SEc-2 Climate change: Vulnerability and Adaptation planning
in South Asia and India

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Vulnerability

Climate Change Vulnerability is defined by the **IPCC** as the "*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, the sensitivity and adaptive capacity of that system."*

Exposure 'refers to the nature and degree to which a system is exposed to significant climatic variations.' for example, exposure to prolonged drought, frequent flood, severe and repetitive cyclone, coastal inundation etc.

Sensitivity 'refers to the degree to which a system is affected, either adversely or beneficial by climate related stimuli. The effect may be direct (e.g. a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g. damages caused by an increase in the frequency of coastal flooding due to sea level rise.)' and

Adaptive capacity refers to 'the ability of a system to adjust to climate change- including climate variability and extremes- to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.'

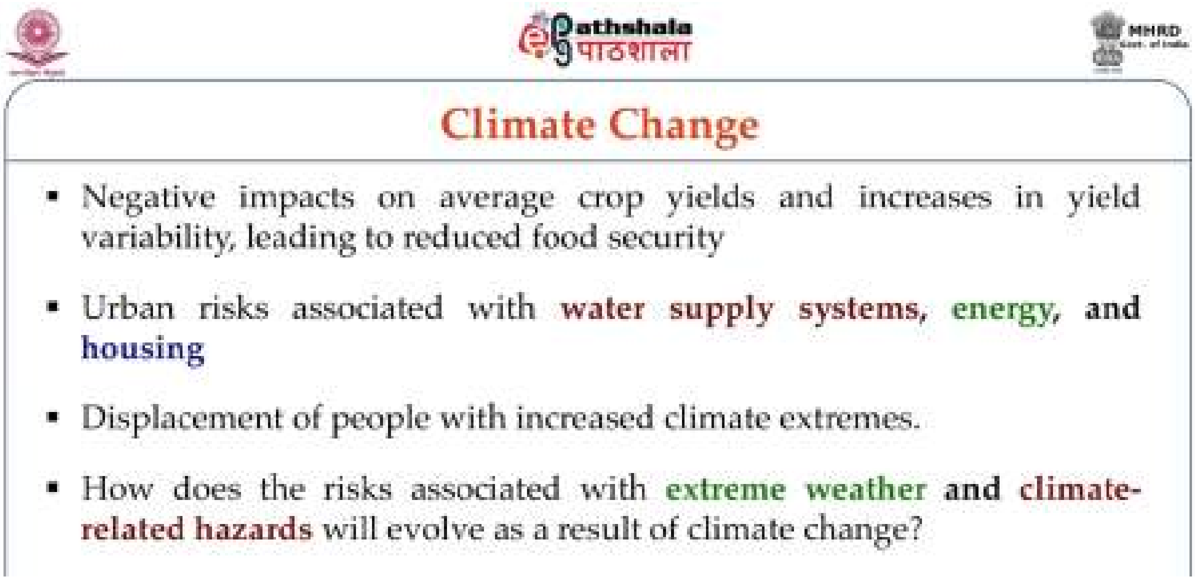
According to wikipedia, Climate change vulnerability (or **climate vulnerability** or **climate risk vulnerability**) is defined as the "*propensity or predisposition to be adversely affected" by climate change. It can apply to humans but also to natural systems (ecosystems). Climate change vulnerability encompasses "a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt*." Vulnerability is a component of climate risk.

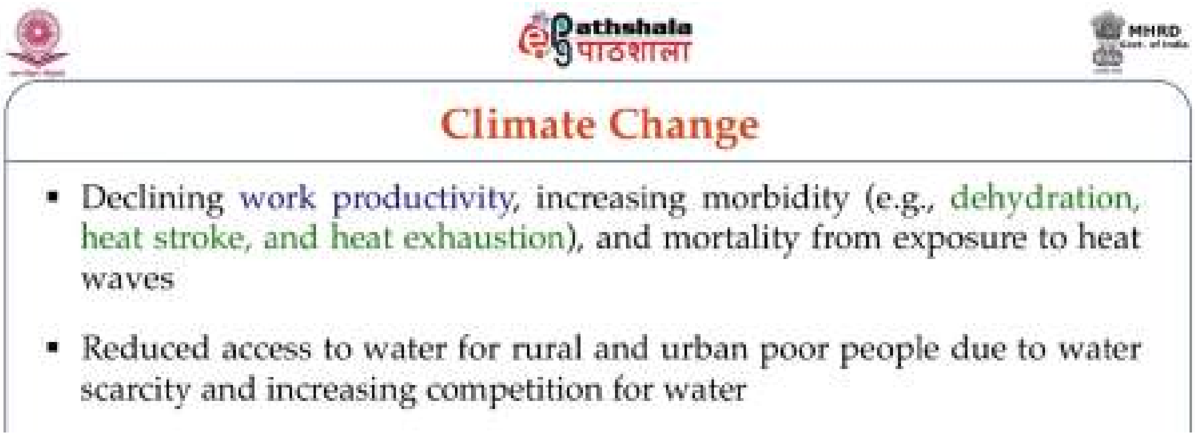
Vulnerability differs within communities and across societies, regions and countries, and can change over time. Approximately 3.3 to 3.6 billion people live in contexts that are highly vulnerable to climate change in 2021.

Vulnerability of ecosystems and people to climate change is driven by certain **unsustainable development patterns** such as "**unsustainable ocean and land use**, **marginalisation**, historical and ongoing patterns of **inequity** such as **colonialism**, and governance."

Therefore, **vulnerability is higher** in locations with "**poverty, governance challenges and limited access to basic services and resources**, violent conflict and high levels of **climate-sensitive livelihoods** (e.g., smallholder farmers, pastoralists, fishing communities)".

Some examples are:





Drought, Agricultural drought, Cyclone, tidal inundation, flood in coastal areas due to cyclone surge, flash flood in upper part of river basins, cloudburst and devastating floods.

Assessing vulnerability to climate change is important for defining the risks posed by climate change and provides information for identifying measures to adapt to climate change impacts. It enables practitioners and decision makers to identify the most vulnerable areas, sectors and social groups.

The impacts of and the vulnerabilities to climate change can vary across **regions**, economic **sectors** and social **groups** or **types of systems** considered.

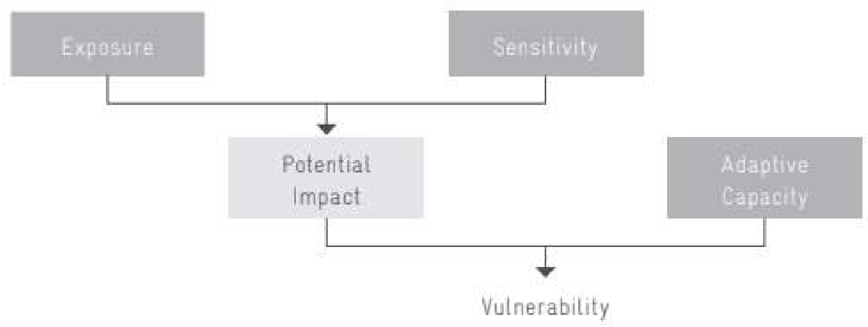
Vulnerability, thus can be broken down into following major categories,

1. **economic vulnerability**, based on socioeconomic factors, (people with low income and people of specific occupations- fishing, pastoralists, agriculture, are more vulnerable as they don't have money to invest in climate resilient infrastructure),
2. **Social vulnerability**, based on the different social groups i.e., coastal communities, urban dwellers, forest dwellers;
3. **geographic vulnerability** (regions prone to frequent climatic hazards- low lying coastal areas, islands, semi desert regions, indigenous people.)
4. **Vulnerability of the system,** based on the types of system considered i.e., natural, social, economic, socio-ecological system.

Any one assessment method does not suit all problems. Area, sector or system specific assessment techniques should be prepared.

Vulnerability is basically a theoretical concept and can not be measured directly. Measuring vulnerability is a systematic process of assigning numbers to a phenomena that we can observe.

Figure 1: Relationship between vulnerability and its defining concepts



(Source: adapted from Allen Consulting, 2005)

Assessing vulnerability is thus mapping it to observable concepts. For example, temperature is the observable concept of heat.

Climate Change Vulnerability in India:

India lies in the centre of South Asia where most of the regions are very prone to climate change vulnerability. Tropical climate, poor economic structure (poverty), high population concentration, poor health infrastructure, high dependency on agriculture and other primary economic activities, highly dense low line coastal areas make these regions most vulnerable to climate extremes.

KEY FINDINGS

- More than **80 percent** of India's population lives in districts **highly vulnerable** to extreme hydro-met disasters
- The **southern zone** of India is the **most vulnerable** to extreme climate events and their compounding impacts, followed by the eastern, western, northern, north-eastern and central zones.
- **59** and **41 per cent** of the total districts in the eastern and western zones of India are **highly vulnerable** to extreme cyclone events.
- The states located in India's northeast are more **vulnerable to floods**, whil the states in the southern and central parts are more vulnerable to **extreme droughts**.
- **Five out of six zones** in India, i.e., South, North, North-East, West and Central have a **low adaptive capacity** to extreme hydro-met disasters. However, the Eastern Zone has a medium-range adaptive capacity to extreme hydro met disasters.
- Assam, Andhra Pradesh, Maharashtra, Karnataka and Bihar are highly vulnerable to extreme climate events such as **floods, droughts and cyclones**, according to the **Climate Vulnerability Index (CVI).**
- Unsustainable landscape, lack of infrastructure planning and human-induced microclimate change are the key drivers of this high vulnerability.

See video here: India's Climate Change Vulnerability Assessment

India's District wise Vulnerability Maps

What are Climate Change Vulnerability Assessments?

Climate Change Vulnerability Assessments (CCVAs) are emerging **tools** that can be used as an initial step in the a*daptation planning process*.

A CCVA focuses on species, habitats, or systems of interest, and helps identify the greatest **risks** to them from climate change impacts. A CCVA identifies **factors** that contribute to vulnerability, which can include both the direct and indirect effects of climate change, as well as the ***non-climate stressors*** (e.g., land use change, habitat fragmentation, pollution, and invasive species?).

Vulnerability assessments are done for **local communities** to evaluate where and how communities or systems will be vulnerable to climate change. There are several organisations and tools used by the international community and scientists to assess climate vulnerability.

For example, the Ministry of Environment, Forests and Climate Change (MoEF&CC) in India published a framework for doing vulnerability assessments of communities in India.

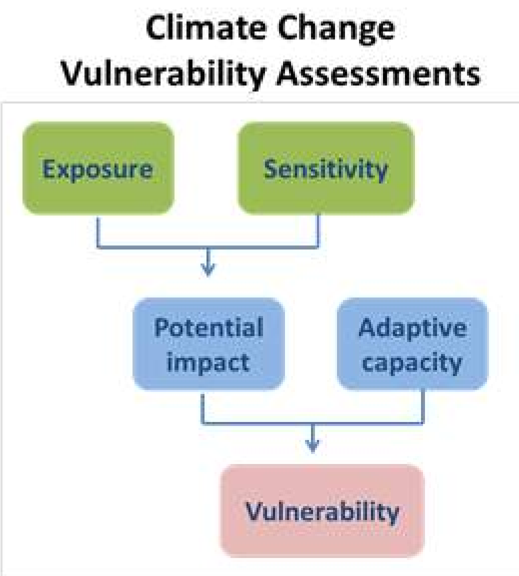
Vulnerability assessment is a key aspect of anchoring assessments of climate change impacts to present development planning. Methods of vulnerability assessment have been developed over the past several decades in natural hazards, food security, poverty analysis, sustainable livelihoods and related fields. These approaches provide a core set of best practices for use in studies of climate change vulnerability and adaptation.

Vulnerability varies widely across peoples, sectors and regions.

Vulnerability is directly related to **climate risks, which** is the risk assessments based on formal analysis of the consequences, likelihoods and responses to the impacts of climate change and how societal constraints shape adaptation options.

There is *no standard method or framework* to conduct a CCVA, and a v*ariety of methods are being implemented* at government, institutional, and organisational levels. Because of this, interpretation of CCVA results should carefully consider whether and how each of the three components of vulnerability (exposure, sensitivity, and adaptive capacity) were evaluated, if non-climate stressors were included in the assessment, how uncertainty is presented, the geographic location covered by the assessment, and whether the entire life cycle of a target species was evaluated, particularly for those that are migratory.

Generally, the approach chosen should be based on the goals of practitioners, confidence in existing data and information, and the resources available (e.g., financial, personnel).



Some of the **most common frameworks** applied regionally are:

- *NatureServe Climate Change Vulnerability Index* (CCVI) – A **quantitative assessment** based on the traits of fish, wildlife, and habitats that might make them more vulnerable to climate change. The CCVI is suitable for assessing large numbers of species and comparing results across taxa.

It is based in Microsoft Excel, relatively easy to use, and includes factors related to direct and indirect exposure, species-specific sensitivity, and documented or modelled responses to climate change.

- ***Climate Change Response Framework*** (CCRF) – A **collaborative, cross-boundary approach** among scientists, managers, and landowners designed to assess the *vulnerability of forested habitats*. The assessment incorporates downscaled climate projections into tree species distribution models to determine future habitat suitability.
- Experts conduct a literature review to summarise the effects of climate change, as well as non-climate stressors, and consider all three components of vulnerability to come to a consensus on a *vulnerability ranking* and *level of confidence*.
- ***Northeast Association of Fish and Wildlife Agencies (NEAFWA) Habitat Vulnerability Model*** – An approach created to **consistently evaluate the vulnerability of all non-tidal habitats** across thirteen Northeastern US states. This method is based on an *expert-panel approach*, and is made up of 4 sections, or modules, based in Microsoft Excel. The modules score vulnerability based on climate sensitivity factors (adaptive capacity is also partially addressed) and non-climate stressors to produce vulnerability rankings and confidence scores.

  Experts use these scores to *construct descriptive paragraphs* explaining the results for each species or habitat evaluated. These narratives help to ensure transparency, evaluate consistency, and clarify underlying assumptions. The National Park Service, the U.S. Forest Service, and several states have used this model successfully to assess habitat vulnerability.
- **Expert opinion workshops and surveys** – These are often **qualitative (or mixed** qualitative/quantitative), and have been used by a number of states including a report on habitat vulnerability in Massachusetts.

These assessments are usually developed independently, and are typically not based on a standardised framework. This allows greater flexibility for the institution conducting the CCVA; however, it is more difficult to make direct comparisons across assessment results since the specific factors evaluated may vary.

In the **third technical paper of IPCC** the method of climate change vulnerability assessment has been discussed. In this paper the climate change vulnerability assessment strategies are discussed in few steps (tasks):

1. **Vulnerability framework and definitions**: This denotes the process of defining the vulnerability in regional perspective and designing the vulnerability assessment framework by reviewing existing regional or national assessments that relate to vulnerability- e.g. national development plans, poverty reduction papers, environmental sustainability plans and natural hazard assessment. The already existing framework can be used as a base for climate change vulnerability assessment. If no framework is available, stakeholder-led exercises are valuable in this respect.
2. **Constructing a development baseline and targeting vulnerable groups**: The second task is to review present conditions in order to target vulnerable groups and establish a development baseline. Who are vulnerable? To what? Where? etc.

   As above, the starting point should be existing vulnerability assessments. Many developing countries have produced related inventories, such as poverty maps, human development indices, and environmental sustainability indices. The development baseline should incorporate two levels of analysis:

   - A comprehensive set of spatial indicators of vulnerability (VI)
   - Identification of target vulnerable groups that are a priority for adaptation policy.

   Vulnerability is a relative measure, it does not exist as something we can observe and measure. Therefore, indicators can only be selected based on choices by the technical team, stakeholders and the vulnerable themselves.

   The choice of the target of the vulnerability assessment should be related to the problems identified in scoping the project. A fundamental issue is whether the target is people, resources or economic activities, or regions.

   - Food security focus for social vulnerability
   - Biodiversity focus for ecosystem services.

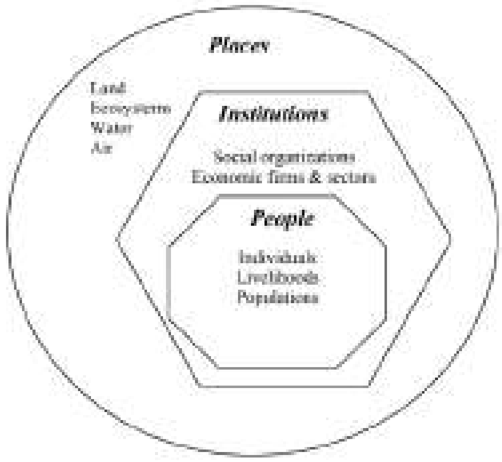


Figure 1. Units of analysis for a vulnerability assessment. The central concern with people is placed within the context of socio-economic institutions and activities and bio-geo-physical resources. A cognitive mapping exercise (basically putting boxes and arrows on a flip chart) can follow this schema to illuminate exposure to climatic variations and to the drivers of socio-economic vulnerability.

The output of this task is a set of **vulnerability indicators (labelled VI)** and identification of vulnerable livelihoods (or other targets), that together form a baseline of present development. The collation of vulnerability indicators underpins the analyses and identification of priorities for adaptation.

3. **Linking the development baseline to climate impacts and risks:** The first two tasks establish present conditions of development; the next step is to refine the analysis and link the development baseline explicitly to climate impacts and risks.

It may be that risk maps of present climatic variations are already available. Certainly, almost all countries will have national models of agricultural production and hydrological sensitivity to climatic variations, for example. If so, these can be added to the indicator data set. If quantitative impact assessments are not available, it should be possible to develop indicators of present climatic risks. Historical episodes, such as the drought of record or extreme rainfall during historical storms can help define at-risk regions. If formal models of (present) climate impacts and data on climatic risks are not available, expert opinion and case examples from similar countries can be used to develop a suite of plausible impacts scenarios.

The output from this task is an understanding of the present probability of a range of climatic conditions and hazards. The conjunction of the climatic hazards and development baseline comprises the present climate vulnerability.

4. **Drivers of vulnerability: linking the present and future**: At this point the vulnerability database (VI) includes climatic risks and identification of target vulnerable groups (Vg).

It is a useful snapshot of present vulnerability reflected in a range of indicators. The next step is to provide a more qualitative understanding of the drivers of vulnerability—what shapes exposure to climatic risks? At what scales?

This analysis links the present (snapshot) with pathways of the future--that may lead to sustainable development or further vulnerabilities.

The techniques for 'mapping' the structure of present vulnerability and how it might change in the future are likely to be qualitative in the first instance. Interactive exercises (such as cognitive mapping) amongst experts and stakeholders can help refine the initial VA framework (Task I) by suggesting linkages between the vulnerable groups, socio-institutional factors (e.g social networks, regulation and governance), their resources and economic activities, and the kinds of threats (and opportunities) resulting from climatic variations. Thought experiments, case studies, in-depth semi-structured interviews, discourse analysis, and close dialogue are social science approaches that have application in understanding the dynamics of vulnerability. The best strategy is to start with exploratory charts and checklists—which can help identify priorities and gaps—before adopting specific quantitative analyses.

Outputs of this task are qualitative descriptions of the present structure of vulnerability, future vulnerabilities and a revised set of VIs that include future scenarios.

5. **Outputs of the vulnerability assessment:** The outputs of a vulnerability assessment include:

- A description and analysis of present vulnerability, including representative
- vulnerable groups (for instance specific livelihoods at-risk of climatic hazards).
- Descriptions of potential vulnerabilities in the future, including an analysis of
- pathways that relate the present to the future.
- Comparison of vulnerability under different socio-economic conditions, climatic

changes and adaptive responses.

The final task is to relate the range of outputs to stakeholder decision making, public awareness and further assessments. These topics are framed in the overall APF design and stakeholder strategy.

The first consideration is whether stakeholders and decision makers already have decision criteria that they apply to strategic and project analyses. For instance, the **Millennium Development Targets** may have been adopted in a development plan. If so, can the set of vulnerability indicators (VI) be related to the MDTs? Is there an existing map of development status that can be related to the indicators of climate vulnerability? It is always better to relate the vulnerability assessment to existing frameworks, terminology and targets than to attempt to construct a new language solely for the climate change issues.

Historically, a common approach has been to aggregate the individual indicators into an overall score (here called an index. For example, the Human Development Index is a complex index of five indicators.) using statistical techniques.

Another aggregation technique is to cluster vulnerable groups (or regions) according to key indicators. More formal methods for clustering, such as principal components analysis, are becoming more common as well.

Finally, the qualitative understanding of vulnerability can be developed as stories. Storylines are part of the many socio-economic scenarios. Within the scenario storyline, hypothetical stories about representative livelihoods are effective ways to portray the conditions of vulnerability and the potential futures of concern. The communication methods are diverse--articles from future newspapers, radio documentaries and interviews can all be effective.

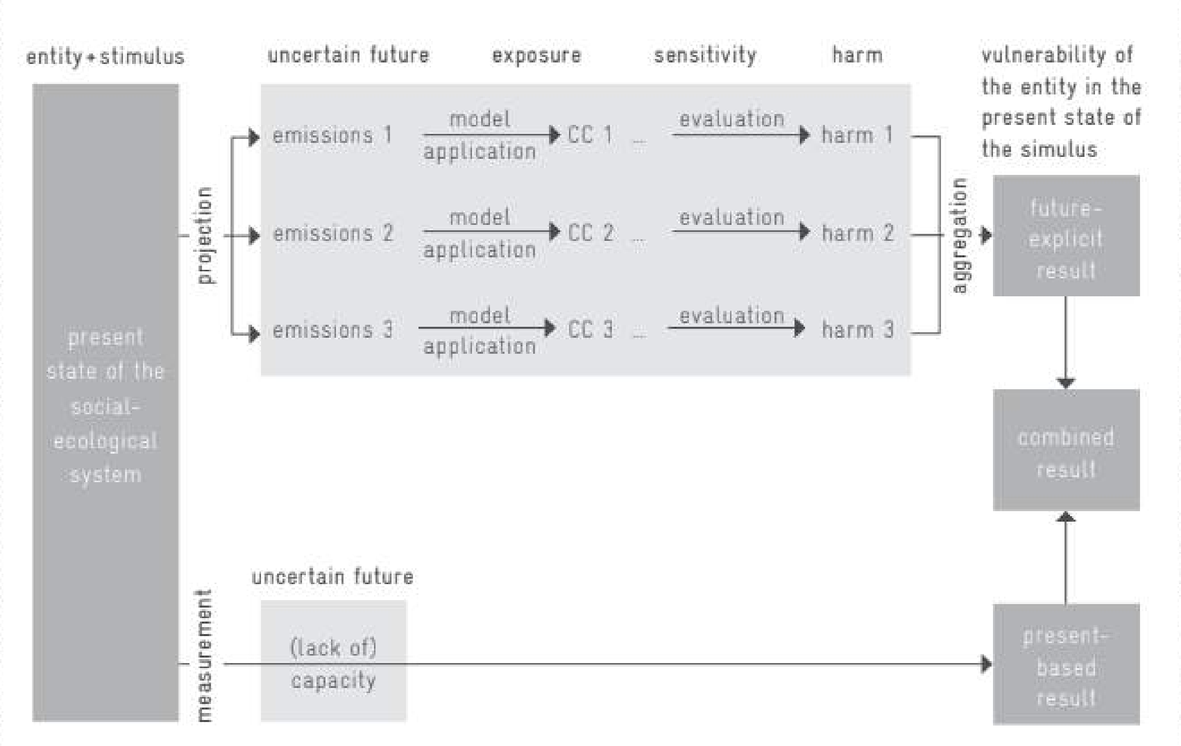
The output should link to further steps in the **Adaptation Planning Framework**.

'A Framework for Climate Change Vulnerability Assessments' prepared by MEFCC, GoI put forward a detailed framework for climate change vulnerability assessment with examples.

The two common methods of vulnerability assessment are the **top-down** approach and **bottom-up** approach.

Top-down approaches (end-point) start with an analysis of climate change and its impacts. Usually preferred at global, national or regional levels and most common in climate impacts and vulnerability studies. This method concentrates on the biophysical effects of climate change.

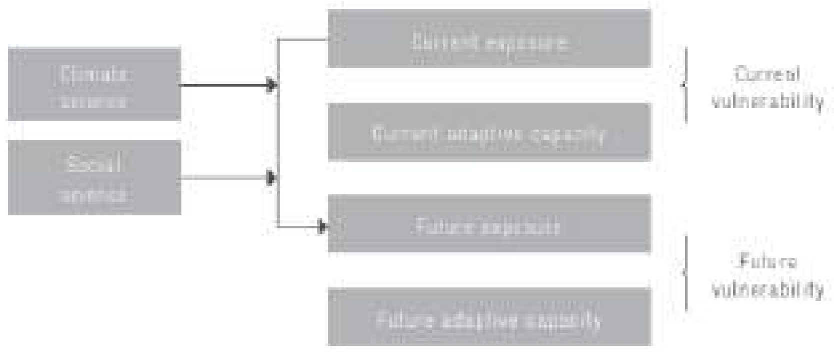
Figure 2: Basic framework of top-down, future-explicit approaches combined with present-based capacity analysis



Top-down approach explicitly considers the existing adaptive capacities and strategies that can reduce negative impacts of climate change. It has the ability to represent direct cause-effect relationships of climate stimuli and their biophysical impacts.

Bottom-up approaches (starting-point) start with an analysis of people affected by climate change. Usually used at the local level. It provides an analysis of what causes people to be vulnerable to natural hazards. It is developed from disaster risk reduction, humanitarian aid and community development. It takes into account the fact that not all social groups are equally vulnerable and vulnerability may differ in class, occupation, ethnicity, caste, gender, disability, age, health status etc. it is participatory (Participatory Rural Appraisal) in nature. Unlike top-down approach it focuses on assessment of current vulnerability rather than trying to assess future vulnerability. It considers collecting information from local areas and does not rely on model generated climatic data.

Figure 3: Basic framework of bottom-up approaches



(Source, UNFCCC Compendium cited in Nair and Bharat, 2011)

Top-down approaches focus mostly on the biophysical impacts of climate change but say less about why, which and how people are vulnerable. Bottom-up approaches, on the other hand, mainly provide information about the vulnerability of different social groups.

Stages and steps

Following table on the following page summarises the general framework for a vulnerability assessment. It is organised in four stages. Each stage consists of multiple steps. The first stage consists of defining the purpose of the vulnerability assessment. These steps are iterative in nature. In every step involvement of all stakeholders must be ensured.

Table 1: Framework for climate change vulnerability assessments

	Stages	Steps	
Involvement of relevant stakeholders	1. Defining the purpose of the vulnerability assessment	Formulate **questions** to be answered by the assessment	Iterative Process
	2. Planning the vulnerability assessment	1. Set the **boundaries** of the vulnerability assessment 2. Define the **general approach** of the vulner-ability assessment	
	3. Assessing current vulnerability	1. Assess the profile of the system of interest 2. Assess the observed climate **(exposure)** 3. Assess the impacts of climate stimuli on the system of interest **(sensitivity)** 4. Assess the responses to climate variability and extremes **(adaptive capacity)** 5. Assess overall **current vulnerability**	
	4. Assessing future vulnerability	1. Assess the future climate **(future exposure)** 2. Assess the future impacts on the system of interest **(sensitivity)** 3. Assess future socio-economic scenarios **(adaptive capacity)** 4. Assess the overall **future vulnerability**	

Stage-1: Defining the purpose:

A clear definition of the purpose of the vulnerability assessment is a prerequisite to its planning. Hey, climate change vulnerability assessment is always directed towards a particular user or audience who will be using the result of the assessment e.g. a state or national government.

Vulnerability assessment may be carried out for various purposes.Generally speaking, the purpose of a vulnerability assessment is to inform decision making. Six broad categories of purposes, are as follows:

- Identify my mitigation targets.
- Identify particularly vulnerable people, regions or sectors.
- Raise awareness of climate change.
- Allocate adaptation funds to particular vulnerable regions, sectors or groups of people.
- Performance of adaptation policy and interventions.
- Conduct scientific research.

The specific purpose of the assessment of vulnerability in flood prone West Bengal was to assess the vulnerability of agriculture based livelihoods to shifting rainfall patterns, erratic rainfall and micro level waterlogging conditions.

Stage-2: Planning the vulnerability Assessment:

The planning stage can be one of the most research-intensive stages of a vulnerability assessment study.

Step-1: Se the boundaries of the vulnerability assessment

1. Defining the resources available for the assessment: (Financial resources, human resources (including skilled personnel) and time)
2. Define the system of interest: (Vulnerability assessment can be carried out at different regional scales. The area of system of interest can be delimited by either socio-economic boundaries- country, state, district, community/ groups or natural/ecological boundaries- river basin, agro-climatic zone)
3. Define the unit of measurement: (The measurement unit for collecting data/information is selected as per the purpose and the system of interest. It may be administrative of socio-economic units e.g. district, block, village, household, gender group or natural/ecological units e.g. river sub-basin, watersheds, agro-climatic zones etc.)
4. Data availability: (Most important deciding factor while selecting methods, tools and levels.)

Step-2: Define the general approach of the vulnerability assessment

Approach of vulnerability assessment depends on purpose, focus, system of interest, unit of measurement and availability of resources. Either of the top-down or bottom-up approach may be selected.

Stage-3: Assessing Current Vulnerability

The objective of a current vulnerability assessment is to identify current vulnerability conditions based on past and current exposure, and the sensitivities and adaptive capacities of the system of interest.

Step-1 Assess the Profile of System of Interest- based on available information on natural resources, state of development and socio-economic and environmental issues.

<u>The current vulnerability assessment</u> provides insights on past-observed climatic trends and factors (exposure) that have contributed to the vulnerability of the system of interest (sensitivity). Current vulnerability assessments also provide an opportunity to learn from adaptive responses in the past (adaptive capacity) – both failures and successes – and thus enable the design of future adaptation responses or adjustments in ongoing climate change adaptation programmes.

There is no predefined set of questions or topics available for studying the profile of the system of interest. However, the following list provides recommendations on formulating key questions to understand the profile of the system of interest.

Questions

- What is the state of natural resources in the system of interest?
  - Identification of natural resources (e.g. forests, agriculture, water)
  - Spatial distribution of natural resources (e.g. area under a certain forest type, soils suitable for crop production, location of rivers)
  - Quantification of natural resources (e.g. available volume of timber and water)
  - Access to these resources (e.g. acces to potable water or water for irrigation, access to agricultural land)
  - Temporal trends of natural resources (e.g. change in forest cover and type, change in groundwater availability for irrigation)
  - Quality of natural resources (e.g. biodiversity, water quality, soil nutrient status)
- What kind of socio-economic dynamics exist in the system of interest?
  - Demographic profile (e.g. number and density of the population, population below poverty line, literacy rate)
  - Livelihood profiles (e.g. main sources of livelihood, diversity of livelihood strategies, gender-specific livelihood strategies)
  - Intra-household dynamics (e.g. due to gender, age, occupation)
  - Inter-household dynamics (e.g. due to caste, class, ethnicity)
  - Human health status (e.g. incidences of vector-borne diseases)

- **What are the environmental issues in the system of interest?**
  - > Identification of key environmental issues (e.g. overgrazing, deforestation, water pollution)
  - > Sectorial implications due to identified environmental issues (e.g. impacts on forest-dependent or agriculture-dependent livelihoods)
  - > Temporal trends (e.g. percentage decline in forest cover, decline in water quality or groundwater table)

- **What are the developmental issues in the system of interest?**
  - > Governance and institutional context (e.g. existing governance structure, rules, regulations, village institutions)
  - > Key developmental issues (e.g. migration from rural areas)
  - > Regions, sectors and groups that should be the focus for development activities (e.g. regions with low access to basic infrastructure, women, children, landless agricultural labourers)

Suggested models and tools: Bottom-up approach

Step-2: Assess the observed climate (exposure): Past observed climatic trends, variability and extremes in the system of interest provide information on the current exposure of the region in question. Specific questions can define how information should be collected in order to assess the observed climate in relation to exposure.

Questions

- **How high is the inter-annual variability of climate variables?**
- **What are the frequency, intensity, timing and duration of extreme events?**
- **What are the observed key climatic hazards in the system of interest?**
- **Where are the hotspots, i.e. where have the largest changes occurred in climate variables from past to present conditions?**
- **How trustworthy is the information available for answering these questions?**

Suggested methods and tools: Top-down approach (Global and regional climate models, statistical analysis of climate data time series) and bottom-up approach (Hazard trend analysis, oral histories, seasonal calendars)

Step-3: Assess the effects of climate stimuli on the system of interest (Sensitivity)

The sensitivity of a system basically describes the dose-effect relationship between its exposure to climatic stimuli and the resulting impacts. Sensitivity is analysed by determining whether the system of interest is significantly affected by climate-related stimuli or not. If the system is affected by climate-related stimuli, particularly current climate variability and extreme events, it should be considered sensitive.

In this step, information on the impact of climate stimuli on the identified sectors of the system of interest is collected at the level of the unit of measurement.

Suggested methods and tools: 1) Top-down:

- Driving forces-Pressures-State-Impacts Responses (DPSIR) framework.
- Indicator based methods.
- Sector- specific simulation models: (Agriculture, water, coastal mareas, human health, terrestrial ecosystem)
- Statistical analysis

2) Bottom-up

- Climate hazard trend analyses
- Community mapping
- Household surveys
- Participatory scenario analysis: ‘What if?’ tool
- Stakeholder consultations
- Timelines
- Transect walks

Step 4: Assess the responses to climate variability and extremes (adaptive capacity)

This stage assesses the capacity of the system of interest to respond and adapt to climate change. This is achieved through assessing how the system has adapted or is adapting to current climate variability and extremes and assessing underlying capacities that may allow further adaptation in the future. Adaptive capacity exists at different scales (family, community, region and nation) and is fundamentally dependent on access to resources. Sufficient resource availability is a prerequisite of adaptive capacity. However, the system requiring the resources for adaptation must also be able to mobilise them effectively. Following types of resources are required for assessment of adaptive capacity to climate change.

Resource	Definition	Variables	Possible indicators
Social	People's relationships with each other through networks and the associational life of their community	• Community attachment • Social cohesion	• Number of community events
Human	Skills, education, experiences and general abilities of individuals combined with the availability of 'productive' individuals	• Productive population • Education infrastructure • Education levels	• Trends in dependency ratios • School/institutional availability
Institutional	Government-related infrastructure (fixed assets): utilities like electricity; transportation; water; institutional buildings and services related to health; social support; and communications	• Political action • Utilities infrastructure • Emergency preparedness • Health services • Communications services	• Elected representation • Age and condition of utilities infrastructure • Number of health services available
Natural	Endowments and resources of a region belonging to the biophysical realm, including forests, air, water, arable land, soil, genetic resources, and environmental services	• Potable water quality • Potable water quantity • Surface water • Soil conditions • Forest reserves • Fish reserves	• Frequency of potable water contamination • Frequency of potable water shortage • Quality and quantity of fish reserves
Economic	Financial assets, including built infrastructure and a number of features enabling economic development	• Employment levels and opportunities • Economic assets	• Trends in job diversity • Trends in income levels • Local business ownership rates

(Source: adapted from Wall & Marzall, 2006)

Step 4 helps in understanding the existing capacities to respond to climatic stimuli and in identifying factors that have enabled effective responses to climatic hazards in the past. A range of questions can be considered in this step.

Questions

- **How have the key environmental, socio-economic and developmental issues been addressed by various measures?**
  (E.g. policies, programmes, local adaptation measures)
- **What response measures exist to deal with climate variability and hazards?**
- **Have the response measures specifically addressed the identified hotspots?**
  (E.g. regions, sectors, groups)
- **How effective have the response measures been?**
- **What factors have determined the effectiveness of identified response measures?**
  > What social networks exist within the system of interest?
  > What knowledge networks exist within the system of interest?
  > What institutional arrangements have helped with adaptation to climate variability and extremes?
  > What natural resources have been conducive for adapting to climate variability and extremes?
  > What economic resources have been conducive for adapting to climate variability and extremes?

Step-5: Assess the overall current vulnerability:

The overall current vulnerability of the system of interest is prepared by combining the outputs from Steps 1 to 4 of Stage 3, namely: 1. Assess the profile of the system of interest; 2. Assess the observed climate (exposure); 3. Assess the effects of climate stimuli on the system of interest (sensitivity); 4. Assess the responses to climate variability (adap-

tive capacity). The following key questions should be asked to develop links between the previous steps of the assessment.

Questions

- What have been the impacts of climate variability and hazards on key environment, natural resource and development issues?
- Which regions, sectors and groups have been most impacted?
- What non-climatic factors determine the severity of climate impacts?
- Which resources have resulted in successful adaptation to climatic variability and extremes?
- What levels of adaptive capacity already exist?
- How is existing adaptive capacity distributed across geographical regions, and across gender, age, and ethnic groups?

Suggested methods and tools: 1) Top-down

• Indicator-based methods

• Sector-specific simulation models

> agriculture

> water

> coastal areas

> human health

> terrestrial ecosystems

2) Bottom-up

• Brainstorming

• Climate hazard trend analyses

• Cognitive mapping

• Community mapping

• Focus group discussions

• Hazard mapping

• Impact matrices

• Participatory scenario analysis: 'What if?' tool

• Seasonal calendars

• Transect walks

• Vulnerability matrices

Stage-4; Assess the future vulnerability

This stage comprises four steps for assessing the future vulnerability of the system of interest. It builds on earlier stages during which current climate conditions were analysed and current climate vulnerability was assessed. This is done under the assumption that adapting to current climate variability and extremes will reduce vulnerability to climate change in the future.

Future vulnerability assessments link projections of the future climate and projections of socio-economic development (non-climatic factors) to possible future scenarios. The projections vary both spatially and temporally and show long-term changes in climatic and socio-economic variables.

Step-1: Assess the future climate (future exposure):

This step attempts to determine how climatic variables will change in the future. Top-down vulnerability assessments use climate models to project the effect of higher levels of greenhouse gases (GHG) on the earth's climate.

Questions

- **What is the projected change in key climatic variables?**
  (E.g. change in inter-annual or inter-seasonal variability of climatic variable, change in average value of climatic variable, change in maximum or minimum value of climatic variable)
- **What is the projected change in extreme events?**
  (E.g. occurrence and timing of floods, dry spells and heat waves)
- **What are the uncertainties in the selected climate projections?**
- **What top-down climate projections are available for use in participatory scenario development?**

Suggested methods and tools:

- Global Climate Modelling (GCM) projections
- Regional Climate Modelling (RCM) projections

Step-2: Assess the future impacts (future sensitivity):

Step 2 of the assessment of future vulnerability will assess how the current vulnerabilities are likely to be affected by the projected changes in climate variables. For top-down approaches, this step involves the use of specific biophysical models to come up with scenarios of sensitivity to future exposure for individual sectors (e.g. agriculture, forests, water and coastal areas). Such sector models attempt to describe future scenarios by integrating the outputs of climate projections and socio-economic scenarios. Top-down assessments of future sensitivity using simulation models are a data-intensive exercise that requires skilled personnel.

Questions

- What likely changes in biophysical parameters are expected as a result of climate change? (E.g. change in land use, land cover, water availability and quality, crop yields and production)
- Will climate change cause the demand for a resource to exceed its supply?
- Does the system have limiting factors that may be affected by climate change?

Suggested Methods and tools:

- Indicator-based methods
- Sector-specific simulation models

Step-3: Assess the future socio-economic scenario (adaptive capacity):

Step 3 of the assessment of future vulnerabilities involves the development of socio-economic scenarios. Assessments may consider human population growth patterns in the system of interest, economic shifts or land use changes.

In future-explicit top-down assessments, socio-economic scenarios are key drivers of projected changes in future GHG emissions and climate variables. They are also key determinants of most climate change impacts, potential adaptations and vulnerability.

Questions:

- What are the socio-economic scenarios that can emerge? (Regions, groups, time frame)
- What possible measures exist for adapting to climate change in the future?
- How will existing capacities for adapting to climate change develop in the future?

Suggested methods and tools:

1) Top-down

Statistical techniques

- Ratio method for population growth
- Trend Analysis

Modelling techniques

- Agent-based modelling
- Dynamic Interactive Vulnerability Assessment (DIVA)
- Integrated Model to Assess the Greenhouse Effect (IMAGE)
- RamCo and ISLAND MODEL
- The South Pacific Island Methodology (SPIM)

Step-4: Assess the overall future vulnerability

Example: Climate Change Vulnerability Assessment of flood in West Bengal

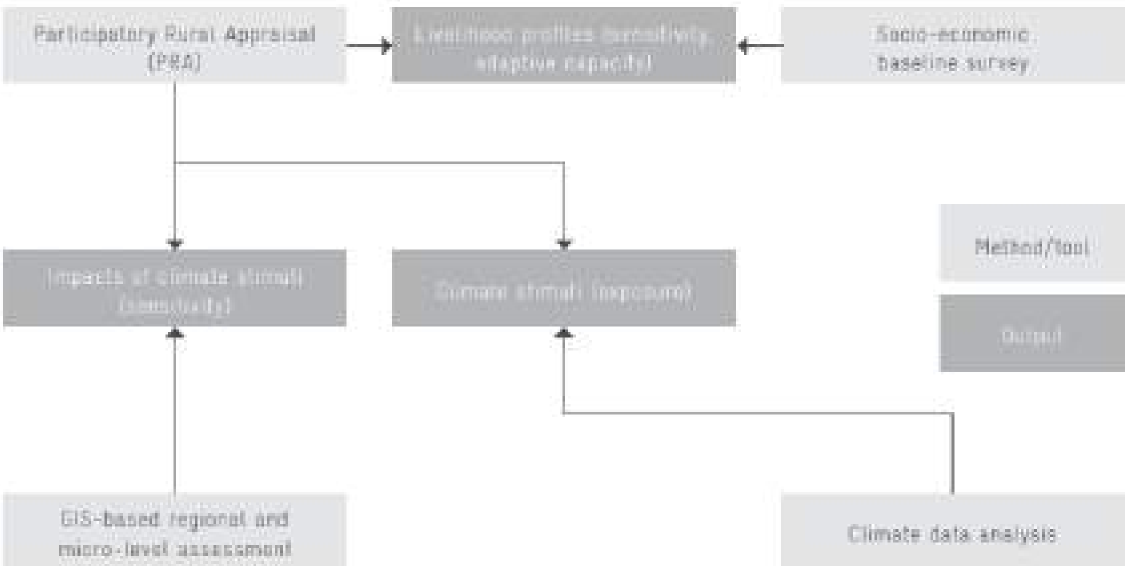
Stage-1: Defining the purpose: Defining the purpose of the vulnerability assessment

Stage-2: Planning the vulnerability assessment: It may be done in following ways:

Participatory rural appraisal (PRA) tools are used at local level to identify the key vulnerabilities of local communities, to understand community members perceived risks and threats to their lives and livelihoods, and to analyse resources and strategies to address or reduce risks. **Household survey** for community information and household assets, food security, level of education and training; **climate trends analysis** for the district, **GIS based regional and micro-level assessments** to identify flood prone areas.

Purpose of assessment:	Identify the vulnerability of local farming systems to shifting rainfall patterns, erratic rainfall, flooding and waterlogging
Financial resources:	Moderate
Human resources:	Qualified personnel available at project sites
Time available:	4-5 months; PRA per project site: 3 days
System of interest:	Manikchak Block in Malda District and Bhagabangola I Block in Murshidabad District
Sectors to be covered:	Crop production, fisheries, livestock keeping
Unit of measurement:	Local communities/villages
Data availability:	Climate data available at the district level, other data to be collected through the household survey and PRA tools
Assessment type (rapid or detailed):	Rapid assessment of current vulnerabilities
Assessment approach:	Mostly bottom-up, with input from climate data analysis and GIS data analysis
Capacity development needs:	People with expertise in GIS application, climate data analysis, PRA tools, socio-economics

Methodology applied in a local-level vulnerability assessment in three villages in West Bengal



Participatory Rural Appraisal (PRA) tools (Bottom-up approach)

- ***Focus groups discussions***
- ***Community mapping***
- ***Seasonal Crop Calendars***
- ***GIS based regional micro-level assessment*** (The aim of this part of the vulnerability assessment was to assess the regional ground condition of surface runoff and identify

areas that are heavily affected by waterlogging. The assessment followed a ***four step*** process:

1. Assessment of topography and land use through GIS and Remote Sensing
2. Field trip/ground survey
3. Discussion with villagers
4. Synthesis of findings and recommendations)

Stage-3: Assessing Current Vulnerability:

Step 1: Assess the profile of the system of interest

Information on the profile of the system of interest was collected through a review of academic literature, governmental and local data sources, household surveys, focus group discussions and other PRA tools, i.e. community mapping, seasonal calendars and transect walks. The assessment of the system of interest in this example begins with an assessment of the wider regional context in which the project sites are located. This initial analysis was largely done through a review of existing literature on the regional context in which the villages are located.

The results of the assessment of the profile of the system of interest were presented in the form of running text, tables, GIS maps, maps and tables derived from PRA exercises, and photographs taken in the respective villages.

Results

At the state, district and block level

At present more than 40 % of the total area of West Bengal is frequently hit by floods. Both of the project sites lie in regions with the highest incidents of flooding and waterlogging in West Bengal.

The Ganges River receives water from 11 states before it passes through Malda District in West Bengal. Before entering the neighbouring country, Bangladesh, parts of the Ganges river flow are diverted southwards at the Farakka Barrage. Apart from the Gangetic waters, Malda District also receives floodwater from the Mahananda River originating in Nepal. The Mahananda River passes through parts of Bihar and through Malda District before it joins the Ganges delta system in Bangladesh.

Murshidabad District lies to the south of Malda District. Located in the north of Murshidabad is the source of the (Bhairab-Jalangi-Sealmari) river system that flows through Murshidabad and its southern neighbour, Nadia district, before joining the Hooghly River in the central-western part of Nadia District.

Government statistics show that the economy of Manikchak Block of Malda District is based on agricultural production. Rice and jute are the main crops and account for more than 90 % of the total amount of crops produced in the district. Rice is cultivated in three seasons. Jute, wheat, potatoes and lentils are only grown in the winter (*rabi*[4]) season. Oilseeds, such as mustard, are also grown in parts of Manikchak Block. Soils in the Manikchak area are predominantly of the clayey loamy type. Of the total cultivated area of about 25,000 hectares in Manikchak Block, close to 30 % is irrigated.

As in Manikchak, the economy of Bhagabangola I Block in Murshidabad District is dominated by agricultural production. Rice is cultivated in three seasons throughout the year. It accounts for more than 90 % of cereal production in the block. Other crops (jute, wheat and potatoes) are cultivated in the winter, or *rabi*, season. Apart from these four major crops, various types of lentils and oilseeds are also produced in some parts of the block.

At the village level

The resource maps show the spatial distribution of farmland and houses in and around the villages. The maps also show the location of rivers and streams as well as other sources of irrigation water in the villages. Moreover, they identify on which agricultural fields double or even triple cropping frequently takes place.

Apart from identifying and quantifying the existing resources within the system of interest, the resource maps were also used to identify some of the key threats to local livelihoods. Agriculture in all three villages suffers severely from waterlogging. The resource maps point out the location, extent and severity of waterlogging on agricultural land in the villages.

Crop calendars show that villagers suffer from food shortages in the months from August to November and that most of the consumed vegetables are purchased from the market rather than produced by the villagers themselves. Moreover, crop cultivation in the villages depends to a high degree on external inputs, i.e. mineral fertilisers, chemical pesticides and hybrid seeds. In Gesarotola village in Malda District, farmers pointed out the very high importance of jute cultivation and how it suffers particularly heavily from erratic rainfall and waterlogging.

The problem identification and ranking methods that were used in focus group discussions (FDGs) produced different results for the two project sites. In Malda, community members listed **waterlogging** and **floods**, **demographic changes** and **health concerns** as their main problems. In Murshidabad, villagers prioritised the generally high degree of poverty, **concerns about raising sufficient funds for dowries**, and **the increasing costs of agricultural production** due to frequent crop failures and the high costs of external inputs.

FGDs about livelihood options and their changes over time drew out different socio-economic dynamics in the two project sites. In Malda, the number of families increased from about 400 in the year 2000 to about 485 in the year 2011. While the total number of families in the area has remained unchanged, the relative importance

[4] There are two major crop growing seasons in the Indian Ganges basin. Summer, or kharif, crops are sown at the onset of the southwest monsoon and harvested from October up to February. The winter, or *rabi*, crop-growing season starts just after the southwest monsoon and extends well into the summer

of farming activities has decreased and the number of people employed as day labourers has increased. Villagers attribute this to a lack of arable land and a low interest in agriculture due to the high costs of production. In 2000, only one third of all families were involved in making *beedi*[7] cigarettes. By 2011, all families had taken up *beedi* production to improve their financial resource base. Similarly, in Murshidabad the number of community members migrating to avoid seasonal unemployment has increased in recent years.

Step 2: Assess the observed climate (exposure)

Due to limited data availability, actual climate data could not be analysed at the level of the selected villages. Instead, data was analysed for the whole districts of Malda and Murshidabad based on long-term climate data provided by the India Meteorological Department (IMD). Climate trends at the level of the individual villages were assessed through the participatory development of seasonal calendars that focus on weather behaviour for the past ten years.

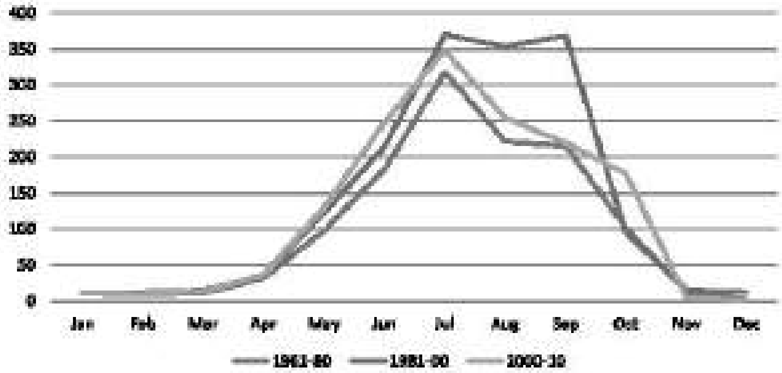
Results

At the district level

Malda District receives an average of 1,593 mm of rain per year. The average temperature is about 9°C in winter and 41°C in summer. The rainy season in Malda District generally lasts from June to September with limited amounts of rainfall in May and October. The months from January to April are characterised by low and infrequent precipitation. Additional rainfall in December has become a rare phenomenon since 1998.

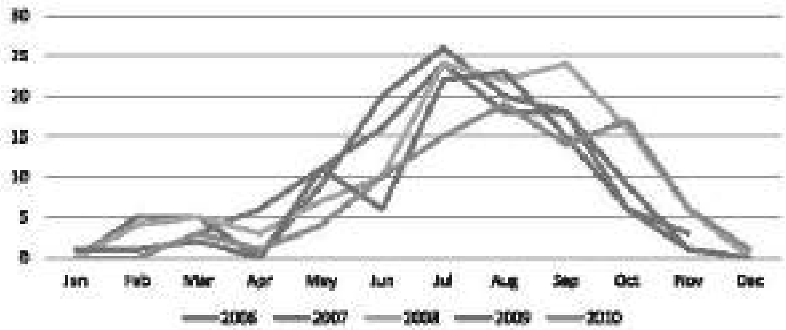
In the years from 1981 to 2000, the rainfall peak of the monsoon season has shifted from July to September. In the period from 2000 to 2010, monsoon rainfall has seen a slight shift back to a rainfall peak in July, as shown in the following figure.

Average rainfall pattern in Malda District



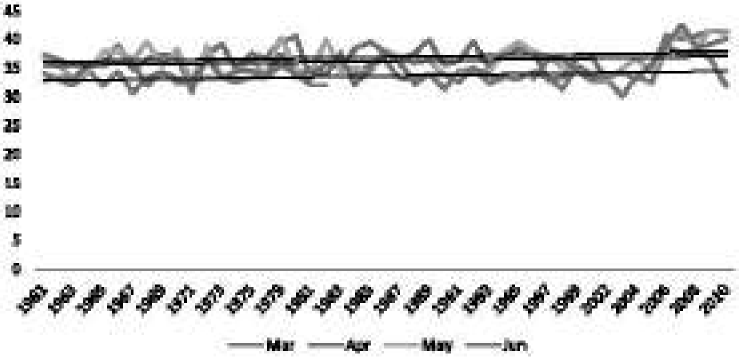
The long-term trend analysis for the past 50 years (1961 to 2010) shows a considerable **increase in total rainfall** in Malda District. Since 1990, **rainfall has become increasingly more erratic**. The number of rainy days and the amount rain per month vary considerably from year to year. Rice harvesting activities in October and November are frequently interrupted by unexpected sudden downpours. The following figure shows the number of rainy days per month for 2006 to 2010.

Number of rainy days in a month in Malda District



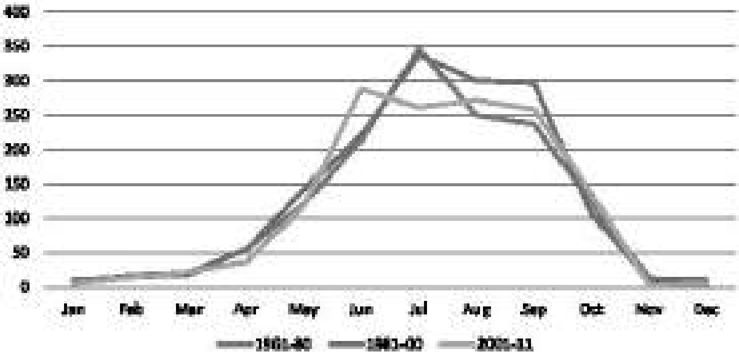
Temperature data analysis from 1961 to 2009 shows that **temperatures in Malda become gradually warmer**. As can be seen in the next figure, **maximum temperatures in summer are becoming hotter while minimum winter temperatures are increasing**. Moreover, **the differences between minimum and maximum winter and summer temperatures are increasing**.

Maximum summer temperature in Malda District



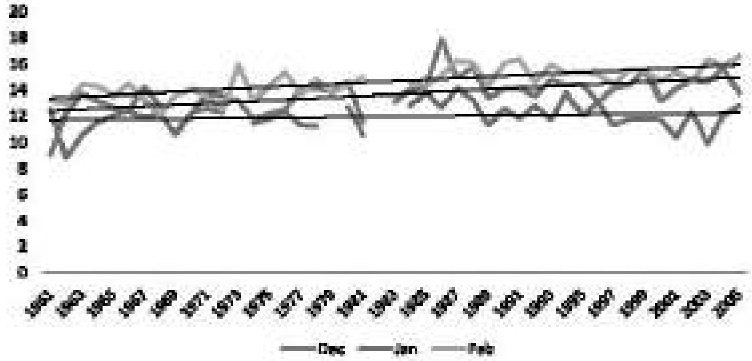
Murshidabad District receives an average of about 1,500 mm of rain per year. The rainy season in Murshidabad generally lasts from June to September with small amounts of rainfall in May and October. The period from January to April exhibits infrequent and low precipitation. Rainfalls in December and November have become rare since 1992. Since 1995, **rainfall intensity has decreased and become more erratic in nature.**

Average rainfall pattern in Murshidabad District



Temperature trend analyses for Murshidabad District show that **minimum winter temperatures are steadily increasing** (except in January). Likewise, the differences between minimum and maximum temperatures are steadily increasing as shown in the following figure. Unlike winter temperatures, summer temperatures show no discernible trend in the years from 1961 to 2010.

Minimum winter temperature in Murshidabad District



At the village level

Focus group discussions and seasonal climate calendars show results that are not always in accordance with statistical analysis at the district level. Nevertheless, villagers identified similar trends to those observed through climate data analysis. In both project sites, farmers identified periods of the year in which **strong and erratic rainfalls cause severe waterlogging** (July to October). Community members also pointed out **increasing temperatures**, especially in the summer months.

Step 3: Assess the impacts of climate stimuli on the system of interest (sensitivity)

Information on the sensitivity of the system of interest was collected through a literature review, a GIS-based regional and micro-level assessment, the participatory mapping exercise as described in Step 1, as well as through focus group discussions and the participatory construction of crop and climate calendars.

Results

At the state and district levels

Large parts of West Bengal are susceptible to **flooding, riverbank erosion and waterlogging.** The districts of Malda and Murshidabad in central West Bengal belong to the districts in West Bengal that are most frequently hit by devastating floods.

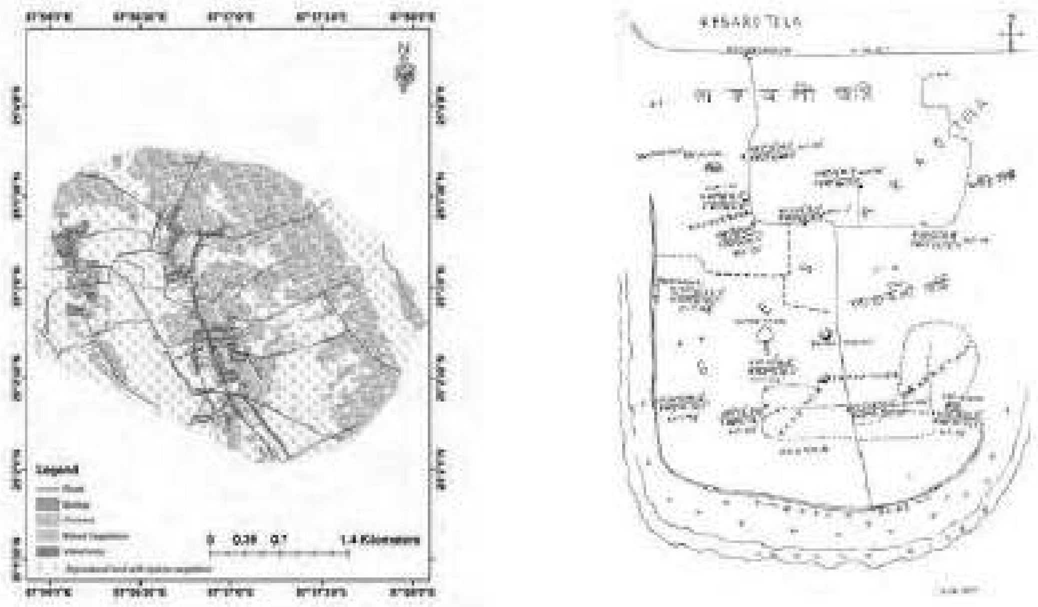
Apart from floods, the **erosion of riverbanks** is also a particular cause for concern. Hot spots for this erosion are found on the left bank of the Ganges upstream from the Farakka Barrage and in other parts of the Ganges-Padma and Bhagirathi-Hooghly river systems. In future, several towns on the banks are threatened with destruction if bank erosion continues unchecked.

At the village level

Government statistics, the socio-economic baseline survey and focus group discussions showed that rain-fed **agriculture remains the primary occupation** in the project areas. The main crops for small farmers are paddy rice, wheat, potato and jute. Apart from flooding, waterlogging over a long period puts additional stress on agriculture in both districts.

The GIS-based regional and micro-level assessment produced various maps of the project villages. First, land use maps were generated by processing high-resolution satellite images. Second, a ground survey was conducted to verify land use characteristics and identify micro-level waterlogging conditions. During the ground survey, areas that were particularly heavily affected by flooding and waterlogging were geo-referenced with handheld GPS devices. The ground survey was conducted in close collaboration with local inhabitants.

Land use map of Gesarotola village in Malda District



This map was prepared using remote sensing data (left), and also using GPS devices and stakeholder interaction (right).

Focus group discussions and seasonal calendars show that, among farmers, the months from September to November are known as the waterlogging – and thus unproductive – period of the year. Due to changes in precipitation patterns, incidences of waterlogging are increasing and agricultural yields are going down. Paddy and jute grown during the summer monsoon have always been sensitive to long periods of waterlogging lasting up to 6 or 7 months in a year. With shifting rainfall patterns, the impact on rice production is expected to worsen.

Added to this, because of the earlier onset of the summer monsoon, the jute harvest has suffered heavily in recent years. This is because heavy rains causing waterlogging have recently been starting in July instead of August, which is the month of the jute harvest. The growth of jute plants is hampered by the stagnant water in July. On the other hand, delaying monsoon can also harm the retting of Jute.

Climate data analysis shows that the duration of high temperatures during summer is extending. This circumstance leads to reduced production of late-sown paddy. Wheat and potato, which are the major winter crops (*rabi* season), mainly suffer from increasing winter temperatures and decreasing rainfall. In this way, erratic rainfall severely affects the livelihoods of villagers. To ensure the family's income, at least one male family member works as a labourer in one of the bigger cities.

Step 4: Assess the responses to climate variability and extremes (adaptive capacity)

Various PRA tools were used to assess the responses of local communities to observed climate variability, trends and extremes in the project areas. Farming households perceive themselves to be highly vulnerable to extreme events, especially flooding, and have developed various strategies to cope with these extreme situations.

These strategies include the protection of property in times of extreme events. During floods, for example, people in the project areas prepare temporary shelters from bamboo. These shelters are being built to protect valuables and important documents (IDs or passports and other legal documents). In very extreme flooding situations, villagers also take shelter in these temporary structures. Another coping strategy involves villagers replacing their mud-made ovens with aluminium ones.

Villagers perceive that the local government for the project sites is unable to provide much support at all in times of flood. It is only in extreme flood events that local government institutions provide boats for transport, packaged food and tarpaulins.

Local farming communities do not just have to deal with extreme events like floods; they must also respond to low crop production or total crop failure due to waterlogging, high temperatures or insufficient rainfall.

The two most common strategies for members of these communities are: 1) to migrate from the areas in which they feel vulnerable due to climate extremes and vulnerability, and 2) to find work as day labourers instead of working in agriculture.

In order to ensure sufficient financial household resources, farmers also often borrow money at a high interest rate from local moneylenders. Another common way to deal with a lack of financial resources in times of crisis is to sell livestock, thereby diminishing the household's resource base.

Step 5: Assess the overall current vulnerability

In order to assess the vulnerabilities of people living in three villages in the districts of Malda and Murshidabad in West Bengal, a variety of methods were combined: participatory exercises, household surveys, literature reviews, and climate data analyses. Climate data analyses were performed to understand which kinds of climatic variability and extremes the villagers are exposed to. Focus group discussions were used to determine people's risk perceptions and to assess the basis of their livelihoods. Seasonal calendars were developed with the participation of local communities to understand how livelihood patterns change throughout the year and what kinds of risks the people and agricultural systems are facing. Household surveys were carried out in the villages to quantify the state of household resources in the project villages. Moreover, the surveys could be used to quantify the importance of different livelihood options in the villages.

The overall current vulnerability assessment for the selected project villages showed that local livelihoods are heavily dependent on rain-fed agricultural production. Shifting rainfall patterns and increasing temperatures lead to decreasing crop yields. Longer periods of waterlogging put an additional stress on crops and further reduce yields. The jute harvest, for example, often suffers greatly from an early onset of the summer monsoon, with heavy rains causing waterlogging as early as in July, as opposed to August in the past. As a result, the growth of jute plants is stunted by the stagnant water. Wheat and potatoes, the main winter crops, mainly suffer from higher winter temperatures and decreasing amounts of rainfall in November and December. As a response to decreasing agricultural production due to shifting rainfall patterns and increasing temperatures, most villagers tend to shift to non-farming activities.

The project sites suffer from additional stresses through flooding and riverbank erosion. Rising temperatures due to global climate change are likely to lead to glacier melt in the Himalayas. In that case, both Malda and Murshidabad Districts could receive higher amounts of floodwater, which would lead to an even higher number of floods in these regions.

Climate Change Adaptation Strategies and Mitigation: South Asia

Climate change **adaptation** is the way we cope up with the already changed climatic conditions. People adapted with changing environmental conditions since long ago and it is a very general phenomena. Many historic and archaeological evidences are available of adaptation to changing environmental conditions in different parts of the world.
But recent changes in climatic conditions are more rapid and induced by human activities. People are changing the natural systems for the sake of development (?).

In order to understand climate change adaptation we need to first understand the impacts of climate change on various facets of the environment including human life and livelihood and the socio-economic condition of people and the state.

Recent changes in the climate is the result of adverse impacts of increasing human activities like, increased GHGs emission, modification of natural systems including ecosystems. For these reasons the world's climate is changing gradually.

Global warming,

Heat waves,

Forest fire,

Increasing and prolonged droughts,

Frequent devastating floods,

Tidal and cyclonic coastal inundation,

Increasing attacks of pests, insects,

Changes in crop production hampering food security,

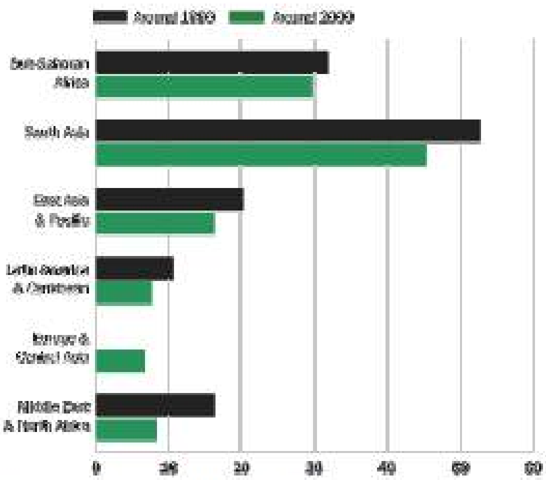
Melting of mountain glacial ice and continental ice sheets etc. are many of such impacts.

Extreme climate events are destroying human properties and lives. Poor people, indigenous marginal people, people based on primary economic activities, people living in coastal areas, people in low lying urban lands are already facing many problems and challenges in their life and livelihood. .

Table 1. Indicators of poverty and vulnerability for South Asian countries

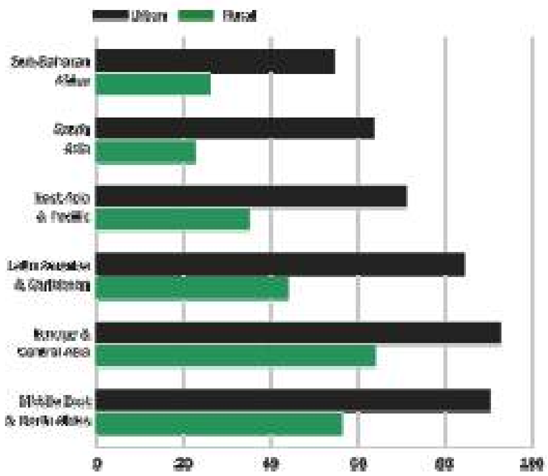
	Daily per capita calorie supply (Kcal) in 1999	% population without sustainable access to improved water source in 2000	Malaria cases (per 100,000 persons) in 2000	% population living below US$1 a day (most recent year during 1990-2002)
Bangladesh	2201	3	40	36
Bhutan	..	38	285	..
India	2417	16	7	34.7
Nepal	2264	12	33	37.7
Pakistan	2462	10	58	13.4
Sri Lanka	2411	2	1110	6.6
Data source	WRI	UNICEF, UNDP HDR	UNDESA, WHO, UNDP HDR	WB, UNDP HDR

Figure 1. Prevalence of malnutrition (percentage of children under 5 years)



Source: World Bank Indicators

Figure 2. Percentage of population with access to improved sanitation in 2002



Adaptation strategies

Adaptation strategies should be based on the nature and extent of present climate change and future projections, the level of socio-economic condition of people affected by climate change and their progress towards development, and the technological level and economic structure of the affected country or nation. So there are many dimensions of climate change adaptation as the mitigation measures are also going side by side to reduce the climate change phenomena in the near future. In India and south asian countries where the majority of the world population live, the majority of poor people live are facing serious climate shifts in the near future.

Adaptation to climate change in these developing countries is vital and has been highlighted by them as having a high or urgent priority. Although uncertainty remains about the extent of climate change impacts, in many developing countries there is sufficient information and knowledge available on strategies and plans to implement adaptation activities now. However, developing countries have limitations in capacity making adaptation difficult. Limitations include both human capacity and financial resources.

Strategies and programmes that are more likely to succeed need to link with coordinated efforts aimed at poverty alleviation, enhancing food security and water availability, combating land degradation and reducing loss of biological diversity and ecosystem services, as well as improving adaptive capacity.

Sustainable development and the Millennium Development Goals are a necessary backdrop to integrating adaptation into development policy. Poverty reduction policies are also important elements of adaptation.

The lack of funding available in various forms, as well as difficulties in accessing the funds which are available, represents a major barrier for adaptation, particularly for local community action.

Many developing countries face difficulties in integrating climate change concerns into national policies due to a lack of resources and institutional capacities. Capacity-building, for example to integrate climate change and socio-economic assessments into vulnerability and adaptation assessments, helps to better identify effective adaptation options and their associated costs.

Sustainable development planning and practices is very essential for effective adaptation to climate change and the adaptation strategies should be integrated to main development policies. Capacity building of people through awareness, education and training is also necessary for better adaptation.

Adapting to climate change will entail adjustments and changes at every level – from community to national and international. Communities must build their resilience, including adopting appropriate technologies while making the most of traditional knowledge, and diversifying their livelihoods to cope with current and future climate stress. Maladaptive practices like deforestation, illegal mining, river encroachments must be prevented and removed.

Adaptation strategies also include sector wise plans as different sectors are affected differently focussing on the existing indigenous knowledge and practices that are climate resilient as well as new technological measures. Multi-sectoral strategies are also taken into consideration as adverse impacts on one sector might influence other sectors. The adaptation strategies must be coordinated with the current and future disaster risk management policies and programmes. Disaster relief funds, disaster management infrastructure are also important for adaptation.

IPCC, World Bank, Asian Development Bank and many other organisations are working hard to help people adapt and make themselves climate resilient.

- The most common climate change impacts are the changes in precipitation pattern leading to flood or droughts. Thus we need to change our crop production system and the land use to minimise the impacts of climate change on people's livelihood.
- Urban flood due to heavy rain can be minimised by adopting proper drainage system in the city, restoration of wetlands, and landscape modification as per the slope, water runoff and wind.
- Coastal surge of water and flooding is another common problem due to climate change. Sea level rise due to melting of ice resulting in more tidal spread of water causing coastal flooding. Modification of coastal drainage, constructing embankments, planting of native plants, changing crop patterns may help people become more climate resilient. Knowledge of the native indigenous people may help much in this regard.
- Coastal low-lying inundation due to sea level rise is another threat to many people living in villages and cities of south-East-Asian countries and the island nations. Many highly populated areas of these regions are in danger of permanent sea water inundation making them climate refugees and sometimes stateless. One report in India saied, 75% of Indian districts are prone to climate extreme events like flooding, droughts, cyclones and thunderstorms.
- Increasing events of cyclones in the tropical areas are another serious issue of climate change impacts. Deforestation in coastal lands makes the problem more acute. More cyclone resistant trees should be planted in coastal areas e.g. mangrove forest regeneration, coastal embankment to protect land from flooding and siltation of salt in soil after flood, changing cropping pattern towards more saline water resistant crops, etc.

Priority adaptation projects identified by NAPAs include:

- improved forecasting for farming, extreme events and disaster management;
- improved water management for drinking and agriculture through understanding water flows and water quality, improved rainwater harvesting and water storage and diversification of irrigation techniques;
- improved food security through crop diversification, developing and introducing drought, flood and saline tolerant crops, improving livestock and fisheries breeding and

farming techniques, developing local food banks for people and livestock, and improving local food preservation;

- better land and land use management through erosion control and soil conservation measures, agroforestry and forestry techniques, forest fire management and finding alternative energy sources to wood and charcoal, as well as better town planning;
- coastal zone management including coral monitoring and restoration and improving coastal defences through afforestation, reforestation, set-back areas and vegetation buffers;
- improved health care through flood shelters and assistance shelters as part of community emergency preparedness programmes, better health education, better access to primary health care such as distribution of treated mosquito nets and better malaria surveillance programmes and habitat clearance;
- capacity-building to integrate climate change into sectoral development plans, involving local communities in adaptation activities, raising public awareness and education on climate change, and enabling representation at international meetings;
- and promotion of sustainable tourism.

Local Coping Strategies

There is a large body of knowledge and experience within local communities on coping with climatic variability and extreme weather events.

In **Asia**, farmers have traditionally observed a number of practices to adapt to climate variability, for example intercropping, mixed cropping, agroforestry, animal husbandry, and developing new seed varieties to cope with local climate. Various water use and conservation strategies include terracing, surface water and groundwater irrigation; and diversification in agriculture to deal with drought. Structural and non-structural measures are used to deal with flood and coastal inundation.

For example, in the **Philippines**, after Typhoon Sisang in 1987, which completely destroyed over 200,000 homes, the Department of Social Welfare and Development decided to instigate a programme of providing typhoon-resistant housing designed to withstand wind speeds of 180 km/h for those living in the most typhoon prone areas.

In **Bangladesh**, the Cyclone Preparedness Program has been set up over 11 coastal area districts by the Bangladesh Red Crescent Society, and is partly funded by the government. The **south-west region of Bangladesh** faces problems of water logging caused by the combined effect of siltation of estuary branches, higher river bed levels, reduced sedimentation in flood protected areas, and impeded drainage, exacerbated by heavy rainfall and sea level rise. This adversely affects available agricultural land, impacting food production, soil productivity, and agricultural livelihoods. The Institute of Development Education for the Advancement of the Landless (IDEAL) is implementing a project called Reducing Vulnerability to Climate Change (RVCC), where the initiatives promoted in Subarnabad focus on new livelihood strategies for income and food generation. These include goat, duck, and hen rearing, chicken and crab farming, tree planting, introduction of salt-water tolerant vegetable gardens and handicraft production. IDEAL has also helped raise awareness about climate change, personal hygiene, sanitation, and the construction of latrines and deep tube wells.

In **Bangladesh**, ongoing projects intend to address food insecurity and food production shortfalls by crop diversification and generation of other employment opportunities aiming at community development, agricultural development, credit facilities, and infrastructure improvement. All these developmental programmes play an important role in enhancing the resilience of the poor. Rain water harvesting and integrated development of watersheds in rainfed areas help in increasing agricultural resilience to erratic weather events under a climate change scenario.

Bangladesh has its own Participatory Disaster Management Programme (PDMP) with the focus towards disaster management and prevention, and also adaptation to climate change. There is no national policy in place yet to comprehensively address climate change risks. The disaster management project mainly focuses on soft measures to reduce the impact of disasters in Bangladesh. In particular, it aims to increase awareness on practical ways to reduce disaster risks and losses, to strengthen national capacity for disaster management (with emphasis on preparedness), enhance knowledge and skills of key personnel in handling disasters, establishing disaster action plans in the most disaster prone areas promoting local–level risk reduction measures, and improving early warning systems.

India is doing many things for climate change adaptation, mitigation and disaster risk reduction. Relief funds both at central and state level, disaster management team (NDRF and SDRF), area specific regional and human development programme- drought prone area programme, coastal zone development programme, hill area development programme, desert development programme, integrated watershed development programme, The National Watershed Development Programme in Rainfed Areas etc. are some of the examples. Highly developed weather forecast system helps alert people and prepare disaster management teams. India's public distribution system works well during food shortages.

Housing programmes for the poor and rural communication through metalled roads are also important initiatives for poverty alleviation and climate change adaptation strategies.

Inclusion of climatic risks in the design and implementation of development initiatives is vital to reduce vulnerability and enhance sustainability. Developmental efforts can help build adaptive capacity through two levels of interventions:

1. climate-specific interventions such as drought proofing, rainwater harvesting, awareness about available drought-resistant varieties, better access to medium/long-range weather forecasts, and possibly early warning networks.
2. broader capacity building through education, access to agricultural credit, health care infrastructure, etc

Figure 9. Climate and development policy linkages for India

NAP - National Agriculture Policy,

NAIS - National Agriculture Insurance Scheme,

DPAP - Drought Prone Areas Programme

IWDP - Integrated Watershed Development Programme

NAMP - National Anti-Malaria Programme,

NVBDCP - National Vector Borne Disease Control Programme

ECA - Electricity Conservation Act,

APDP - Accelerated Power Development Programme,

CDM - Clean Development Mechanism

JFM - Joint Forest Management CRF -

Calamity Relief Fund,

NCCF - National Calamity Contingency Fund,

CZM - Coastal Zone Management

SGSY - Sampoorna Grammen Swarozgar Yojana,

SGRY - Swarnajayanti Grammeen Rozgar Yojana

The World Bank project "Addressing Vulnerability to Climate Variability and Climate Change through an Assessment of Adaptation Issues and Options" has the overarching goals of enhancing the consideration of climate and climate-related issues in India's development process, and achieving a more effective integration and mainstreaming of climate issues in the Bank's project preparation and appraisal processes. Activities include

ƒ identification of policies, measures and practices that might be modified to reduce vulnerabilities

ƒ analysis of appropriate institutional and participatory mechanisms to merge current community driven development priorities with the need to address wider environmental externalities such as adaptation to climate change

ƒ assessment of the climate-related risks associated with a subset of Bank operations in India.

Other relevant programmes in South Asian countries include the Village Aid Programme and the Integrated Rural Development Programme (IRDP) facilitating digging canals, increasing connectivity and adaptation of improved farm practices in Pakistan; the IRDP and the Minimum Needs Programme for infrastructure development and programmes on watershed management and on capacity building in **India**; Grameen Bank programme for rural credit to rural poor and the **Bangladesh** Rural Advancement Committee on providing education and training in **Bangladesh** and irrigation projects in **Sri Lanka**.

Table V-[illegible] **Adaptation measures in key vulnerable sectors highlighted in national communications of developing countries**

Vulnerable sectors	Reactive adaptation	Anticipatory adaptation
Water Resources	– Protection of groundwater resources – Improved management and maintenance of existing water supply systems – Protection of water catchment areas – Improved water supply – Groundwater and rainwater harvesting and desalination	– Better use of recycled water – Conservation of water catchment areas – Improved system of water management – Water policy reform including pricing and irrigation policies – Development of flood controls and drought monitoring
Agriculture and food security	– Erosion control – Dam construction for irrigation – Changes in fertilizer use and application – Introduction of new crops – Soil fertility maintenance – Changes in planting and harvesting times – Switch to different cultivars – Educational and outreach programmes on conservation and management of soil and water	– Development of tolerant/resistant crops (to drought, salt, insect/pests) – Research and development – Soil-water management – Diversification and intensification of food and plantation crops – Policy measures, tax incentives/subsidies, free market – Development of early warning systems
Human health	– Public health management reform – Improved housing and living conditions – Improved emergency response	– Development of early warning system – Better and/or improved disease/vector surveillance and monitoring – Improvement of environmental quality – Changes in urban and housing design
Terrestrial ecosystems	– Improvement of management systems including control of deforestation, reforestation and afforestation – Promoting agroforestry to improve forest goods and services – Development/improvement of national forest fire management plans – Improvement of carbon storage in forests	– Creation of parks/reserves, protected areas and biodiversity corridors – Identification/development of species resistant to climate change – Better assessment of the vulnerability of ecosystems – Monitoring of species – Development and maintenance of seed banks – Including socioeconomic factors in management policy
Coastal zones and marine ecosystems	– Protection of economic infrastructure – Public awareness to enhance protection of coastal and marine ecosystems – Building sea walls and beach reinforcement – Protection and conservation of coral reefs, mangroves, sea grass and littoral vegetation	– Integrated coastal zone management – Better coastal planning and zoning – Development of legislation for coastal protection – Research and monitoring of coasts and coastal ecosystems

Source: National communications of non-Annex I Parties[illegible] and UNFCCC Sixth compilation and synthesis of initial national communications from Parties not included in Annex I to the Convention. Note by the secretariat. Addendum 5. Climate change impacts, adaptation measures and response strategies[illegible]