (see Figure 12.2).

(d) Raster data

Raster data is stored as a grid of values that are rendered on a map as pixels. Each pixel value represents an area on the Earth's surface.

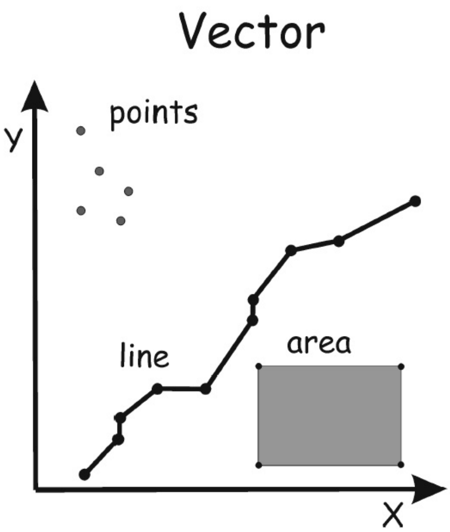

Figure 12.2: Vector data types (Source: University Libraries, 2022)

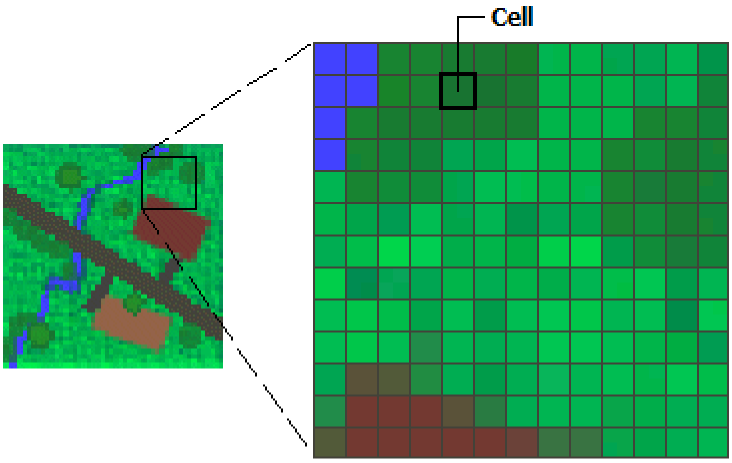

Figure 12.3: Raster Data (Source: ArcGIS Desktop, 2022)

12.2.3 Applications of GIS

GISs have various industrial applications, and technological advancements have significantly enhanced GIS data, especially in terms of how it can be used and what can be achieved as a result. GISs are powerful decision-making tools for any business or industry given their capacity to facilitate environmental, demographic, and topographic data analysis. Data intelligence compiled using GIS applications helps companies, certain industries, and consumers make informed decisions.

GIS can help individuals and organizations to better understand spatial patterns and relationships. The fields in which GIS are applied include, among many others:

- Agriculture
- Urban planning
- Environmental science
- Planning and civil engineering
- Business
- Health care
- Real estate
- Hydrology
- Geography
- Cartography
- Statistics
- Photogrammetry
- Surveying
- Mathematics
- Computer science
- Civil engineering
- Remote sensing
- Differential GPS

12.2.4 Web GIS and the example of the ArcGIS platform

Web GIS is an advanced form of geographic information system available on web platforms. It can be implemented as software-as-a-service (SaaS), as software on-premises, or as a hybrid of these.

The ArcGIS platform is a web GIS that combines GIS servers, portals, and apps to enable everyone in an organization to discover, use, make, and share maps from any device, anywhere, anytime. The ArcGIS platform is a location-focused platform-as-a-service (PaaS) that enables the integration of location capabilities into apps, business systems, and products. The ArcGIS platform provides users with access to Esri's powerful location services via their APIs of choice, including open-source APIs. It also makes it possible to create apps using ArcGIS APIs, software development kits, and app builders.

The ArcGIS platform delivers, as discrete services, the technology that powers Esri's own industry-leading mapping and spatial analytics products, which are used by thousands of organizations worldwide. With this level of access, users can build innovative solutions using the most comprehensive, high-quality set of location services, data, and mapping tools available.

12.3 Components of ArcGIS Desktop

ArcGIS Desktop consists of several integrated applications, including ArcMap, ArcCatalog, ArcToolbox, ArcScene, ArcGlobe, and ArcGIS Pro. We will now briefly look at each of these applications:

12.3.1 ArcGIS

ArcGIS is a GIS software for the handling and analysis of geographic information, which it visualizes by building layer maps. It builds these layers because, like many GIS software packages, ArcGIS creates maps that require categories organized as layers.

12.3.2 ArcMap

ArcMap is used to create, view, query, edit, compose, and publish maps, and to analyze geographic data. With ArcMap, spatial data can be queried in order to find and understand relationships among geographic features. The package is also used to represent data in a wide variety of ways, creating charts and reports for communicating understandings with others.

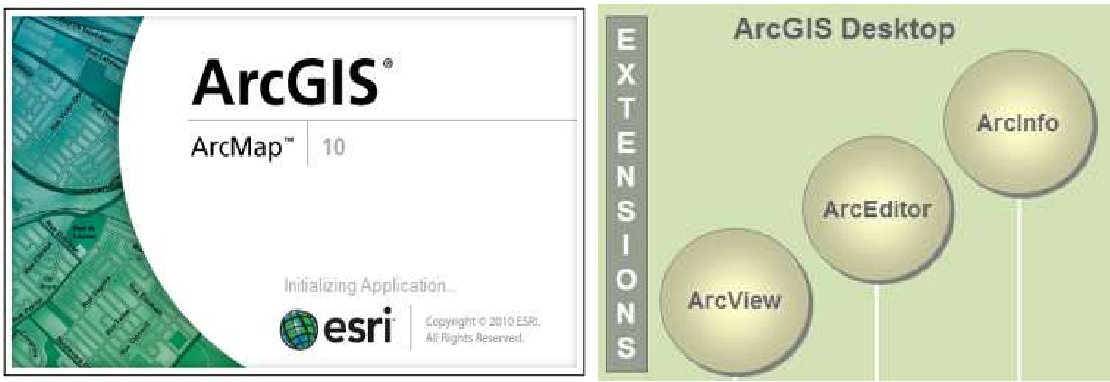

Figure 12.4: ArcGIS and ARC Desktop

12.3.3 ArcCatalog

The ArcCatalog application provides a catalog window that is used to organize and manage various types of geographic information for ArcGIS Desktop. ArcCatalog is the data management application that users employ to browse datasets and files held on their computer, database, or other sources.

With ArcCatalog, users can find, preview, document, and organize geographic data and can create sophisticated geodatabases for storing that data. ArcCatalog provides a framework for organizing large and diverse stores of GIS data, and its interface for storing and manipulating spatial data is user-friendly, reflecting the Microsoft Windows interface. ArcCatalog also recognizes the various GIS formats (covered in Section 4).

12.3.4 ArcToolbox

A toolbox is a container that holds all the tools required to perform any advanced task in a particular domain. Similarly, ArcToolbox is a simple application that serves as a container in which all the tools required to facilitate advanced geoprocessing tasks are found. Through its user-friendly interface it is possible to access and organize a collection of geoprocessing tools, models, and scripts.

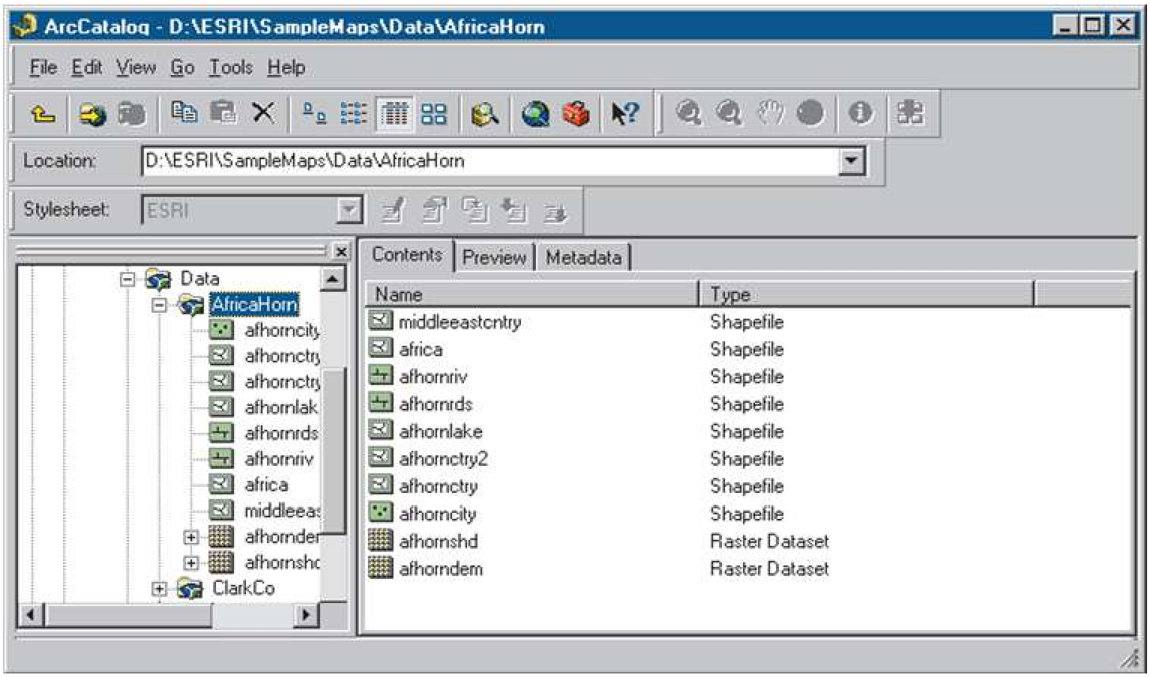

Figure 12.5: Sample of the ArcCatalog interface (Source: Screenshot Taken from Software)

Figure 12.6: ArcToolbox interface (Source: Screenshot Taken from Software)

12.3.5 ArcGlobe

ArcGlobe is a 3D visualization application that allows users to view large amounts of GIS data on a globe surface and thus provides an alternative display option to ArcMap. With ArcGlobe, the spatially referenced data placed on the 3D globe surface is displayed in its true geodetic location, image files can be rapidly displayed, and it is possible to zoom in quickly and easily from a global view to a local view. Note that ArcGlobe uses a spherical (i.e., not spheroidal) Earth.

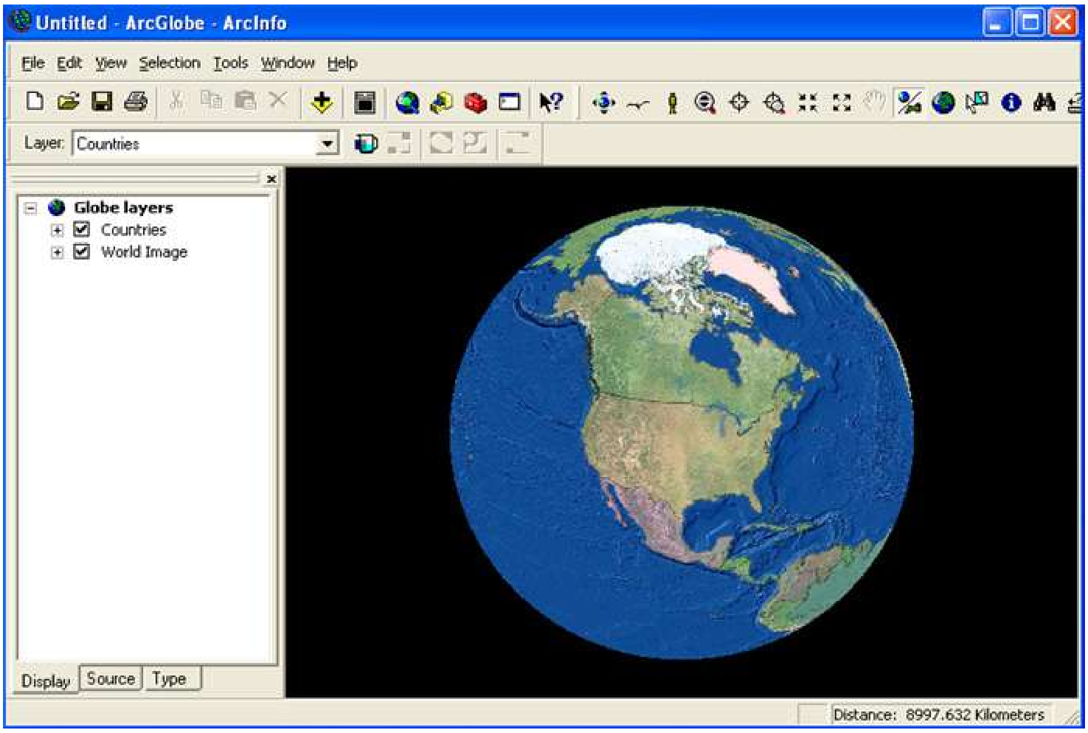

Figure 12.7: ArcGlobe interface (Source: Screenshot Taken from Software)

12.3.6 ArcScene

ArcScene is a 3D visualization application that allows users to view GIS data in three dimensions and to overlay many layers of data in a 3D environment.

12.3.7 ArcGIS Pro

ArcGIS Pro is the latest professional desktop GIS application from Esri. With ArcGIS Pro, users can explore, visualize, and analyze data, can create 2D maps and 3D scenes, and can share their work to ArcGIS Online or the ArcGIS Enterprise portal.

12.3.8 ArcGIS extensions

A suite of extensions is available to enhance the use of ArcGIS. Purchased and licensed separately, these extensions integrate seamlessly with the core product. Some extensions enhance general analysis and productivity, while others provide tailored solutions for specific industries.

Extension	Features
ArcGIS 3D Analyst	• ArcGlobe: Interactive 3D scenes • Globe views in ArcCatalog • Globe publishing in ArcGIS Publisher • 3d raster and TIN modeling tools
ArcGIS Business Analyst	• Customer and store prospecting • Market penetration analysis • Drive-time analysis
ArcGIS Data Interoperability	• Directly read, transform, and export any data format • Tools for data transformation and direct use
ArcGIS Geostatistical Analyst	• Advanced kriging and surface modeling • Exploratory spatial data analysis tools • Probability, threshold, and error mapping
ArcGIS Network Analyst	• Network and transportation analysis • Minimum path, closest facility, allocate, and traveling salesman • Advanced network data modeling and simulation
ArcGIS Publisher	• Publish Map and Globe documents for use with free ArcReader application • Package and compress data • Optional data encryption • Developer SDK for customizing ArcReader
ArcGIS Schematics	• Database-driven schematic rendering and display • Schematic views of GIS networks and tabular information • Multiple schematic representations
ArcGIS Spatial Analyst	• Advanced raster and vector tools • Spatial modeling • ArcGrid Map Algebra
ArcGIS Survey Analyst	• Comprehensive survey information management using the geodatabase • Advanced survey computation • Improved GIS data accuracy via links to survey locations
ArcGIS Tracking Analyst	• Time-based map display and rendering • Playback tools (play, pause, forward, rewind) • Work with time-based data (features whose geometry or attributes move and change)
ArcScan for ArcGIS	• Integrated raster-vector editing • Vectorizing features from raster • Raster snapping
ArcWeb Services	• Subscriptions to multiple GIS Web services • Access to rich data and GIS tools • Plug in, turn on, and use
Maplex for ArcGIS	• Advanced label placement and conflict detection for high-end cartographic production • Simplifies the labor-intensive placement of map text

Figure 12.8: Examples of ArcGIS extensions

GIS database and file format

12.4 Geodatabase

An ArcGIS geodatabase is a collection of geographic datasets of various types held in a common file system folder, a Microsoft Access database, or a multiuser relational database management system (e.g., Oracle, Microsoft SQL Server, PostgreSQL, Informix, IBM DB2). The geodatabase is the native data structure for ArcGIS and is the primary data format used for editing and data management.

Geodatabases have a comprehensive information model for representing and managing geographic information. This model is implemented as a series of tables holding feature classes, raster datasets, and attributes.

12.4.1 Vector and raster files and their formats

Vector data comprise spatial features that are assigned a geographic location. The model of vector data is a set of features, each represented as a point, line, or polygon, with an associated coordinate pair to mark each location of the object.

A raster image file is a rectangular array of regularly sampled values, known as pixels (picture elements). Each pixel has one or more numbers associated with it, specifying a color that the pixel should be displayed in. Rasters are used in digital aerial photographs, imagery from satellites, digital pictures, and even scanned maps. Data stored in a raster format represent real-world phenomena, such as thematic data (also known as discrete data) that represent features like land use or soils.

Raster images are files with the following file extensions: TIFF, JPEG, CMP, BMP, and some PDFs. When digitizing lines, points, and areas from raster files, the user clicks on the tiny pixel cells on the screen to measure the desired item. The measurement value generated from raster files is rarely 100% accurate.

When working with imaged raster data for GIS purposes, there are four types of resolution to be aware of: spatial resolution, spectral resolution, temporal resolution, and radiometric resolution.

Vector data file formats in GIS	Description (Most of the definition was picked from Esri. Esri is an international supplier of geographic information system software, web GIS and geodatabase management applications)
Shapefiles	Hybrid vector data format using SHP, SHX, and DBF files (by Esri)
ArcInfo Coverage	The ArcInfo Coverage GIS format is a geo-relational data model that stores vector data (by Esri)
GeoJSON	Lightweight format based on JSON, used by many open-source GIS packages
AutoCAD DXF	AutoCAD drawing interchange file (DXF) is an exchange format for the content of AutoCAD drawing files (DWG)
Keyhole Markup Language	Keyhole Markup Language is an XML notation for expressing geographic annotation and visualization within two-dimensional maps and three-dimensional Earth browsers
TIGER	Topologically integrated geographic encoding and referencing
Personal Geodatabase	Integrated vector data storage strategy using Microsoft Access's MDB file format (by Esri)
File Geodatabase	Geodatabase format, stored as folders in a file system (by Esri)
OSM (OpenStreetMap)	OpenStreetMap is the world's largest crowdsourcing GIS data project, and OSM is its XML-based file format

Table 12.1: GIS vector data file formats

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Figure 12.9: GIS raster data file formats (Source: GIS Map, 2022)

12.5 Using GIS data in environmental management

GIS's main application in natural resource management is on environmental issues such as flooding, drought, landslide, soil erosion, earthquake, etc. It is also used to support work addressing the current problems of climate change, habitat loss, population growth, pollution, etc. Computer-based GIS mapping and analysis is useful when conducting geographic planning, identifying environmental changes, and implementing action plans. GIS data are also used for climate mapping and for predicting future changes in the climate.

12.6 Using GIS in climate change and development planning

Climate scientists gather vast amounts of data to track environmental problems and investigate the causes. Spatial reasoning is crucial for analyzing and synthesizing findings from sources such as remote sensors and satellite imagery. Researchers draw on geographic information to reveal how the planet has changed through the years, predict the transformations that are yet to come, and communicate what they learn to policymakers and the public.

Continuing advances in GIS technology have established mapping as a crucial means of identifying connections between the state of the climate and other areas of concern. Open-source databases allow for unprecedented collections of spatial information, and high-speed data processing reveals changing conditions in real time.

12.7 Use of GIS in agriculture

The use of GIS in agriculture, a sector that is the mainstay of the Bangladesh economy, is no longer a new phenomenon. Sustainable agricultural production depends on the judicious use of natural resources (land, soil, water, plant genetic, climate, rainfall, and topography) through acceptable technology management under the prevailing socio-economic infrastructure.

Droughts, floods, swarms of insects, and poor farming techniques have plagued the agricultural community for centuries. While improvements have been made to ensure the safety and yields of crops worldwide, these factors and many more continue to make or break the individuals and communities affected by them. GISs are incredibly helpful in tackling these kinds of issues as they enable users to map and project current and future fluctuations in precipitation, temperature, crop output, and more. By mapping the geographic features of current (and potential) farmland, scientists and farmers can work together to create more effective and efficient farming techniques with the potential to increase yields. For instance, GIS can be used in analyses comparing soil data and historical farming practices to determine the best crops to plant in given locations.

12.8 Using GIS data in agricultural extension

Bangladesh's Department of Agricultural Extension (DAE) is working to modernize agricultural extension services through the use of GIS technology, which it is applying in the following ways:

- Crop database – crop maps showing area, production, yield, etc.
- Cropping patterns database for upazilas (local districts)
- Crop warehouse/cold storage database
- Geolocation of new technology and demonstrations of project activities
- Satellite-based projected climate scenarios/weather forecasts (monthly, seasonal, annual)
- Location-based agro-advisory services

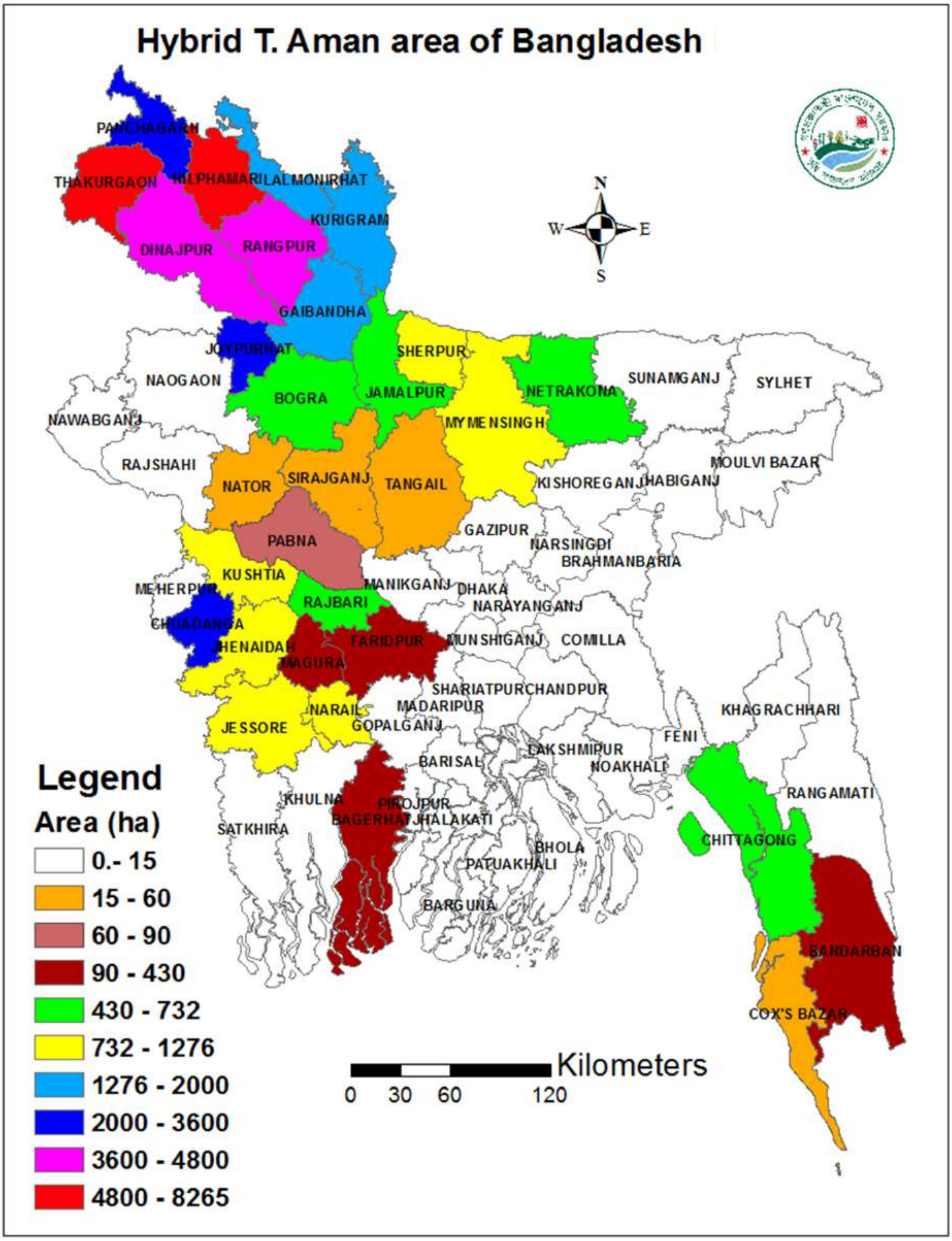

Figure 12.10: Map of Hybrid. T. Aman of Bangladesh (Source: Author's Own Work)

Map projection, georeferencing, and their uses

12.9 Map projection

A map projection is a method for taking the curved, three-dimensional surface of the Earth and displaying it on something flat like a computer screen or a piece of paper. Mapmakers have devised methods for taking points on the curved surface of the earth and "projecting" them onto a flat, two-dimensional surface as x and y coordinates. Since the Earth is roughly the shape of an oblate spheroid, map projections are necessary for creating maps of the Earth or parts of the Earth that are represented on a plane such as a piece of paper or a computer screen.

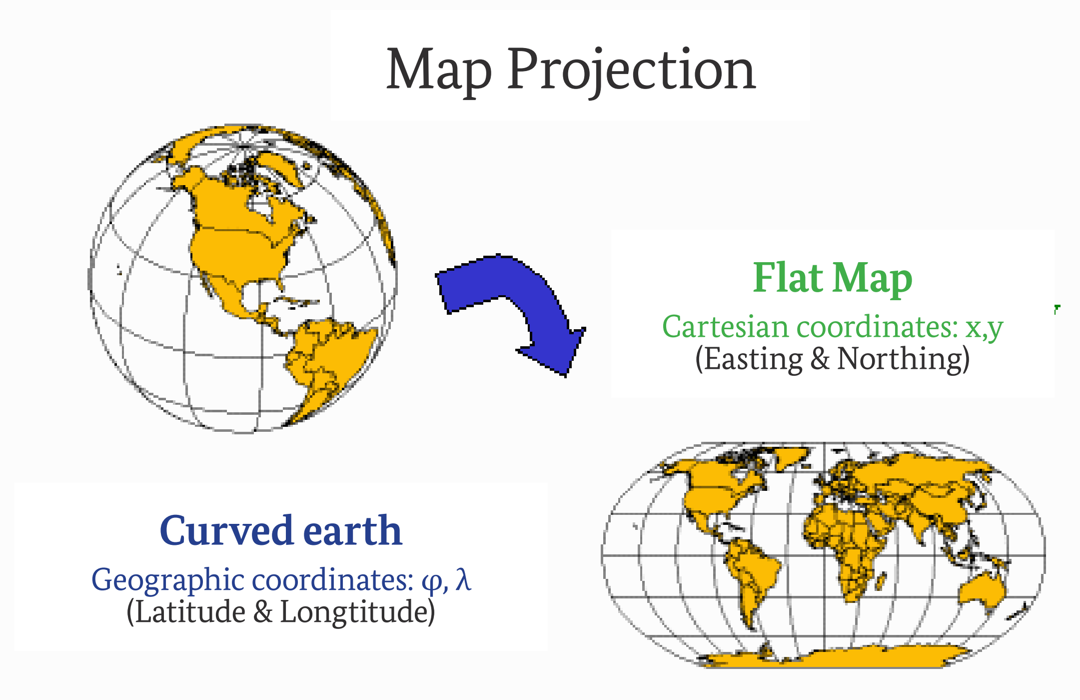

Figure 12.11: Map projections transform locations on the curved earth from geographic coordinates into Cartesian coordinates on a flat map (Source: Maidment, N. D.)

12.9.2 Types of map projections

- Equal-area (or equivalent) projections: maps that maintain area but distort other properties.
- Conformal (or orthomorphic) projections: maps that maintain shape but distort other properties (it is impossible to have a projection that is both conformal and equal area).
- Azimuthal projections: maps that maintain direction but distort other properties.
- Equidistant projections: maps that maintain distance but distort other properties.

Certain map projections, or ways of displaying the Earth in the most accurate ways by scale, are more well-known and used than other kinds. Three common types of map projection are cylindrical, conic, and azimuthal.

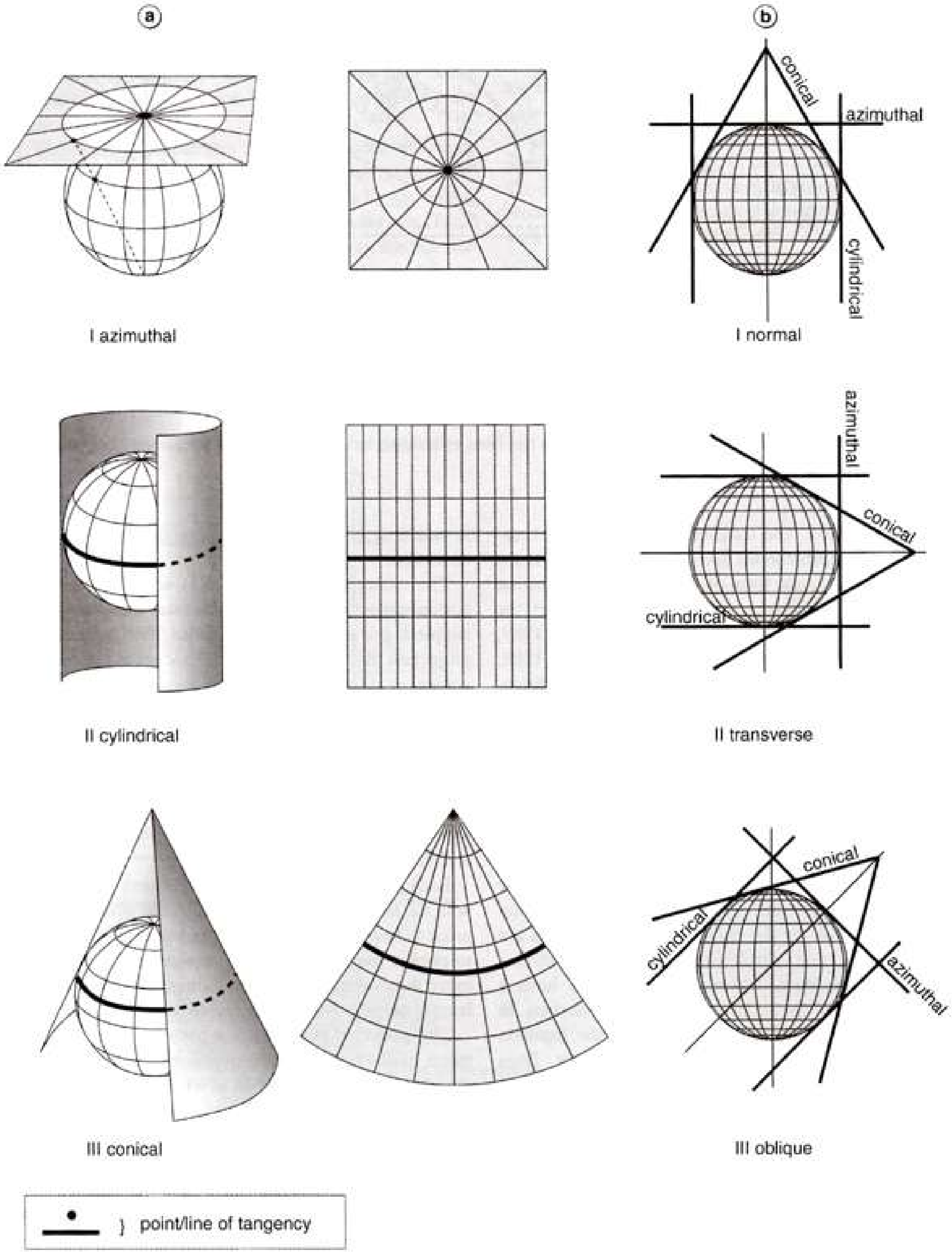

Figure 12.12: Some different types of projection (Source: UNSTATS, 2012)

12.10 Georeferencing

12.10.1 Concept of Georeferencing

Georeferencing is crucial to make aerial and satellite imagery, usually raster images, useful for mapping, as it explains how other data relate to the imagery. Very essential information may be contained in data or images that were produced at a different point of time. Basically, Georeferencing is the process of taking a digital image – it could be an aerial photograph, a scanned geological map, or a picture of a topographical map – and adding geographic information to the image so that the GIS or mapping software can "place" the image in its appropriate real-world location.

12.10.2 Uses of georeferencing

Georeferencing in the digital file makes basic map analysis possible, such as pointing and clicking on the map to determine the coordinates of a point, calculate distances and areas, and determine other information.

12.10.3 Georeferencing and its purpose in GIS

As previously mentioned, georeferencing is the name given to the process of transforming a scanned map, aerial photograph, etc., so that it appears "in place" in GIS. By associating features on the scanned image with real-world x and y coordinates, the software can progressively warp the image so that it fits with other spatial datasets.

12.11 Latitude and longitude

Lines of latitude are called parallels. Lines of longitude are called meridians. The Prime Meridian passes through Greenwich, London, UK.

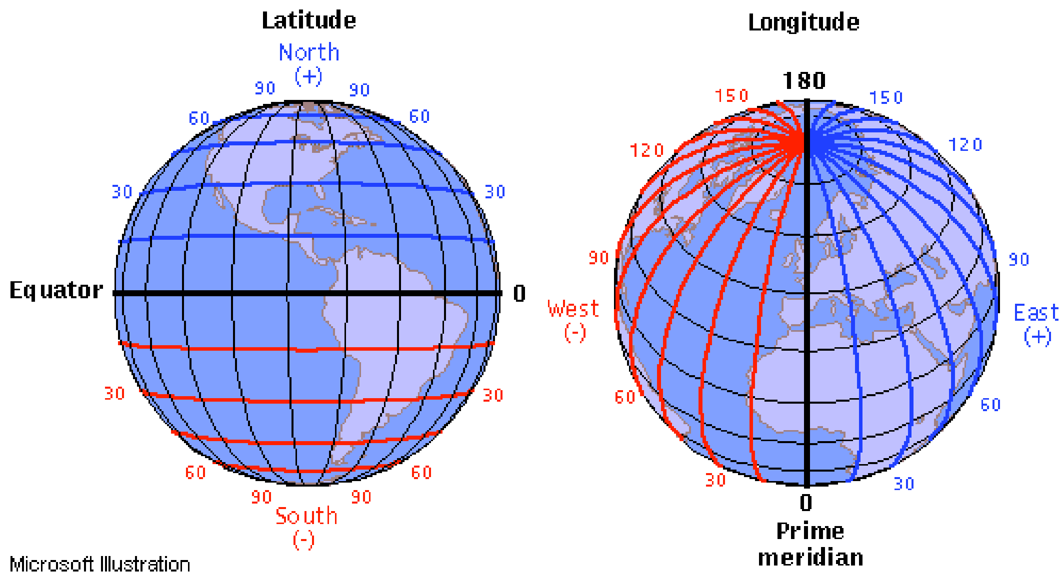

Figure 12.13: Latitude and Longitude (Source: Journey North, 2019)

12.12 Datum

A datum provides a frame of reference for measuring locations on the surface of the Earth. It defines the origin and orientation of latitude and longitude lines. The most recently developed and most widely used datum is that of the World Geodetic System 1984 (WGS84).

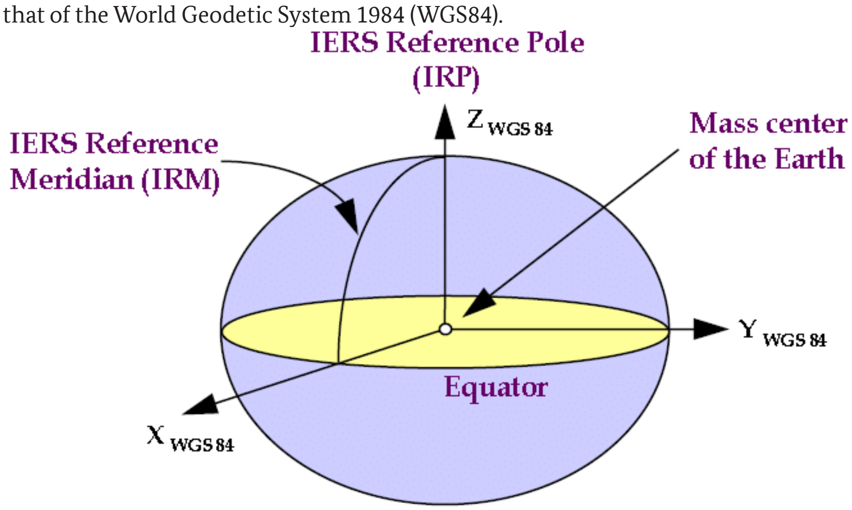

Figure 12.14: World Geodetic System (Source: Jaafar, 2015)

12.13 Coordinate systems

A coordinate system is a system that uses numbers or coordinates to determine the position of a point or geometric element within a geographic framework. This allows geographic datasets to use common locations for integration.

In geometry, a coordinate system is a system that uses one or more numbers, or coordinates, to uniquely determine the position of the points or other geometric elements on a manifold such as Euclidean space.

12.13.1 Geographic coordinate systems

A geographic coordinate system (GCS) defines locations on the Earth using a three-dimensional spherical surface. A GCS includes an angular unit of measure, a prime meridian, and a datum (based on a spheroid).

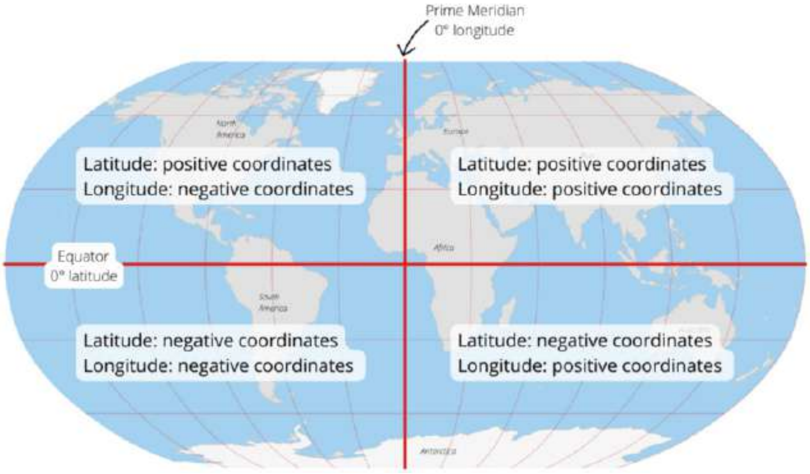

Figure 12.15: Geographic coordinate system (Source: GIS LOUNGE, 2022)

12.13.2 Projected coordinate system

A projected coordinate system is a flat, two-dimensional representation of the Earth. It is based on a sphere or spheroid geographic coordinate system, but it uses linear units of measure for coordinates, so that calculations of distance and area are easily done in terms of those same units.

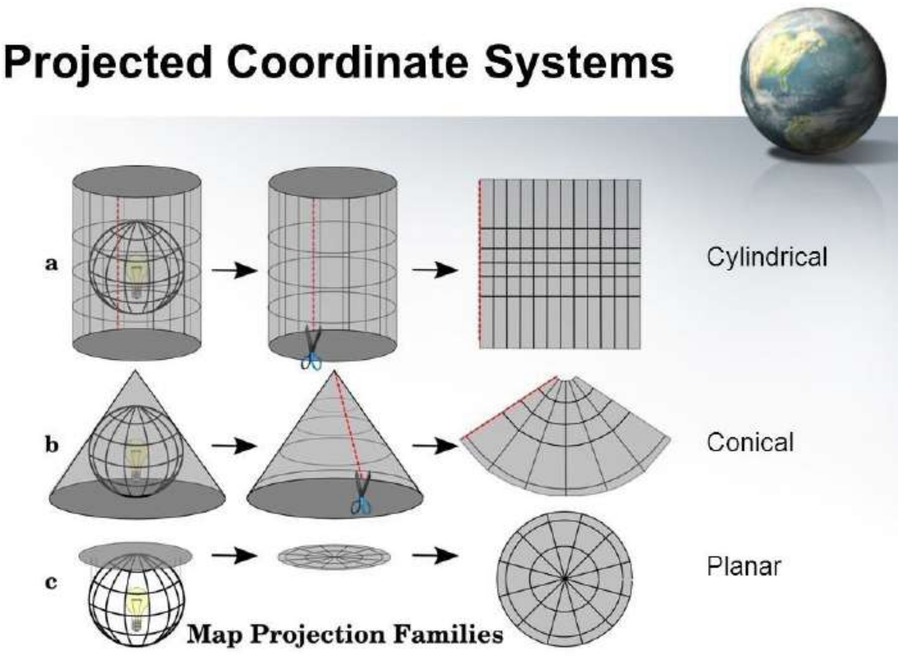

Figure 12.16: Projected coordinate system (Source: ASPEXIT, 2020)

12.13.3 Examples of some common projections

(a) Lambert Conformal Conic: This projection is one of the best for middle latitudes. It is similar to the Albers Conic Equal Area projection except that Lambert portrays shape more accurately than area. The Albers projection is an equal area conic projection. It uses two standard parallels to reduce some of the distortion found in a projection with only one standard parallel. The projection is best suited for land masses extending in an east-to-west orientation at mid-latitudes.

(b) Transverse Mercator: This is a cylindrical projection with the central meridian placed in a particular region.

(c) Universal Transverse Mercator: This is a specialized application of the Transverse Mercator projection in which the globe is divided into 120 zones, each spanning six degrees of longitude.

GPS and its use in GIS

12.14 Global Positioning System

The Global Positioning System (GPS) is a space-based satellite navigation system – the Global Navigation Satellite System (GNSS) developed by the US Department of Defense – that provides location and time information. Initially developed in 1973 for military use, GPS was opened up for civilian use in 1980.

GPS comprises a grouping of 24 well-spaced satellites that orbit the Earth and make it possible for people with ground receivers to their determine their geographic location with great accuracy. GPS works in all weathers, anywhere, and at all times on the Earth or near the Earth. It is widely used across the globe because it is low-cost, and GPS receivers are widely available and affordable.

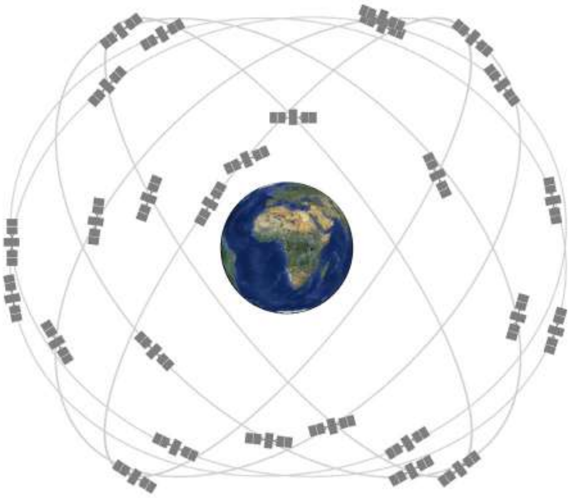

Figure 12.17: Visualization of the GPS constellation in motion with the Earth rotating (Source: Rezaeian & Pocock (2012).

Figure 12.18: GPS sets (Techno Planet Systems, 2022)

Figure 12.19: GPS satellite orbiting the Earth (Source: Seos, 2022)

12.14.1 Systems and devices that use GPS

- Street navigation systems: never get lost with this type of GPS, which gives turn-by-turn directions, including distances, speed, and estimated time of arrival.
- Sports GPS systems and watches.
- Systems incorporated in personal digital assistants (PDAs).
- Smartphones and other mobile devices enabled with GPS.
- For kids' tools.

12.14.2 Uses of GPS

There are five main uses of GPS:

- Location – determining a position.
- Navigation – getting from one location to another.
- Tracking – monitoring the movement of objects or persons.
- Mapping – creating maps of places and the world.
- Timing – enabling precise time measurement.

Popular applications of GPS include in automobile and marine navigation, tracking, farming, and research. GPS is particularly useful during disasters given that flooding, tsunamis, storm surges, and volcanoes can be monitored using the technology. During emergencies, GPS data is integrated with GIS to overlay real-time activity.

GPS data can be collected in the following formats:

- Degrees, Minutes, Seconds – e.g., 23°42'35"N, 90°24'25"E
- Decimal Degrees – e.g., 23.709921° N, 90.407143° E
- Degrees, Decimal Minutes – e.g., 23° 42.595'N, 90° 24.429'E
- Universal Transverse Mercator (UTM) – e.g., 235628.49 m E, 2624517.84 m N

12.14.3 GPS data interoperability with ArcGIS Software

ArcGIS's Data Interoperability extension allows spatial data formats to be integrated into GIS analyses. In addition, the extension provides the ability to model new customized spatial data formats based on built-in formats and transformers.

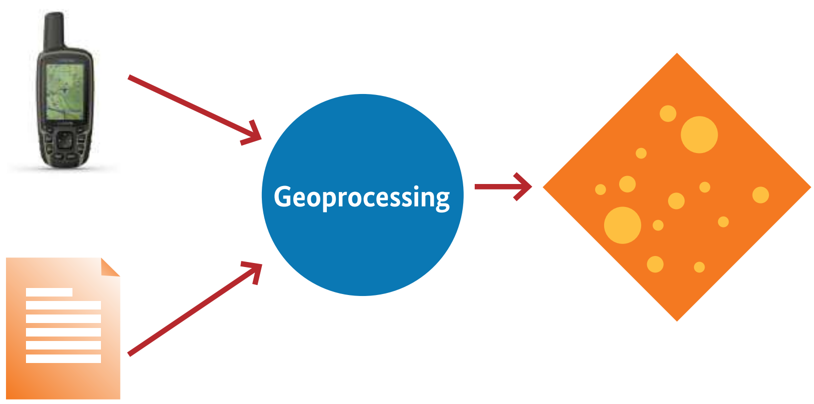

Figure 12.20: GPS data interoperability (Source: Author's Own Work)

Introduction to geoprocessing in ArcGIS and to spatial analysis

12.15 Geoprocessing in ArcGIS

Geoprocessing is a framework and set of tools for processing geographic and related data. The comprehensive suite of geoprocessing tools can be used to perform spatial analysis or manage GIS data in an automated way. Geoprocessing is for everyone that uses ArcGIS Pro. Whether you are a new or advanced user, geoprocessing will likely be an essential part of your day-to-day work.

A typical geoprocessing tool performs an operation on a dataset such as a feature class, raster, or table, and creates a resulting output dataset. For example, the Buffer tool takes features as input, creates buffer areas around the features to a specified distance, and writes those buffer areas to a new output dataset.

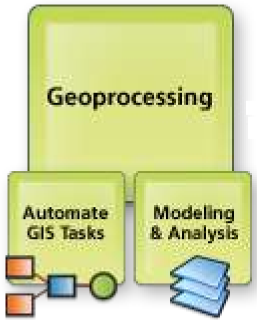

Figure 12.21: Geoprocessing (Source: Esri, 2022)

In addition to the suite of tools, geoprocessing is also a powerful framework that supports control of the processing environment and allows you to build custom tools that can further automate your work. You can use the geoprocessing tools included in ArcGIS Pro as building blocks to create an infinite number of custom tools that automate repetitive tasks or solve complex problems.

12.16 Spatial analysis

Spatial analysis is a set of methods whose results change when the locations of the objects being analyzed, or the frame used to analyze them, change. With spatial analysis, it is possible to solve complex location-oriented problems and to better understand where and what is occurring in the world. Moving beyond mere mapping, spatial analysis makes it possible to study the characteristics of places and the relationships between them, and it lends new perspectives for decision-making.

Spatial analysis in GIS involves three types of operation: attribute query, spatial query, and the generation of new data sets from the original databases.

12.16.1 Vector analyses and raster analyses

Vector data analysis uses the geometric objects of point, line, and polygon. The accuracy of analysis results depends on the accuracy of these objects in terms of their location and shape. Topology can also be a factor for some vector data analyses such as buffering and overlay.

Raster data analysis is based on cells and rasters. It can be performed at the level of individual cells, groups of cells, or cells within an entire raster. Some raster data operations use a single raster; others use two or more rasters.

Vector graphics are digital art that is rendered by a computer using a mathematical formula. Raster images are made up of tiny pixels, making them resolution dependent, and are best used for creating photos.

GIS data for climate risk and vulnerability assessments

12.17 Application of GIS in assessing risk and vulnerability

Climate change affects the sustainability of development interventions, depending on their geographical location, sector coverage, and physical design. Development decisions and activities today must therefore adequately consider climate change to avoid unnecessary damages, wasted investments, and risks to life in the future.

Bangladesh ranks high on list of countries most vulnerable to climate change. The 2021 World Climate Risk. Index (CRI) places Bangladesh seventh worst affected country by extreme weather yet the country contributes only a small percentage (only 0.56%) of global greenhouse gas emissions.

For this reason, screening of risks to climate change and natural hazards in the early stages of project development will be necessary. Climate risk screening (CRS) is the preliminary yet systematic evaluation of climate risks and natural hazards that may affect the objectives and activities of development projects of the government.

Bangladesh is committed to ensuring climate change preparedness by producing the National Adaptation Programme of Action (NAPA) in 2005 and the Bangladesh Climate Change Strategy and Action Plan (BCCSAP) in 2009. The BCCSAP presents six pillars for climate actions, across which a total of 44 programs were identified for relevant interventions. As per draft NAP, reducing risk and vulnerabilities to climate change impacts eleven climate risk and vulnerable areas have been identified for proper interventions. NAP has undertaken around 113 interventions covering various stress areas all over the country based on developed adaptation pathways and sectors (BCCSAP, 2009)

Disaster risk (R) is widely considered a function of H (hazard probability), E (exposed elements at risk), and V (associated vulnerabilities affecting the degree of loss and damage caused by a certain intensity of the hazard). After IPCC issued its Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX) in 2012, the definition of 'disaster risk management' has changed significantly. One of the major changes is the inclusion of socioeconomic factors as one of the major drivers for vulnerability. The following figure shows the components and cycle of disaster risk in relation to climate change and development.

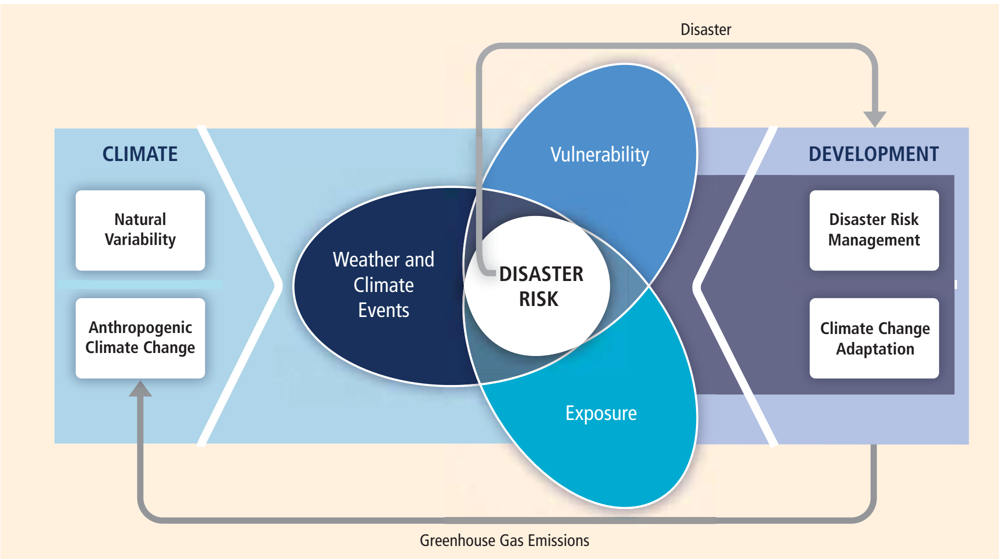

Figure 12.22: Climate and Disaster Risk Model describing the relationship between vulnerability, exposure, and risk (Source: Prevention Web, 2022)

As per Climate and Disaster Risk Model- SREX, IPCC 2012, Risk is a function of Hazard (H), Exposure (E), and Vulnerability (V) (IPCC, 2012)

Risk = f (H, E, V)

Where R = risk, H = hazard, E = exposure, and V = vulnerability.

The Vulnerability Score V is defined as-

V = (Socioeconomic Vulnerability / Adaptive Capacity)

According to the IPCC 5th Assessment Report, the major impacts are- 10% drop in rice production, and 30% fall in wheat production by 2050. So, we need High-level screening approach for risks from climate and geophysical hazards at an early stage of project development for development planning (IPCC,

To analyze disaster and climatic hazards, exposures, vulnerabilities and risks, GIS technology is very much useful. Using GIS, the maps of hazards, exposures, vulnerabilities and risks can be generated. For developing projected climate scenarios, GIS is very much useful.

12.20 Understanding climate change through GIS maps

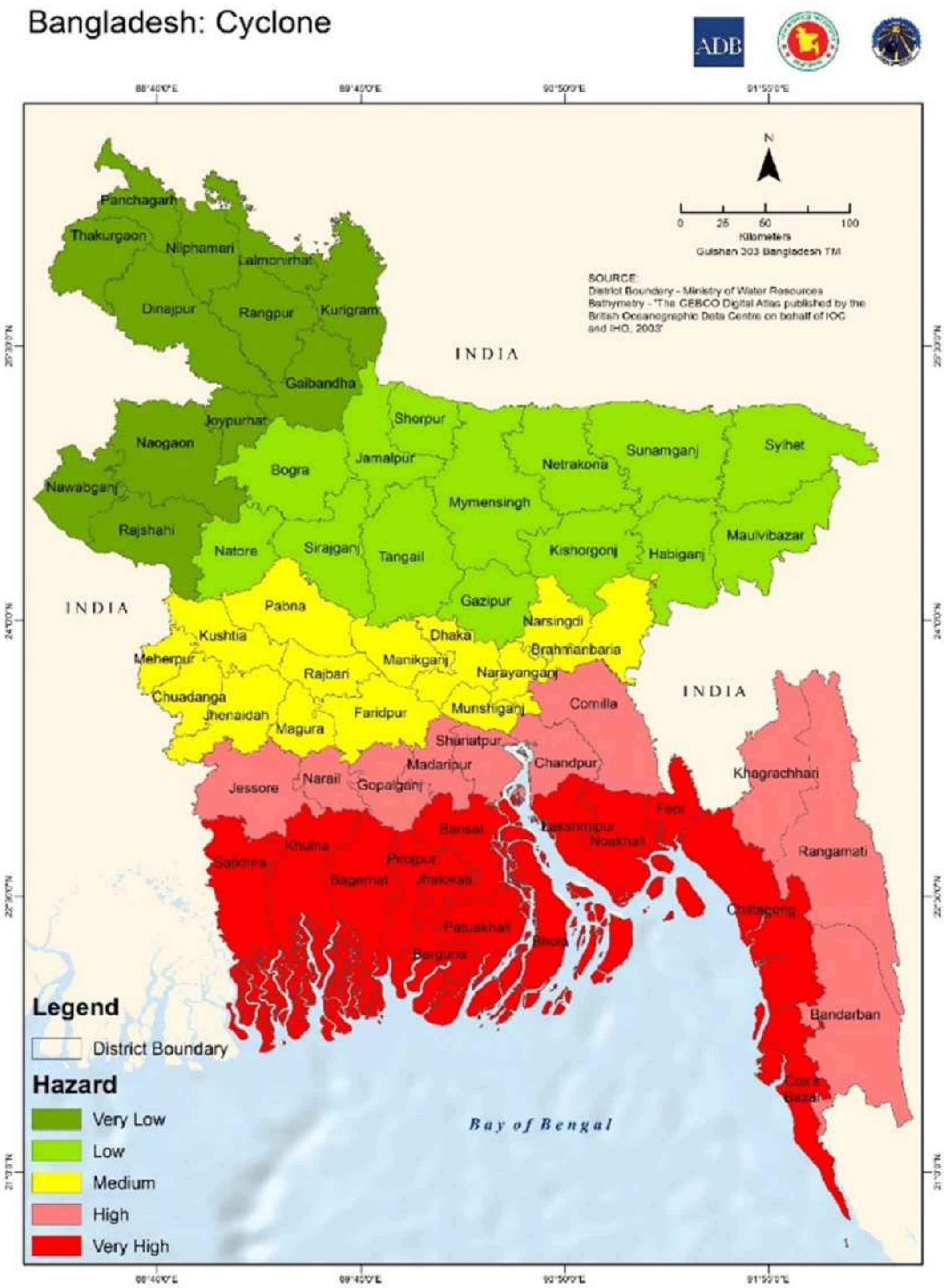

Figure 12.23: Cyclone hazard map of Bangladesh (Source: ADB, 2021)

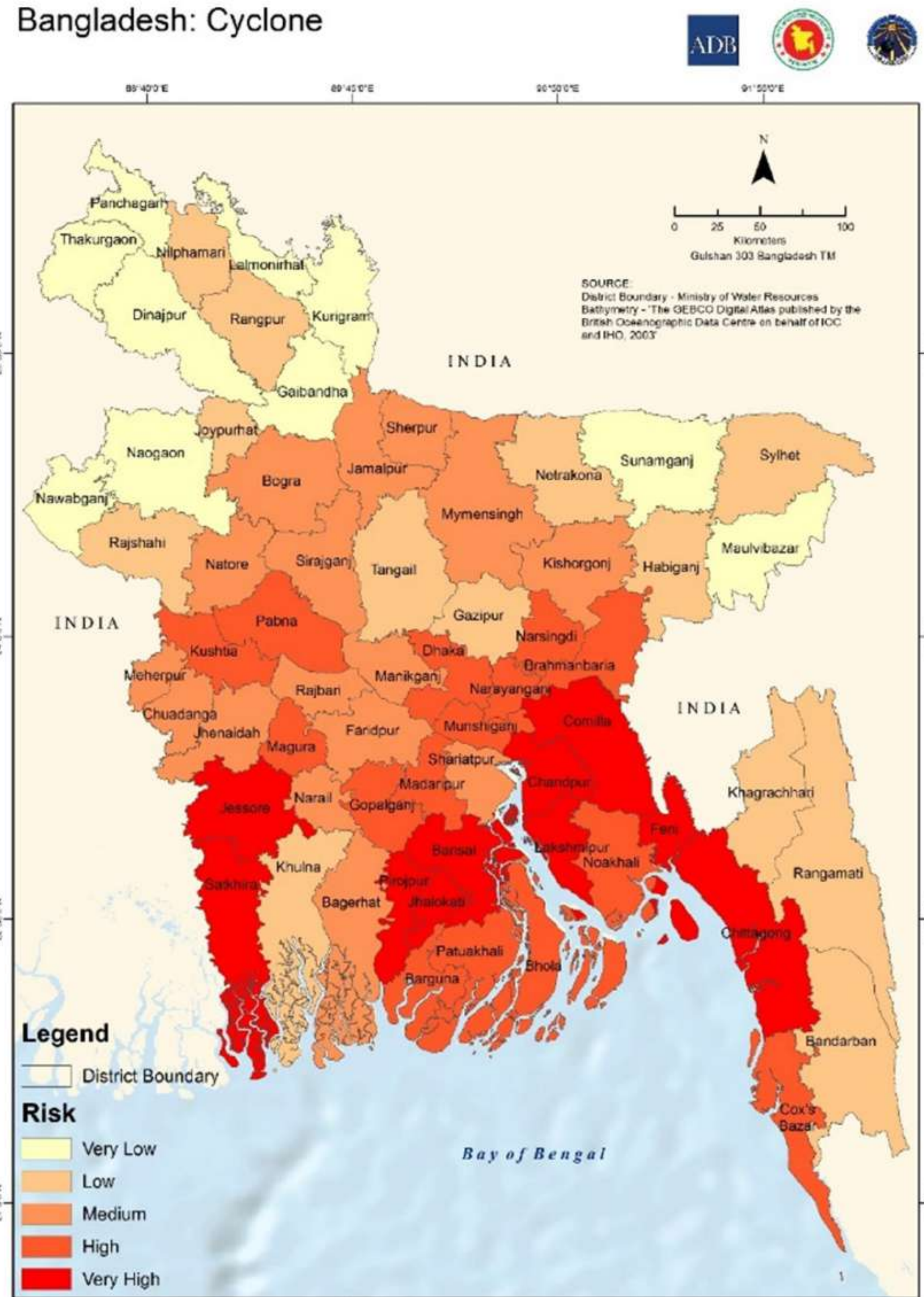

Figure 12.24: Cyclone risk map of Bangladesh (Source: ADB, 2021)

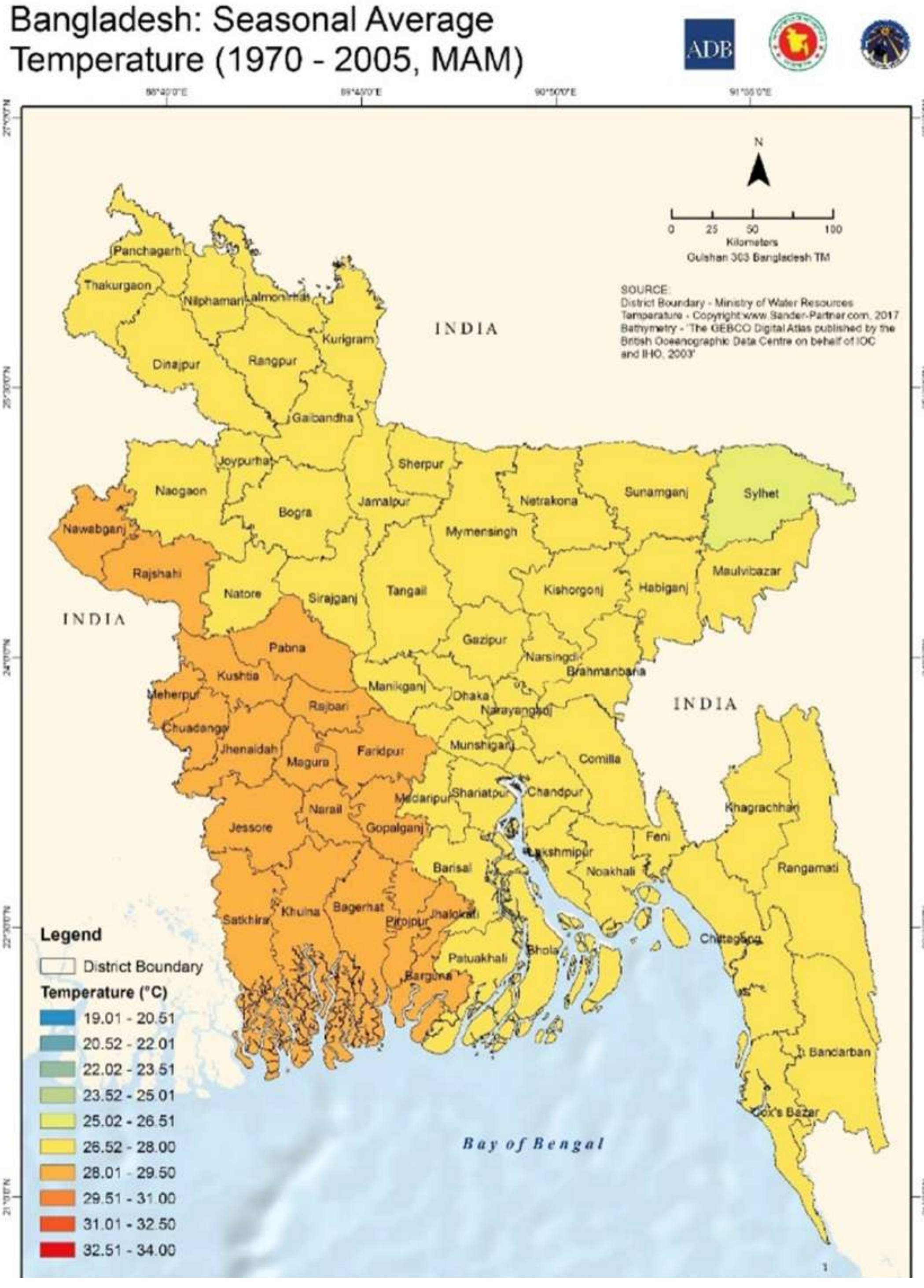

Figure 12.25: Bangladesh seasonal average temperature map (1970–2005) (Source: ADB, 2021)

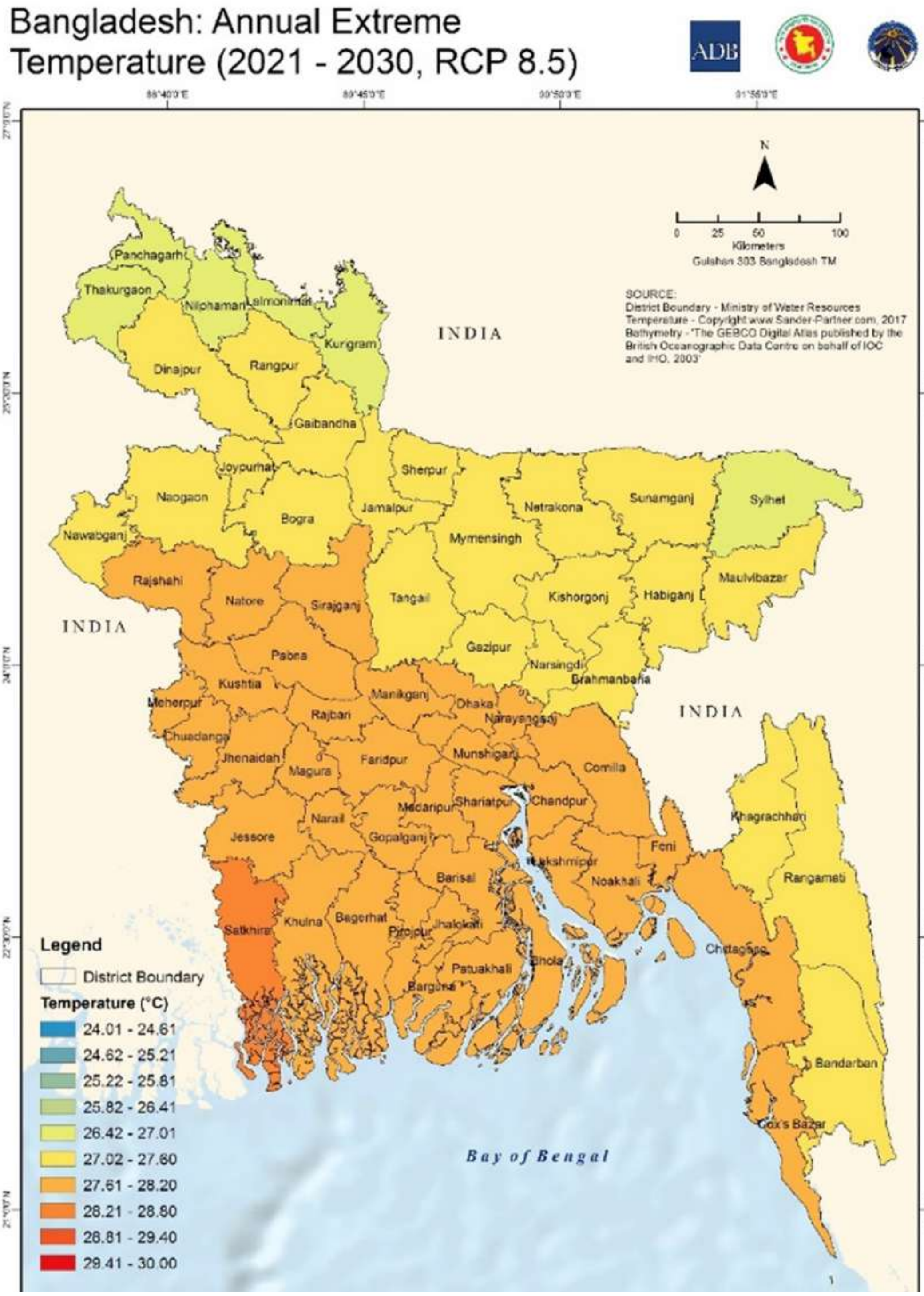

Figure 12.26: Bangladesh annual extreme temperature map (2021–2030) (Source: ADB, 2021)

Box 10.1 Theory into Practice

Implementation of Learning

By completing this module, government officials will have a basic understanding of GIS and they will be able to learn how GIS can be used in climate risk management and development planning. But for in-depth knowledge, they need to participate in an advance course based on her/his area of interest.

https://www.youtube.com/c/GISHelper

https://www.youtube.com/channel/UCqpzWp7L5mFIDZ2_iHejoSQ

Exercise

Section 10

12.22 Group work

a. Prepare a study area map for Sylhet district from the shape file provided.
b. Create an attribute table with the population data provided.
c. Prepare a population map of the eight divisions of Bangladesh.
d. From the map provided, identify which hospital is located near the school.
e. From the map provided, identify which zone is most vulnerable to climate change and which zone needs an embankment facility.

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Notes