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Mainstreaming Disaster Risk Reduction & Climate Change Adaptation in District Level Planning

A Manual for District Planning Committees

January 2017

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Table of Contents

Preface *v*
Foreword *vii*
Abbreviations and Acronyms *ix*

1. Introduction **1**
1.1 Background 1
1.2 Aim and Objectives 5

2. Disaster Risk Reduction **7**
2.1 Hazard, Risk, Vulnerability and Capacity Assessment (HRVCA) 9
2.2 Risk Informed Development Planning 12

3. Climate Change Adaptation **17**
3.1 Risks Emanating from Climate Change 20
3.2 Sectors/Departments likely to get Impacted by Climate Change 30
3.2.1 Agriculture & Horticulture 30
3.2.2 Water Resources 30
3.2.3 Ecosystems 31
3.2.4 Coastal Systems and Low-lying Areas 31
3.2.5 Health 32
3.2.6 Forest and Environment 33
3.2.7 Infrastructure 33
3.2.8 Tourism 34
3.2.9 Industry 34
3.2.10 Education 35
3.2.11 Animal Husbandry/Fisheries 35
3.2.12 Glacial Lake Outburst Flood (GLOF) 36
3.2.13 Gender Risks in Climate Change 37

4. Prevention and Mitigation Measures **39**
4.1 Structural Mitigation Measures 39
4.2 Non-structural Mitigation Measures 40
4.3 Hazard-specific Mitigation Measures 45

5. Mainstreaming of DRR and CCA in District Level Planning **47**
5.1 Procedure/Methodology for Mainstreaming of DRR and CCA in District Level Planning 48

6. Checklists **51**
6.1 Checklist for Community Physical Infrastructure, Shelter and Settlement 51
6.2 Checklist for Water Resources 53
6.3 Checklist for Educational Infrastructure 54
6.4 Checklist for Health Infrastructure 56
6.5 Checklist for Agriculture, Food Security and Livelihood 58
6.6 Checklist for Animals and Fisheries 59
6.7 Checklist for Rural Roads 60
6.8 Checklist for Environment 60
6.9 Checklist for Migration 61
6.10 Checklist for Gender Issues in DRR and CCA 61

References **63**

Annexures **65**

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Preface

Path-breaking constitutional amendments and greater fiscal devolution offers enormous opportunities for local governance institutions to play a greater role in the planning and implementation of initiatives at the district level. Local communities and governance institutions are often the first to face the brunt of disasters and are often first responders. As climate change continues to cut across regions, geographies and communities, being able to adapt to this risk and uncertainity is a key challenge facing district planners across the country.

UNDP is delighted to support the publication of this important manual which aims to aid the process of institutionalising disaster risk reduction and climate change adaptation in district planning. It outlines the importance of disaster risk reduction and climate change adaptation to district planners, and offers tools and instruments to help in mainstreaming of relevant measures in district level planning. It also provides useful templates and checklists against which projects and development initiatives can be vetted through the lens of improving resilience.

We hope that this manual will also provide a useful reference point for those engaged in development planning, from the perspective of reducing disaster risk and adapting to climate change.

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सत्यमेव जयते

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Foreword

The Indian sub-continent is highly prone to natural hazards. The catastrophes such as flood, hail storm, earthquake, cyclone, drought etc. have been causing loss of lives besides immense destruction to physical infrastructure and economic assets. Loss of human lives due to disasters has been reduced to a large extent over the last decade due to several structural and non-structural measures. However, physical damage and economic losses are increasing due to many factors including lack of risk sensitive development planning at district levels. Therefore, there is an urgent need for integrating Disaster Risk Reduction (DRR) & Climate Change Adaption (CCA) into the ongoing and existing developmental plans, so that physical and economic damages from disasters are minimised.

2. The Ministry of Home Affairs (MHA) has been working with the Central Ministries, Departments and State Governments to mainstream DRR and CCA into the ongoing and new developmental schemes, However, it has been felt that DRR and CCA considerations are not adequately considered in the district level developmental planning process due to lack of appropriate tools/manual. The District Planning Committees play an important role in district level planning. However, their members are often not sensitised on risk sensitive planning.

3. This manual is an effort to fill the gaps with regard to institutionalising DRR and CCA into developmental planning at district levels. It offers guidance to District Planning Committees, District Disaster Management Authorities, Planning Officers, concerned line Departments and Institutions for mainstreaming DRR and CCA measures in planning and implementation of various on-going and new projects. It provides a set of checklists for vetting different development projects through the lens of DRR and CCA as well to ensure that development projects are resilient to disasters and do not add to existing disaster risk faced by the communities.

4. I hope this manual will be useful to build capacities of District Planning Committees, Planning Officers and others in mainstreaming DRR & CCA measures into district level development planning.

(Sanjeev K Jindal)

Abbreviations and Acronyms

ADB	:	Asian Development Bank
ADPC	:	Asian Disaster Preparedness Centre
ANM	:	Auxiliary Nurse Midwife
ANSS	:	Advanced National Seismic System
BRGF	:	Backward Region Grant Fund
CCA	:	Climate Change Adaptation
C-DAC	:	Centre for Development of Advanced Computing
CPDAC	:	Coastal Protection and Development Advisory Committee
CSS	:	Centrally Sponsored Scheme
CWC	:	Central Water Commission
CWPRS	:	Central Water and Power Research Station
DDC	:	District Development Council
DDMA	:	District Disaster Management Authority
DDMP	:	District Disaster Management Plan
DIA	:	Disaster Impact Assessment
DMG	:	Department of Mines and Geology
DPC	:	District Planning Committee
DRR	:	Disaster Risk Reduction
EERI	:	Earthquake Engineering Research Institute
EIA	:	Environmental Impact Assessment
EQ	:	Earthquake
FCHW	:	Female Community Health Worker
FMIS	:	Flood Management Information System
FMWCs	:	Farmer-Managed Water Courses
GDP	:	Gross Domestic Product
GEC	:	Gujarat Ecology Commission
GIZ	:	Gesellschaft für Internationale Zusammenarbeit
GLOF	:	Glacial Lake Outburst Flood

GoI	:	Government of India
GSI	:	Geological Survey of India
HH	:	Household
HR	:	Human Resource
HRVCA	:	Hazard Risk Vulnerability Capacity Assessment
ICAR	:	Indian Council of Agricultural Research
ICEF	:	India-Canada Environment Facility
ICIMOD	:	International Centre for Integrated Mountain Development
ICRC	:	International Committee of the Red Cross
IDNDR	:	International Decade for Natural Disaster Reduction
IDRN	:	India Disaster Resource Network
IEC	:	Information Education Communication
IMD	:	India Meteorological Department
INCOIS	:	Indian National Centre for Ocean Information Services
IPCC	:	Intergovernmental Panel on Climate Change
IRIS	:	Incorporated Research Institutes for Seismology
ISRO	:	Indian Space Research Organisation
JNNURM	:	Jawaharlal Nehru National Urban Renewal Mission
KAP	:	Knowledge, Attitude and Practice
MDGs	:	Millennium Development Goals
MGNREGS	:	Mahatma Gandhi National Rural Employment Guarantee Scheme
MHA	:	Ministry of Home Affairs
MoEF	:	Ministry of Environment and Forest
MoPR	:	Ministry of Panchayati Raj
MSSRF	:	M.S. Swaminathan Research Foundation
NAPCC	:	National Action Plan on Climate Change
NDMA	:	National Disaster Management Authority
NDRF	:	National Disaster Response Force
NEHRP	:	National Earthquake Hazard Reduction Program
NEIC	:	National Earthquake Information Centre
NEIST	:	North East Institute of Science and Technology
NGO	:	Non Governmental Organisation
NGRI	:	National Geophysical Research Institute
NICEE	:	National Information Centre for Earthquake Engineering
NIDM	:	National Institute of Disaster Management
NRSC	:	National Remote Sensing Centre
NSIDC	:	National Snow and Ice Data Centre
PDNA	:	Post Disaster Needs Assessment
PES	:	Payment for Ecosystem Services
PESO	:	Petroleum and Explosives Safety Organisation

PHC	:	Primary Health Centre
POL	:	Petroleum, Oil and Lubricant
PRIs	:	Panchayati Raj Institutions
RIDP	:	Risk Informed Development Planning
SAPCC	:	State Action Plan on Climate Change
SASE	:	Snow and Avalanche Study Establishment
SDG	:	Sustainable Development Goals
SDMA	:	State Disaster Management Authority
SDMP	:	State Disaster Management Plan
SECED	:	Society of Earthquake and Civil Engineering Dynamics
SEIA	:	Social and Environmental Impact Assessment
SIA	:	Social Impact Assessment
SPM	:	Summary for Policymakers
SREX	:	Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation
TLC	:	Temporary Learning Centre
UNDP	:	United Nations Development Programme
UNEP	:	United Nations Environment Programme
UNFCCC	:	United Nations Framework Convention on Climate Change
UNISDR	:	United Nations International Strategy for Disaster Reduction
USAID	:	United States Agency for International Development
USGS	:	United States Geological Survey
VFDS	:	Village Forest Development Society
WASH	:	Water, Sanitation and Hygiene
WDC	:	World Data Centre
WHO	:	World Health Organization
WIGH	:	Wadia Institute of Himalayan Geology
WSM	:	World Stress Map
WWF	:	World Wild Fund for Nature

Introduction

1

1.1 Background

History of planning process at local level

Panchayats have been the backbone of Indian villages since the beginning of recorded history. In 1946, Mahatma Gandhi, the Father of the Nation, had aptly remarked that the Indian Independence must begin at the bottom and every village ought to be a Republic or Panchayat having powers. Gandhiji's dream has been translated into reality with the introduction of the three-tier Panchayati Raj system to ensure people's participation in rural reconstruction.

Decentralised planning found expression for the first time in the First Five Year Plan (1951-56), when it was suggested that the planning process be undertaken at the state and district levels too. Under these arrangements, a District Development Council (DDC) was constituted in each district to prepare plans, based in varying degrees upon a village-level participative process. The first Administrative Reforms Commission (1967) stressed the need for meaningful planning at the district level, especially focusing on local variations in development patterns. The Planning Commission issued its first guidelines for district planning in 1969 that led to several states formulating district plans.

The 73rd and 74th Amendments of the Constitution marked a new era in the federal democratic setup clearly envisaging a reversal of the hitherto centralised approach to district planning. The 74th Constitutional Amendment Act mandated the establishment of District Planning Committees (DPCs) for consolidating plans prepared by Panchayats and municipalities in the district into the Draft District Plan. In conformity with the above, most of the states have enacted legislation for the constitution of the DPCs.

In order to assess the functions and resources of PRIs and understand the impediments to the optimal realisation of the goals of the 73rd and 74th Constitution (Amendment) Acts, the Ministry for Panchayati Raj (MoPR) and the Planning Commission jointly commissioned an Expert Group for planning at the grassroot level, chaired by Ramachandran in 2005. The Ramachandran Committee Report envisages strong roles for local governments, greater rural-urban coordination and planning, and emphasises the inclusion of marginalised groups via participatory process. It recommends that the DPC should be a permanent institution equipped with a secretariat to support its functioning. The DPC should be the nodal agency for district level planning and related tasks, including those relating to Central Plan schemes, need to be routed through DPCs. The DPC can take the assistance of technical and academic institutions and experts to perform its functions effectively. The Group laid out detailed guidelines for the district level planning process and the role of DPCs therein.

Rationale for development of this manual

Even though decentralised district planning found expression in the first Five Year Plan and the creation of DDCs initiated the participation of districts in the planning process, yet planning continued to be a top down vertical process. The role of local bodies, non-governmental organisations (NGOs) and voluntary support institutions were largely ignored or went unnoticed. As a result, most developmental programmes have worked in contravention to inclusive growth. Thus, poverty and vulnerability of communities could not be sufficiently addressed in most of the flagship programmes of governance.[1]

The process of district planning, as envisaged by the erstwhile Planning Commission of India, offers a significant window of opportunity to local governments to influence the entire range of government interventions in a district. A crucial step towards this end has been the establishment and strengthening of DPCs for consolidating plans prepared by Panchayats and municipalities in the district into the District Plan.

While the policy environment is conducive to planning processes at district level, it has been observed that there are a number of practical issues and challenges which hinder the process of participatory and decentralised planning, comprehensiveness and integrated nature of the process in many states. The Fifteenth Report of the Second Administrative Reforms Commission on 'State and District Administration' (2008) also draws attention to the implementation challenges of developmental programmes. Some of the key challenges include:

- Lack of capacity to play the critical role of coordination and facilitation of convergence related to integrated district planning processes
- Lack of clear operational guidelines and directives enabling integration of plans at the level of DPCs
- Poor rural-urban linkages etc.
- Critical need for enhancement of the ownership, capacities and development perspectives of functionaries of local governments – through intense orientation related to inclusive planning and monitoring of delivery of essential services

The Planning Commission took action on these proposals and communicated to the States that the approval of Annual Plan proposals for 2006-07 will be contingent upon the constitution of DPCs in all the districts. Another crucial step towards activating the decentralised planning process in the country through DPCs is visible in the Planning Commission's instructions for district planning under the Eleventh Plan and guidelines for access to BRGF. The Planning Commission also produced a Manual for Integrated District Planning in November 2008 to provide a step-by-step guide to district planning, which will assist planners at the local, district and State levels.

However, it is found that disaster risk reduction (DRR) and climate change adaptation (CCA) considerations are not appropriately addressed during the process of district planning through the DPCs. This is primarily due to lack of adequate appreciation of hazards, risks and vulnerability, lack of tools & techniques and capacity at the grassroots level. The need for providing tools and training field officers and the people on the ground in processes and procedures for mainstreaming DRR and CCA in development planning is well recognised.

There is a need for the DPCs to improve their understanding of DRR and CCA in terms of a development issue. The major constraints in mainstreaming of DRR and CCA in district planning are: (a) a recognised lack of understanding of DRR and CCA; (b) insufficient

[1] http://www.jnu.ac.in/cslg/courses/LG643.pdf

Climate Change

Adaptation Strategies

Hazard Specific Adaptation Measures To Deal With Climate Risks Due To Extreme Weather Conditions

1. EXTREME HEAT

- Put in place an early warning system with strong surveillance and trigger mechanism
- Promote construction of green and sustainable houses using heat reflecting construction material
- Construct sheds for homeless during extreme heat
- Promote plantation drives
- Construct drinking water points

2. CHANGING RAINFALL PATTERNS

- Strengthen forecasting and warning dissemination system against flood, flash flood and drought
- Enforce building codes to ensure that homes and infrastructure are not at risk
- Promote flood/drought resistant crops

3.EXTREME COLD

- Strengthen early warning dissemination to the last mile
- Improve housing designs to withstand extreme weather conditions
- Construct shelters for homeless and fire places for poor community

6. SEA LEVEL RISE

- Ensure strict enforcement of building codes and appropriate urban planning to address future climate-related disasters
- Promote shelter bed plantation for coastal protection
- Build coastal embankments
- Ensure strict enforcement of coastal regulation zone codes

Climate Change Adaptation requires coming together of the key sectors such as Agriculture, Environment, Health, and Housing etc to take concerted initiatives to mitigate the risks

guidance on how to mainstream these components; and (c) the limited opportunities for mainstreaming in the district level planning due to a lack of instruments and capacity in this field.

However, there are also opportunities with regard to mainstreaming of DRR and CCA in district level planning such as: (a) awareness of the need to mainstream DRR and CCA into district planning; (b) the robust structure of the DRR planning framework in the country, which provides a suitable channel for facilitating mainstreaming; and (c) the fact that DRR and CCA are receiving more attention and financial and technical support from both within the country and the international community.

Set against this background, efforts have been made towards developing a manual to help the DPCs in mainstreaming of measures of DRR and CCA in district level planning.

Intended users of this manual

The primary users of the manual are DPCs and district planning officers who have the primary responsibility of district level planning. Additionally, different line departments and institutions may find the manual useful in obtaining resources and tools for mainstreaming of DRR and CCA measures in their planning as well as in the implementation of the activities and projects. District Disaster Management Authorities (DDMAs) can also benefit from this manual in undertaking initiatives aimed at increasing resilience of their respective districts to various disasters.

1.2 Aim and Objectives

The overall aim of this manual is to guide the DPCs and District Planning Officers on the importance of DRR and CAA and the approach to mainstreaming these components in their district level planning.

Specifically, the key objectives of this manual are:

- To establish the importance of DRR and CCA;
- To develop basic understanding of disaster risks associated with developmental planning;
- To provide guidelines that can help district planners in mainstreaming DRR and CCA;
- To critically examine proposals and developmental plans/projects formulated at the district level from the DRR perspective;
- To ensure incorporation of disaster mitigation measures in the developmental plans/projects;
- To ensure incorporation of appropriate adaptive strategies in various sectors in view of the climate change and global warming challenges; and
- To enhance resilience at individual, community, and institutional level.

Limitations

Mainstreaming of DRR and CCA is too broad a subject to be dealt with wholly in one manual. The readers are required to use this manual as a reference to look at developmental planning from lens of DRR, and to identify ways of mainstreaming DRR and CCA in their plans/projects to specific contexts. It is advised that the readers supplement their understanding with past experience and unfolding situations and local needs.

This manual, however, does not attempt to deal with highly specialised or technical aspects associated with disaster risk and their relationships with complex development matters such as economic, political, social and environmental issues.

Disaster Risk Reduction

2

What is a hazard?

A hazard is a natural or human-made event that threatens to adversely affect human life, property or activity to the extent of causing a disaster. A hazard has a potential to cause harm or damage to:

- People - Leading to death, injury, disease and stress
- Human activity – Impeding economic and educational activities
- Property – Leading to economic loss
- Environment – Leading to destruction of fauna and flora, pollution, and loss of amenities

Some examples of hazards are earthquakes, volcanic eruptions, cyclones, floods, landslides, and other such events.

It is to be noted that **not all hazards can convert into disasters**, for instance, high speed winds or cyclones in inhabited areas of a desert may not result in any loss or damage to life/property, and hence this may not be called a disaster. Similarly, mild earthquake tremors are hazards, but when the intensity of the earthquake is high and it causes loss of life and damage to property etc., it is termed as a disaster.

What is a disaster?

The Disaster Management Act, 2005 defines disaster as *"a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or man made causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of, property, or damage to, or degradation of, environment, and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area".*

Earthquake, cyclone, hailstorm, cloud-burst, landslide, soil erosion, snow avalanche, flood etc. are examples of disasters originating from natural hazards, while fire, epidemics, road, air, rail accidents and leakages of chemicals/nuclear installations etc. fall under the category of human-made disasters.[2]

Disasters result from the combination of three key elements: i) **natural hazards**, including earthquakes, cyclones, excess rainfall, tsunamis, etc.; ii) **exposure** (of people and property to these hazards); and iii) **vulnerability** (of the human and physical capital exposed) due to physical, social, economic, governance, and environmental factors that increase the susceptibility of a community to the impact of a natural hazard.

Vulnerability

An apt description of 'vulnerability' *"is insecurity, the reverse of security";* reflecting *"the*

[2] *Disaster Management* in India, Ministry of Home Affairs, Government of India (www.undp.org/content/dam/india/docs/disaster_management_in_india.pdf)

characteristics of a person or group in terms of their capacity to anticipate, cope with, resist, and recover from the impact of a natural hazard. It involves a combination of factors that determine the degree to which someone's life and livelihood is put at risk by a discrete and identifiable event in nature or in society".[3]

Vulnerability refers to exposure to contingencies and stress and the difficulty in coping with them. It has two components: exposure to hazards, and difficulty (through lack of resources) to cope with and recover from these hazards. The two components reflect:

- an 'external' side of risks, shocks and stress to which a structure, individual, household, community or nation is subject, and
- an 'internal' side of lack of resources to cope without damaging loss.[4]

These descriptions suggest that vulnerability cannot be described without reference to a specific hazard or shock. "Vulnerabilities" are one side of a coin; the other side represents the resources people have to resist, cope with, or recover from a hazard, or "capacities". Vulnerability is about "not having" while capacities are about "having". Vulnerability must always be assessed in relation to a specific hazard or threat. The question to be asked is: "Vulnerability in relation to what?" Is it earthquake, conflict or environmental deterioration or any other threat?

Capacity

Individuals, households, communities and nations must have resources that can resist the impact of a hazard and/or recover quickly from them. A hazard does not cause a disaster unless there are people affected by it/people who do not have the capacity to resist. For example, all countries of the world widely possess something very dangerous:

People's capacities are also highlighted by what are known as "coping strategies". These are responses linked to capacities (or resources), which, in the face of a hazard, determine how vulnerable an individual or household can be. There are various ways in which households move from coping to destitute, or to not coping.

Disaster risk

Disaster risk is defined as the *potential disaster losses, in lives, health status, livelihoods, assets and services, which could occur to a particular community or a society over some specified future time period.*

In other words, disaster risk may be understood as *"The likelihood of harmful consequences resulting from the interaction of hazards (threats), vulnerability (low capacity or coping ability) and the environment (supporting factors)".*

Risk is usually associated with the human inability to cope with a particular situation. The definition of risk must be associated with the idea of probability, which can be applied at two different levels:

- Either to the hazard itself (the probability that a harmful event, such as earthquake, flood, or conflict, will occur), or
- Hazard's impact on the population and its environment (inability to withstand the effects; degree of vulnerability).

Disaster risk conveys or is linked to the probability of a disaster occurring as a result of a threat and one's inability to withstand the threat.

Example

People living in the flood prone areas of Bihar are exposed to many natural hazards (flooding, drought, earthquake, cyclonic winds, fire, spread of diseases such as malaria, typhoid etc.) and are unable to protect themselves sufficiently (hence, vulnerable) against the adverse effects of these hazards. Therefore, a major part of the population is at a constant risk of disaster.

[3] Blaikie et al (2003). At Risk: natural hazards, people's vulnerability and disasters, Routledge, 2003

[4] Robert Chambers (1995). Poverty and livelihoods: whose reality counts? Environment and urbanisation, Vol. 7, No. 1, April 1995

Disaster risk reduction

Disasters often follow natural hazards. A disaster's severity depends on how much impact a hazard has on society and the environment. The scale of the impact in turn depends on the choices we make for our lives and for our environment. These choices relate to how we grow our food, where and how we build our homes, what kind of government we have, how our financial system works and even what we teach in schools. Each decision and action makes us more vulnerable or more resilient to disasters.

Disaster risk reduction (DRR) is the concept and practice of reducing disaster risks through systematic efforts to analyse and reduce the causal factors of disasters. Reducing exposure to hazards, lessening vulnerability of people and property, wise management of land and the environment, and improving preparedness and early warning for adverse events are all examples of disaster risk reduction.

DRR includes disciplines like disaster management, disaster mitigation and disaster preparedness, but is also part of sustainable development. In order for development activities to be sustainable, they must also reduce disaster risk. On the other hand, unsound development policies will increase disaster risk as well as losses resulting from disasters. Thus, DRR involves all levels of the society, government, and the professional and private sector.

The relation between growth and disaster risk is best demonstrated at the local, community and family levels where the routines of daily life are analysed based on the level of risk people face each day. In other words, risk, being part of our lives, cannot be separated from the whole process of what constitutes development and the daily social interactions (e.g. provision of general services to ensure security and healthy livelihood, job security etc.) at the national, community or the family level.

For example, if people, in their desperation, are forced to access unsafe land and live in/or build poor houses (which contributes to the expansion of existing slums), or to struggle with minimum incomes and exist on a livelihood of insecurity and continue to be marginalised, then all these combined factors, which creates a dynamic exacerbating pressure on families and communities, are indications of an impending disaster. In this spiral of a worsening environment, the mounting disaster risk is like a time bomb that a population is forced to live with in their daily struggle for survival. And as such any development plans/programmes should, therefore, incorporate from their inception, the concept of DRR to alleviate peoples' low living standards and the risk they face.

DRR should be seen as an integral part of environment (as well as climate change) and development. The impending risk analysis should be done in the light of disasters and possible threat of high intensity disasters due to climate change. Accordingly, mitigation and adaptation programmes should be developed. The mitigation plan should address the issues of structural and non-structural interventions along with the fiscal and monetary tools (for DRR & adaptation) for pre and post disaster planning. If DRR is mainstreamed, sustainable development can be attained and miseries of the people can be minimised. The top down and bottom up institutional linkages for policy formulation and programme execution would be interdependent with each other.

2.1 Hazard, Risk, Vulnerability and Capacity Assessment (HRVCA)

Hazard, Risk, Vulnerability and Capacity Assessment (HRVCA) is concerned with collecting, analysing and systematising information on a given community's vulnerability to hazards in a structured and meaningful way. This information is then used to diagnose the key risks and existing capacities of the community, ultimately leading to activities aimed at reducing people's vulnerability to potential disasters and increasing their capacity to survive them and resume their lives.

Experiences of various agencies on HRVCA have shown that there are interesting spin-offs from the process. One of these is how disaster management can be better integrated with other projects so that they support each other. This enables agencies to respond more effectively to people's local concerns – e.g., unsafe drinking water, exposure to malaria or traffic accidents – whilst pursuing disaster preparedness activities within the community. Overall, this implies a more integrated approach to the idea of vulnerability.

HRVCA uses various participatory tools to gauge people's exposure to and capacity to resist natural hazards. It is an integral part of disaster preparedness and contributes to the creation of community-based disaster preparedness programmes at the rural and urban grass-roots level.

HRVCA enables local priorities to be identified and appropriate action taken to reduce disaster risk and assists in the design and development of programmes that are mutually supportive and responsive to the needs of the people most closely concerned.

The aims of HRVCA are to:

- assess risks and hazards facing communities and the communities' capacities for dealing with these;
- involve communities, local authorities and humanitarian and development organisations in the assessment from the outset;
- draw up action plans to prepare for and respond to the identified risks; and
- identify risk reduction activities to prevent or lessen the effects of expected hazards, risks and vulnerabilities.

HRVCA is complementary to national and sub-national risk, hazard, vulnerability and capacity mapping exercises that identify communities most at risk. A HRVCA is then undertaken in these communities to diagnose the specific areas of risk and vulnerability and determine what action can be taken to address them. To complete the circle, what a HRVCA unearths at the local level can provide a valuable indication of national and sub-national vulnerabilities and capacities.

Different types of hazards

A High Power Committee on Disaster Management, constituted in 1999, has identified 32 various disasters categorised into five major sub-groups (Table 2.1).

Hazard profile of India

India has been vulnerable, in varying degrees, to a large number of natural as well as human-made disasters on account of its unique geo-climatic and socio-economic conditions. It is highly vulnerable to floods, droughts, cyclones, earthquakes, landslides, avalanches and forest fires. Twenty-seven of its 36 states and union territories are disaster prone. Almost 58.6 percent of the landmass is prone to earthquakes of moderate to very high intensity; over 40 million hectares (12 percent of land) are prone to floods and river erosion; of the 7,516 km long coastline, close to 5,700 km is prone to cyclones and tsunamis; 68 percent of the cultivable area is vulnerable to drought; and hilly areas are at risk from landslides and avalanches.

India is one of the 10 worst disaster prone countries of the world. The country is prone to disasters due to several factors, both natural and human induced, including adverse geo-climatic conditions, topographic features, environmental degradation, population growth, urbanisation, industrialisation, non-scientific development practices etc. These factors, either in original or by accelerating the intensity and frequency of disasters, are responsible for heavy toll of human lives and disrupting the life supporting system in the country.

The basic reason for the high vulnerability of the country to natural hazards is its unique geographical and geological situations. As far as the vulnerability to disaster is concerned, the four distinctive regions of the country, i.e.

Figure 2.1 Multi-Hazard Map of India

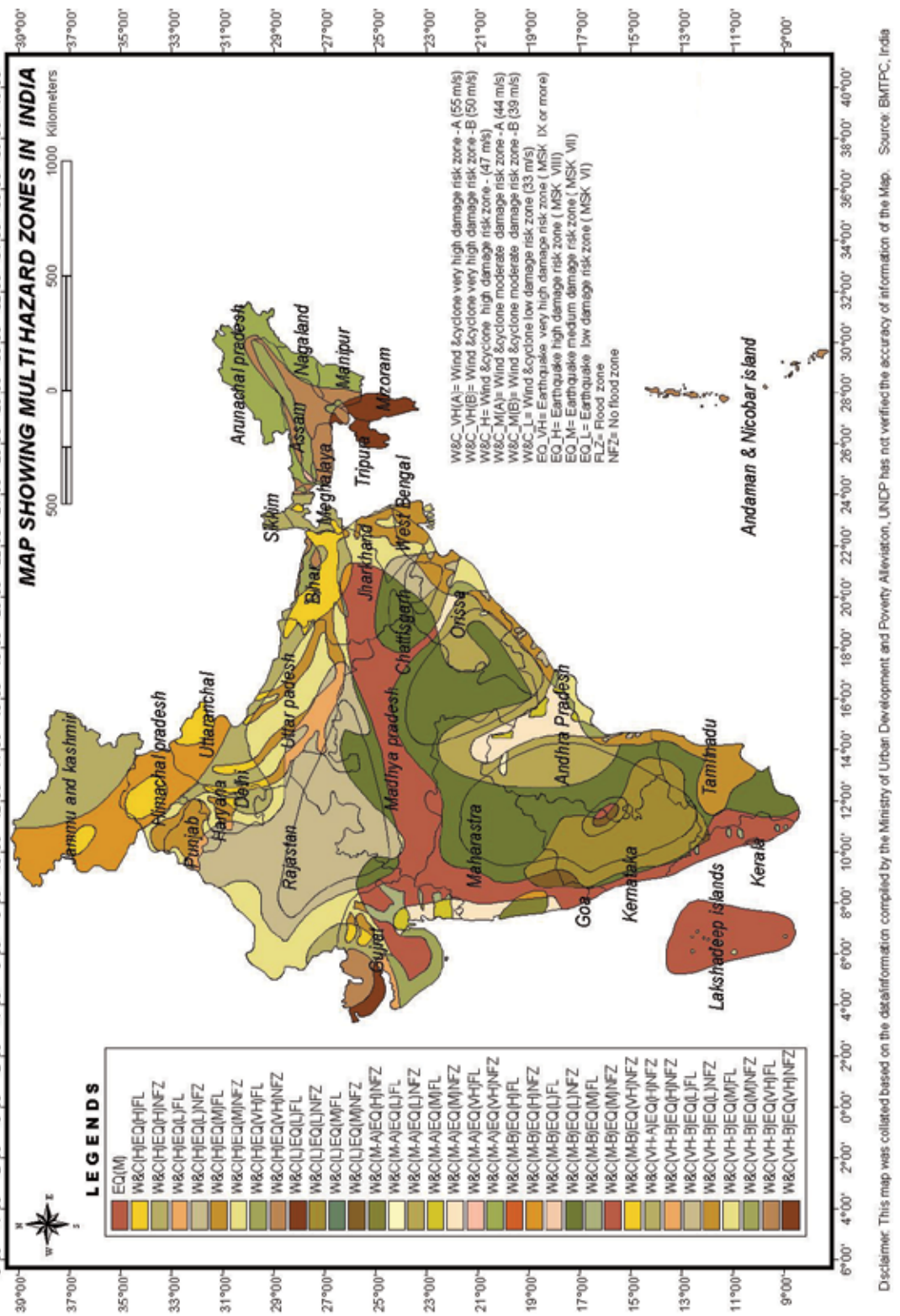


Table 2.1 Categorisation of Disasters

Sl.	Broad type of disaster	Disaster
	Water and climate related disasters	1. Floods and drainage management 2. Cyclones 3. Tornadoes and hurricanes 4. Hailstorm 5. Cloud burst 6. Heat wave and cold wave 7. Snow avalanches 8. Droughts 9. Sea erosion 10. Thunder and lightning 11. Tsunami
	Geological related disasters	1. Landslides and mudflows 2. Earthquakes 3. Dam failures/dam bursts 4. Minor fires
	Chemical, industrial and nuclear related disasters	1. Chemical and industrial disasters 2. Nuclear disasters
	Accident related disasters	1. Forest fires 2. Urban fires 3. Mine flooding 4. Oil spills 5. Major building collapse 6. Serial bomb blasts 7. Festival related disasters 8. Electrical disasters and fires 9. Air, road and rail accidents 10. Boat capsizing 11. Village fire
	Biological related disasters	1. Biological disasters and epidemics 2. Pest attacks 3. Cattle epidemics 4. Food poisoning

the Himalayan region, the alluvial plains, the hilly part of the peninsula, and the coastal zone have their own specific problems. While the Himalayan region is prone to disasters like earthquakes and landslides, the plains are affected by floods almost every year. The desert part of the country is affected by droughts and famine, while the coastal zone is susceptible to cyclones and storms.

2.2 Risk Informed Development Planning

Development is an event which bears a change from the previous state of existence. In the context of human wellbeing, development traces the change from one level of existence to another accounting for greater prosperity. Furthermore, development must also acknowledge and account for the growing levels of capacity of the people and their reducing vulnerabilities as a result of the growing capacities. The question, therefore, is how development and the idea of risk of disaster fit in a single, seamless equation that explains how disasters or risks affect development and what must, therefore, be done in order to evade such situations.

To arrive at this solution, a point needs to be established first concerning our outlook towards disaster. In 2013, Yeb Sano, UNFCCC Negotiator, said in Philippines, after Typhoon Haiyan had hit the country, *"We must stop calling events like these [typhoons] as natural disasters. Disasters*

Benefits of Disaster Risk Reduction

- A Vietnam Red Cross mangrove planting programme implemented in eight provinces in Vietnam to provide protection to coastal inhabitants from typhoons and storms cost an average US$ 0.13 million a year over the period 1994 to 2001, but reduced the annual cost of dyke maintenance by US$ 7.1m. The programme also helped save lives, protect livelihoods and generate livelihood opportunities.
- Spending one percent of a structure's value on vulnerability reduction measures can reduce probable maximum loss from hurricanes by around a third in the Caribbean, according to regional civil engineering experts.
- One dollar spent by Federal Emergency Management Agency (FEMA) on hazard mitigation generates an estimated US$ 4 on average in future benefits according to a study of FEMA grants (including for retrofitting, structural mitigation projects, public awareness and education and building codes).
- Only two schools were left standing in Grenada after the passage of Hurricane Ivan (September 2004). Both had been subject to retrofit through a World Bank initiative. One of the schools was used to house displaced persons after the event.
- Between 27 August and 18 September 1995, Hurricanes Luis and Marilyn damaged 876 housing units in Dominica, causing a total loss of US$ 4.2 million. The small wooden houses that were destroyed did not comply with local building codes. But all the buildings that had been retrofitted via simple modifications to local construction techniques under the Caribbean Disaster Mitigation Project's Safer Construction Programme funded by the United States Agency for International Development (USAID) successfully withstood the hurricanes.

are never natural. They are intersection of factors other than physical. They are the accumulation of the constant breach of economic, social, and environmental thresholds". [5] If we analyse this statement it shows that disasters are nothing but the adverse manifestations of hazards, which occur due to reasons extending from bad infrastructure to bad policy outcomes concerning the economic, gender, and cultural minorities.

Risk resistant schemes and policy making is extremely important, considering that when the risks manifest as disasters they push back development and the ability to develop exponentially. It is, therefore, imperative that development planning be risk informed and that this information flow seamlessly through all levels of system in order to create a robust development mechanism. This practice is called Risk Informed Development Planning (RIDP) as developed by the United Nations Children's Fund (UNICEF). The aim for this process is to simply provide a development planning interface that allows creation of contingency plans and robust decision-making, informed of the risks that face the geographical area and the people living there.

Role of DPCs in risk informed development planning

With the above background and the importance of risk informed development planning, the role of DPCs becomes highly crucial to ensure that the plans developed at district level have enough consideration given to appreciate the local risks, and appropriate measures are taken to reduce

[5] Hillier and Nightingale (2013). *How disasters disrupts development.* Oxfam International December 2013

the risks through disaster resilient development planning. This calls for several small but important steps such as:

- Inclusion of DRR as terms of reference for developing proposals/projects in the district so that the proposals/projects appropriately address the local risks of the area as well as mitigate any risk arising from that particular project itself that may be posed on the environment, community, or the local ecosystems etc.;
- Providing a checklist on DRR to be completed and annexed with the project proposals;
- Involvement of a disaster management expert/specialist for review/vetting of proposals/projects at district level;
- Prioritisation of plan/programmes addressing disaster risks in the district based on the local vulnerabilities and needs;
- Establishing linkages with Social and Environmental Impact Assessment (SEIA) of the proposed projects and activities;
- Sensitisation and orientation of various stakeholders for risk sensitive planning;
- District level HRVCA with village, Gram Panchayat and block level risk mapping; and
- Vetting the district sectoral plans through the disaster lens to see whether they improve the capacities and reduce vulnerability levels.

It is to be noted that these are only illustrative actions and there will be more actions/options available to ensure risk informed development planning based on the local vulnerabilities and needs. The DPCs are advised to take leads from this manual but not be constrained by these options alone. These options are just to trigger a thought process; the DPCs should apply their local knowledge and experience to ensure that contextualised and need based planning is done for the district.

Poverty and Disasters

Poverty and vulnerability to natural hazards are closely linked and mutually reinforcing. Disasters are a source of hardship and distress, potentially temporarily forcing certain groups below the poverty threshold and also contributing to more persistent, chronic poverty. Disasters can result in the loss of lives, homes and assets, disrupt livelihood opportunities, schooling and provision of social services, erode savings and create health problems, sometimes with long-term consequences. Disasters can also disrupt ongoing poverty reduction activities and force a diversion of related financial resources into relief and rehabilitation efforts. Poverty can be further reinforced by deliberate risk-averting, ex-ante livelihood choices that poorer households may make. For example, poorer households may choose to forego the potential benefits of higher yielding or more profitable crops in favour of more hazard-tolerant ones.

Poor and socially disadvantaged groups, in turn, are among the most hazard vulnerable, reflecting their social, cultural, economic and political environments – for instance, the substandard quality and often, dangerous location of housing (e.g., on flood plains, riverbanks or steep slopes); lower levels of access to basic services, particularly for the rural poor and illegal squatters; uncertain ownership rights, reducing incentives to manage resources sustainably or invest in structural mitigation measures; often more vulnerable livelihoods; and limited access to financial resources, constraining their ability to diversify livelihoods and recover post disaster. The poor can also exacerbate their own risk where limited livelihood opportunities force over-exploitation of the local environment. Meanwhile, the covariate nature of natural hazards implies that there is limited scope for formal and informal community-based support systems in the aftermath of a disaster.

The Role of District Planning Committee (DPCs) in

RISK INFORMED DEVELOPMENT PLANNING

The cost of disasters worldwide has reached an average of $250 billion to $300 billion every year

India has been hit by 431 major disasters in the last three decades resulting in enormous loss to life and property

India's average annual economic loss due to disasters — **$9.8 billion** Approx ₹65,000 crores

India's Average Annual Loss by Disasters

Earthquake	-	19
Cyclone	-	447
Storm Surge	-	727
Tsunami	-	1,160
Flood	-	7,472
Total	-	**9,825**

Figures in Million $

Sources : Global Assessment Report on Disaster Risk Reduction 2015

Economic losses due to disasters can be reduces by incorporating risk mitigation measures in developmental projects

The Key Considerations for the District Planning Committees

1 **Include DRR in the Development Projects**

Take Appropriate **MITIGATION** Measures

Consider disaster risks before initiating developmental projects

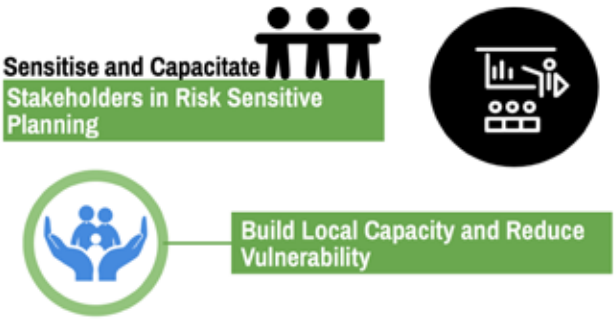
2 Ensure Risk Sensitive and Informed Developmental Projects

Take professional advice of a disaster management expert to vet the project proposals

Ask for a checklist on DRR to be annexed with the project proposals

3 Consider Vulnerabilities and Needs of the Community

4 Sensitise and Build Capacity of the Key Stakeholders



5 Facilitate Integration and Inter-Departmental Linkages

Link District Level Hazard Vulnerability Risk Analysis with

Ensure Inter-departmental linkages of the key sectors

Climate Change Adaptation

3

Climate change adaptation (CCA) can be better understood by having clarity about the basic terms and concepts related to the subject.

Weather

It is important not to confuse weather and climate. Weather is the short term daily and hourly changes in conditions such as temperature, rain, wind and humidity, which can most reliably be predicted only up to about fifteen days in advance.

Climate

Climate is defined as the average weather or 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. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organisation. The relevant 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.[6]

Climate variability

Climate variability is variations from the mean state (and other statistics, such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability).[7]

Climate change

Climate change refers to a change in the state of the climate that can be identified (e.g. by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.[8]

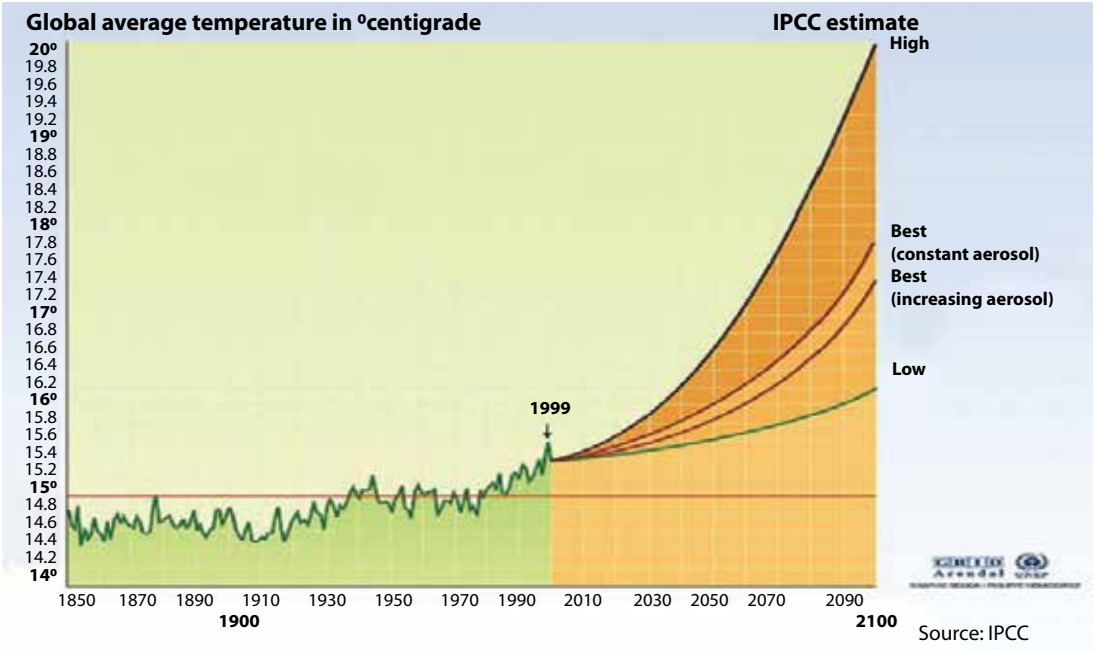
Global warming and climate change are now well recognised and accepted. The fourth Assessment Report of Intergovernmental Panel on Climate Change (IPCC) takes into account the increase in the global average air and ocean temperatures, precipitation and extreme rainfall, widespread melting of snow and ice, storms/storm surges/ coastal flooding and rising global mean sea level and reports that climate change is expected to increase the frequency and intensity of current extreme weather events and give rise to new

[6] Climate Change 2007 – Impacts, Adaptation and Vulnerability Contribution of Working Group II to the Fourth Assessment Report of the IPCC

[7] IPCC SREX (2012). Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation.

[8] Climate Change 2007 – Impacts, Adaptation and Vulnerability Contribution of Working Group II to the Fourth Assessment Report of the IPCC

Figure 3.1 IPCC Estimates of Climate Change



Source: IPCC

vulnerabilities with differential spatial and socio-economic impacts on communities. The unprecedented increase is expected to have severe impacts on the hydrological cycle, water resource, droughts, flood, drinking water, forest and ecosystems, sea level/coastal area, losses of coastal wetlands and mangroves, food security, health and other related areas. The impact would be particularly disastrous for developing countries, including India, and further degrade the resilience of poor, vulnerable communities, which make up between one quarter and one half of the population of the most Indian cities.

Reason for concern

There is clear evidence that the observed change in surface temperature, rainfall, evaporation and extreme events and climate change is a significant environmental challenge. The main impact of global climate change will be felt due to changes in climate variability and weather extremes;

- Observations during the last decade and projections indicate that extreme events, i.e. heat waves, cold waves, more floods, more droughts, more intense cyclones and flash floods will increase.
- Extreme rainfall has substantially increased over large areas, particularly over the west coast and west central India. There is, thus, an urgent need for a paradigm shift in disaster management, especially under changing climate.

Policy responses to climate change

There are two main policy responses to climate change: mitigation and adaptation. Mitigation addresses the root causes, by reducing greenhouse gas emissions, while adaptation seeks to lower the risks posed by the consequences of climatic changes. Both approaches will be necessary, because even if emissions are dramatically decreased in the next decade, adaptation will still be needed to deal with the global changes that have already been set in motion.

Impact of climate change on India

The key environmental challenges in India have been sharper in the past two decades. Climate change is impacting the natural ecosystems and is expected to have substantial adverse effects in India, mainly on agriculture on which 58 percent of the population depends for livelihood, water

How Climate Change is Intensifying Disasters in India

There is considerable evidence that economic damage caused by extreme weather events has increased substantially over the last few decades. For a country like India, with over 70 percent of its population relying directly or indirectly on agriculture for their livelihoods, the impact of extreme weather events is critical. People often live in areas of high ecological vulnerability and relatively low levels of resource productivity and have limited and insecure rights over productive natural resources. These combined factors are significant forces contributing to vulnerability to natural disasters (Baumann et al., 2003).

Changes in the precipitation patterns and any intensification of the monsoons will contribute to flood disasters and land degradation and will thus have far-reaching consequences for the entire economy (Stern, 2006). In the last decade, India has been repeatedly battered by successive monsoons, flooding and droughts. For example, the state of Odisha has experienced floods in 49 of the last 100 years, droughts in 30 and cyclones in 11 years. The occurrence of droughts, floods and cyclones in a single year is not unusual. In addition, the number of villages in India experiencing drought is increasing (Tompkins, 2002). India's water supply depends not only on monsoon rains but also on glacial melt water from the Hindu Kush and the Himalayas. Rising temperatures will cause snowlines to retreat further, increasing the risk of floods during the summer monsoon season (Greenpeace India, 2010).

Currently, as much as 68 percent of India is drought-prone and 12 percent (more than 40 million hectares) is flood-prone. India has a long coastline of about 7,516 kilometres of flat coastal terrain and shallow continental shelf with high population density and is extremely vulnerable to cyclones and its associated hazards like storm tide, high velocity wind and heavy rains. Although the frequency of tropical cyclones in the North Indian Ocean, including the Bay of Bengal and the Arabian Sea, is the lowest in the world (7 percent of the global total), their impact on the east coast of India is more devastating in relative terms (Mittal, 2010). About 8 percent of the area in the country is prone to cyclone-related disasters. The number of storms with more than 100 millimetres of rainfall in a day is reported to have increased by 10 percent per decade (UNEP, 2009).

storage in the Himalayan glaciers which are the source of major rivers and groundwater recharge, sea-level rise, and threats to a long coastline and habitations. Climate change will also cause increased frequency of extreme events such as floods and droughts. These, in turn, will impact India's food security problems and water security.

Link between DRR and CCA

DRR and climate change mitigation and adaptation share common goals; both aim to reduce the vulnerability of communities and achieve sustainable development.

While emphasis of DRR is on prevention, mitigation, preparedness and recovery from geological hazards such as earthquakes, landslides etc. as well as hydro-meteorological disasters such as floods, cyclones, CCA is mainly linked with hydro-meteorological disasters and aims at reducing vulnerability due to climate change/variability risk through adaptation to gradual changes in climate over a long period.

Environmental and socio-economic impact of climate change

Climate change has been widely acknowledged

as a phenomenon likely to have a significant and perhaps decisive impact on the prospects for development and security worldwide for many decades. Various studies indicate that the likely impacts would be:

- Dry areas will tend to become drier and wet areas will tend to become wetter.
- Coastal storms will increase in frequency and become more intense.
- Disease curtains will migrate northward and southward from the equator.
- India and China may face unprecedented levels of water scarcity, while low-lying areas such as Bangladesh will face unprecedented levels of flooding.
- The timing and intensity of the monsoon, which is the single most important weather process in Asia, are likely to change, although the precise character of this transformation is not yet known.
- It is possible that weather patterns that are vital to the predominantly agricultural economy of much of Asia, such as the beginning of the rainy season, will become harder to predict in the decades ahead.
- The change in climate and weather patterns will pose severe challenges to public health.
- Loss of livelihood opportunities due to various hazards will result in increased population movement and may add to the numbers of climate refugees.
- Climate change and the challenges will diminish state capacity and will create various obstacles to development.
- Environmental damage is a potential result of climate change.

3.1 Risks Emanating from Climate Change

The IPCC describes vulnerability to climate change as being determined by three factors: exposure to hazards (such as reduced rainfall), sensitivity to those hazards (such as an economy dominated by rain-fed agriculture), and the capacity to adapt to those hazards (for example, whether farmers have the money or skills to grow more drought-resistant crops).

Adaptation measures can help reduce vulnerability – for example by lowering sensitivity or building adaptive capacity – as well as allowing populations to benefit from opportunities of climatic changes, such as growing new crops in areas that were previously unsuitable.

Scientists are not the only ones talking about these changes. From the apple growers in Himachal to the farmers in Vidharbha and those living in disappearing islands in the Sunderbans are already struggling with the impacts of climate change. But this is just the beginning. We need to act to avoid catastrophic climate change. While not all regional effects are known yet, some likely future effects, if current trends are allowed to continue, are described in the following sub-sections.

Relatively likely and early effects of small to moderate warming

- Rise in sea level due to melting glaciers and the thermal expansion of the oceans as global temperature increases
- Massive release of greenhouse gases from melting permafrost and dying forests
- A high risk of more extreme weather events such as heat waves, droughts and floods (the global incidence of drought has already doubled over the past 30 years)
- Severe regional impacts (e.g., in Europe, river flooding will increase and in coastal areas the risk of flooding, erosion and wetland loss will increase substantially)
- Natural systems, including glaciers, coral reefs, mangroves, Arctic ecosystems, alpine ecosystems, Boreal forests, tropical forests, prairie wetlands and native grasslands, severely threatened
- Increase in existing risks of species extinction and biodiversity loss
- Poorer countries least able to protect themselves from rising sea levels
- Spread of disease and decline in agricultural production in developing countries of Africa, Asia and the Pacific

At all scales of climate change, developing countries will suffer the most.

Longer term catastrophic effects if warming continues

- Greenland and Antarctic ice sheets are melting. Unless checked, warming from emissions may trigger the irreversible meltdown of the Greenland ice sheet in the coming decades, which would add up to a seven metre rise in sea-level over some centuries. New evidence showing the rate of ice discharge from parts of the Antarctic means that it is also facing a risk of meltdown.
- The slowing, shifting or shutting down of the Atlantic Gulf stream current is having dramatic effects in Europe, disrupting the global ocean circulation system.
- Catastrophic releases of methane from the oceans are leading to rapid increases in methane in the atmosphere and the consequent warming.
- Ganges-Brahmaputra delta (also Bangladesh): More than 1 million people will be directly affected by 2050 from risk through coastal erosion and land loss, primarily as a result of the decreased sediment delivery by the rivers, but also through the accentuated rates of sea-level rise.
- The gross per capita water availability in India will decline from ~1820 m3/yr in 2001 to as low as ~1140m3/yr in 2050

Adapting with the changing climate

Humans have been adapting to their environments throughout history by developing practices, cultures and livelihoods suited to local conditions. Building homes on stilts to protect against monsoon rains and consequent flooding is a good example. However, climate change raises the possibility that existing societies will experience climatic shifts (in temperature, cyclonic storm frequency, flooding and other factors) that previous experience has not prepared them for.

Adaptation measures therefore should be planned in advance or put in place spontaneously in response to a local pressure. They include large-scale infrastructure changes – such as building walls to protect against sea-level rise or improving the quality of road surfaces to withstand hotter temperatures – as well behavioural shifts such as individuals using less water, farmers planting different crops and more households and small/marginal enterprises buying insurance against flood and cyclone.

Never before has humanity been forced to grapple with such an immense environmental crisis. If we do not take urgent and immediate action to stop global warming, the damage could become irreversible. The likely impact of climate change and key actions to be undertaken to mitigate the same is described in following matrix:

Table 3.1 Matrix of Climate Change Impact and Expected Projections

Extreme Heat	
What we know	• India is already experiencing a warming climate.
What could happen	• Unusual and unprecedented spells of hot weather are expected to occur far more frequently and cover much larger areas. • Under 4°C warming, the west coast and southern India are projected to shift to new, high-temperature climatic regimes with significant impacts on agriculture.
What can be done	• Urban planners to adopt measures to mitigate the risk particularly in "heat-islands" within the cities to counteract this effect. • Early warning system with strong surveillance and trigger to be put in place.
Changing Rainfall Patterns	
What we know	• A decline in monsoon rainfall since the 1950s has already been observed. The frequency of heavy rainfall events has also increased.

What could happen	• A 2°C rise in the world's average temperatures will make India's summer monsoon highly unpredictable. • At 4°C warming, an extremely wet monsoon that currently has a chance of occurring only once in 100 years is projected to occur every 10 years by the end of the century. • An abrupt change in the monsoon could precipitate a major crisis, triggering more frequent droughts as well as greater flooding in large parts of India. • India's northwest coast to the southeastern coastal region could see higher than average rainfall. • Dry years are expected to be drier and wet years wetter.
What can be done	• Improvements in hydro-meteorological systems for weather forecasting and the installation of flood warning systems can help people move out of harm's way before a weather-related disaster strikes. • Building codes will need to be enforced to ensure that homes and infrastructure are not at risk.
Droughts	
What we know	• Evidence indicates that parts of South Asia have become drier since the 1970s with an increase in the number of droughts. • Droughts have major consequences. In 1987 and 2002-2003, droughts affected more than half of India's crop area and led to a huge fall in crop production.
What could happen	• Droughts are expected to be more frequent in some areas, especially in northwestern India, Jharkhand, Odisha and Chhattisgarh. • Crop yields are expected to fall significantly because of extreme heat by the 2040s.
What can be done	• Investments in R&D for the development of drought-resistant crops can help reduce some of the negative impacts.
Groundwater	
What we know	• More than 60 percent of India's agriculture is rain-fed, making the country highly dependent on groundwater. • Even without climate change, 15 percent of India's groundwater resources are overexploited.
What could happen	• Although it is difficult to predict future ground water levels, falling water tables can be expected to reduce further on account of increasing demand for water from a growing population, more affluent lifestyles, as well as from the services sector and industry.
What can be done	• The efficient use of ground water resources will need to be incentivised.
Glacier Melt	
What we know	• Glaciers in the northwestern Himalayas and in the Karakoram range, where westerly winter winds are the major source of moisture, have remained stable or even advanced. • On the other hand, most Himalayan glaciers - where a substantial part of the moisture is supplied by the summer monsoon - have been retreating over the past century.
What could happen	• At 2.5°C warming, melting glaciers and the loss of snow cover over the Himalayas are expected to threaten the stability and reliability of northern India's primarily glacier-fed rivers, particularly the Indus and the Brahmaputra. The Ganges will be less dependent on melt water due to high annual rainfall downstream during the monsoon season. • The Indus and Brahmaputra are expected to see increased flows in spring when the snows melt, with flows reducing subsequently in late spring and summer.

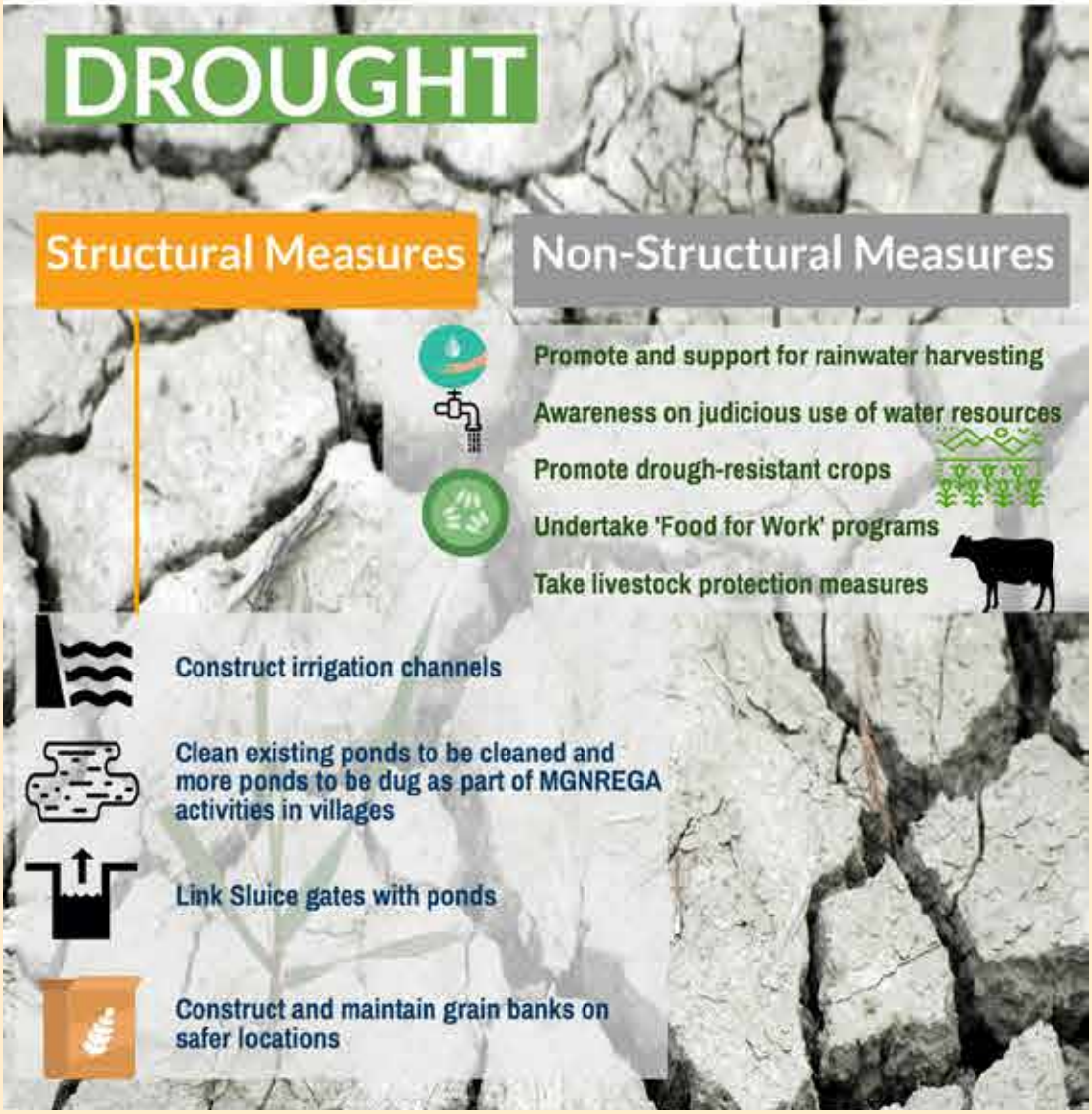
	• Alterations in the flows of the Indus, Ganges, and Brahmaputra rivers could significantly impact irrigation, affecting the amount of food that can be produced in their basins as well as the livelihoods of millions of people (209 million in the Indus basin, 478 million in the Ganges basin, and 62 million in the Brahmaputra basin in the year 2005).
What can be done	• Major investments in water storage capacity would be needed to benefit from increased river flows in spring and compensate for lower flows later on.
Sea level rise	
What we know	• Mumbai has the world's largest population exposed to coastal flooding, with large parts of the city built on reclaimed land, below the high-tide mark. Rapid and unplanned urbanisation further increases the risks of sea water intrusion.
What could happen	• With India close to the equator, the sub-continent would see much higher rises in sea levels than higher latitudes. • Sea-level rise and storm surges would lead to saltwater intrusion in the coastal areas, impacting agriculture, degrading groundwater quality, contaminating drinking water, and possibly causing a rise in diarrohea cases and cholera outbreaks, as the cholera bacterium survives longer in saline water. • Kolkata and Mumbai, both densely populated cities, are particularly vulnerable to the impacts of sea-level rise, tropical cyclones, and riverine flooding.
What can be done	• Building codes will need to be strictly enforced and urban planning will need to prepare for climate-related disasters. • Coastal embankments will need to be built, where necessary, and Coastal Regulation Zone codes enforced strictly.
Agriculture and food security	
What we know	• Even without climate change, world food prices are expected to increase due to growing populations and rising incomes, as well as a greater demand for bio-fuels. • Rice: While overall rice yields have increased, rising temperatures with lower rainfall at the end of the growing season have caused a significant loss in India's rice production. Without climate change, average rice yields could have been almost 6 percent higher (75 million tons in absolute terms). • Wheat: Recent studies show that wheat yields peaked in India and Bangladesh around 2001 and have not increased since despite increased use of fertilisers. Observations show that extremely high temperatures in northern India - above 34°C - have had a substantial negative effect on wheat yields, and rising temperatures can only aggravate the situation.
What could happen	• Seasonal water scarcity, rising temperatures, and intrusion of sea water would threaten crop yields, jeopardising the country's food security. • Should current trends persist, substantial yield reductions in both rice and wheat can be expected in the near and medium term. • Under 2°C warming by the 2050s, the country may need to import more than twice the amount of food-grain than would be required without climate change.
What can be done	• Crop diversification, more efficient water use, and improved soil management practices, together with the development of drought-resistant crops can help reduce some of the negative impacts.
Energy Security	
What we know	• Climate-related impacts on water resources can undermine the two dominant forms of power generation in India, namely, hydropower and thermal power generation, both of which depend on adequate water supplies to function effectively. • To function at full efficiency, thermal power plants need a constant supply of fresh cool water to maintain their cooling systems.

What could happen	• The increasing variability and long-term decreases in river flows can pose a major challenge to hydropower plants and increase the risk of physical damage from landslides, flash floods, glacial lake outbursts, and other climate-related natural disasters. • Decreases in the availability of water and increases in temperature will pose major risk factors to thermal power generation.
What can be done	• Projects will need to be planned taking into account climatic risks.
Water Security	
What we know	• Many parts of India are already experiencing water stress. Even without climate change, satisfying future demand for water will be a major challenge. • Urbanisation, population growth, economic development, and increasing demand for water from agriculture and industry are likely to aggravate the situation further.
What could happen	• An increase in variability of monsoon rainfall is expected to increase water shortages in some areas. • Studies have found that the threat to water security is very high over central India, along the mountain ranges of the Western Ghats, and in India's northeastern states.
What can be done	• Improvements in irrigation systems, water harvesting techniques, and more-efficient agricultural water management can offset some of these risks.
Health	
What we know	• Climate change is expected to have major health impacts in India, e.g., increasing malnutrition and related health disorders such as child stunting, with the poor likely to be affected most severely. Child stunting is projected to increase by 35 percent by 2050 compared to a scenario without climate change. • Malaria and other vector-borne diseases, along with diarrheal infections, which are a major cause of child mortality, are likely to spread into areas where colder temperatures had previously limited transmission. • Heat waves are likely to result in a very substantial rise in mortality and death, and injuries from extreme weather events are likely to increase.
What could happen	• Health systems will need to be strengthened in identified hotspots.
What can be done	• Improvements in hydro-meteorological systems for weather forecasting and the installation of flood warning systems can help people move out of harm's way before a weather-related disaster strikes. • Building codes will need to be enforced to ensure that homes and infrastructure are not at risk.
Migration and conflict	
What we know	• South Asia is a hotspot for the migration of people from disaster-affected or degraded areas to other national and international regions. • The Indus and the Ganges-Brahmaputra-Meghna Basins are major trans boundary rivers and increasing demand for water is already leading to tensions among countries over water sharing.
What could happen	• Climate change impacts on agriculture and livelihoods can increase the number of climate refugees.
What can be done	• Regional cooperation on water issues will be needed.

Source: World Bank – India-Climate Change Impacts [9]

[9] www.worldbank.org/en/news/feature/2013/06/19/india-climate -change-impacts

Hazard Specific Mitigation Measures



EARTHQUAKE

Structural Measures

Buildings must conform to earthquake resilient features (BIS Codes)

Building bye laws applicable to the specific earthquake zone of the region should be followed

Non-Structural Measures

Awareness on building bye laws applicable for the specific earthquake zone should be followed

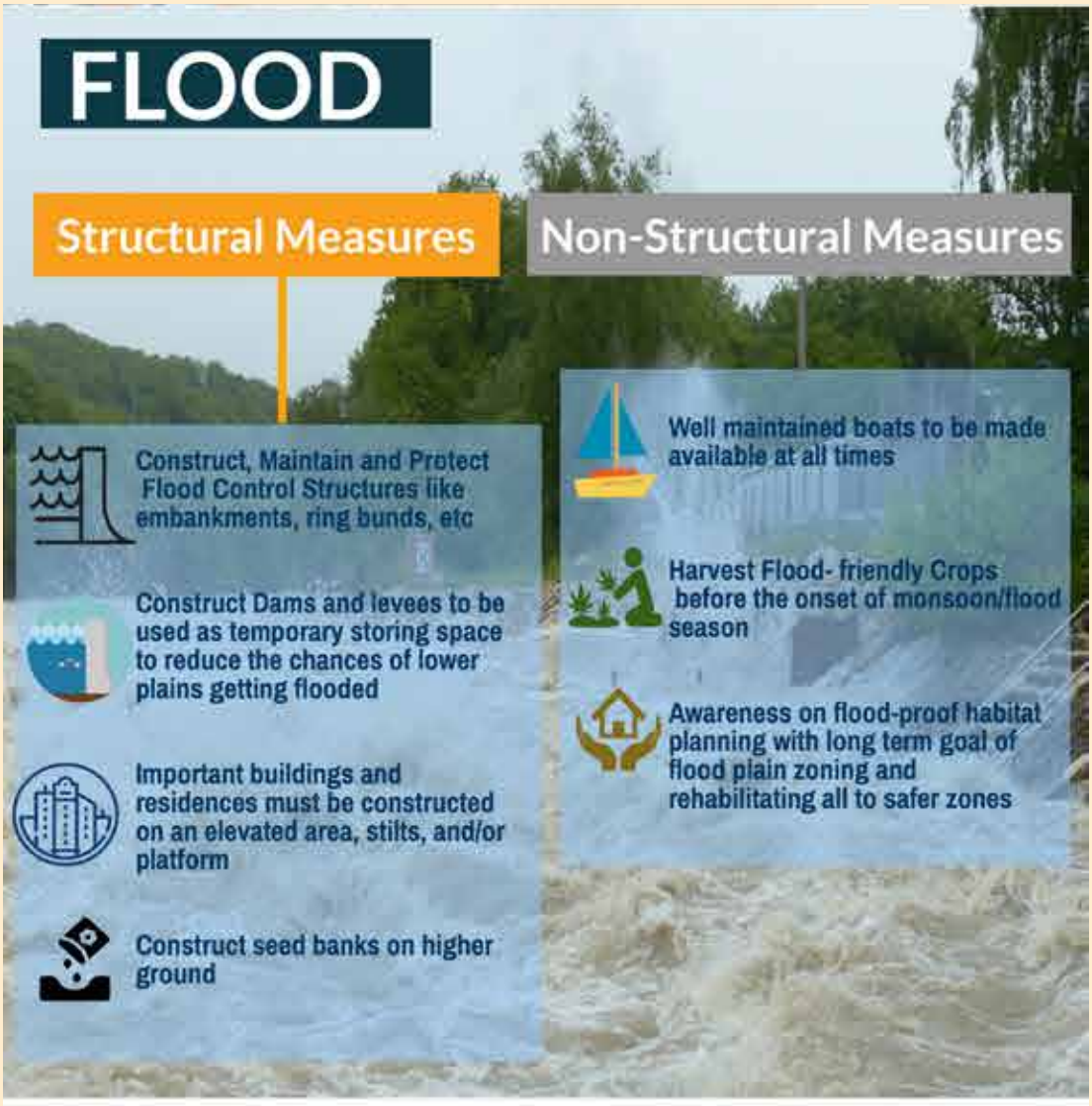
Policy decisions about construction of structures with due approval from specified authorities have to be taken

Formulate and amend building codes that are appropriately detailed with properly stated legal implications

Formulate guidelines both for earthquake-resistant constructions as well as for retrofitting

Capacity building initiatives for architects, engineers and masons on Safe Construction Practices


FIRE
Structural Measures
Non-Structural Measures
Establish fire stations as per Fire Safety Bye laws
Exit
Maintain proper fire exits and proper exit signage (e.g., exit signs pointing to them that can function in a power failure)
Compliance with electrical codes to prevent overheating and ignition from electrical faults
Place and maintain the correct type of fire extinguishers in easily accessible places
Promote usage of fuel blocks during summers to minimise cases of fire during summer
Awareness campaign on fire hazard and strategies to prevent fire incidents
Maintain fire alarm systems for detection and warning of fire.
Obtain and maintain a complete inventory of firestops
Conduct regular fire-drills for preparedness


FLOOD
Structural Measures
Non-Structural Measures
Construct, Maintain and Protect Flood Control Structures like embankments, ring bunds, etc
Construct Dams and levees to be used as temporary storing space to reduce the chances of lower plains getting flooded
Important buildings and residences must be constructed on an elevated area, stilts, and/or platform
Construct seed banks on higher ground
Well maintained boats to be made available at all times
Harvest Flood- friendly Crops before the onset of monsoon/flood season
Awareness on flood-proof habitat planning with long term goal of flood plain zoning and rehabilitating all to safer zones

CYCLONE & HIGH-SPEED WINDS

Structural Measures

Design and Maintenance considerations to be addressed to improve the cyclone preparedness. This should cover:

(i) buildings, including multi-purpose cyclone shelters;

(ii) road links, culverts and bridges;

(iii) canals, drains, and surface water tanks, etc.;

(iv) saline embankments; and

(v) communication towers and power transmission networks

Improve the existing road network and provide at least one link road, in all-weather conditions, for each village that is accessible during cyclone or flooding periods as well

Non-Structural Measures

Ensure availability of adequate numbers of shelters, community centres/school buildings, places of worship, etc., which can be utilised for moving people from vulnerable areas to safety

Ensure that cyclone-resistant features are incorporated in the Government housing projects

Awareness on various aspects of cyclone awareness

Prepare checklist of elements that can be prepared for and learning to mitigate their risks

India's efforts to address climate change concerns

While ambitious mitigation targets are persistently being proposed internationally, localised adaptation strategies are also making their way in nationally steered action plans. Below are some of the key initiatives taken by Government of India to address the current and future challenges being posed by climate change:

- The National Action Plan on Climate Change (NAPCC) has already set a landmark for initiating climate change mitigation and adaptation actions in the country.
- The eight national level missions emerging from NAPCC cater to address socio-economic and environmental concerns arising from climate change. These missions are State Action Plan on Climate Change (SAPCC)
- National flagship programmes such as Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), Jawaharlal Nehru National Urban Renewal Mission (JNNURM) etc. attempt to address climate change issues.

The NAPCC has already set a landmark for initiating climate change mitigation and adaptation actions in the country. The eight national level missions emerging from NAPCC cater to address socio-economic and environmental concerns arising from climate change. India also recognises that strategy for addressing climate change has to be based on a sustainable development strategy, which is particularly addressed in the 12th Five Year Plan of the country. Current government expenditure in India on adaptation to climate variability exceeds 2.6 percent of the GDP with agriculture, water resources, health and sanitation, forests, coastal zone infrastructure and extreme events being specific areas of concern.

3.2 Sectors/Departments likely to get Impacted by Climate Change

From heat waves and wildfires in Australia to flooding in India, climate change affects different parts of the world in different ways. As per the IPCC, depending upon the scenario visualised, the projected global average surface warming will result in temperature increases worldwide at the end of the 21st century, relative to the end of the 20th century, ranges from 0.6 to 4 °C.

Different sectors and departments are likely to be affected by climate change in different ways, as described below:

3.2.1 Agriculture & Horticulture

Studies done at the Indian Agricultural Research Institute indicate the possibility of loss of 4-5 million tons in wheat production with every rise of 1°C temperature throughout the growing period even after considering carbon fertilisation. Losses for other crops are still uncertain but are expected to be smaller, especially for kharif crops. It is, however, possible for farmers and other stakeholders to adapt to a limited extent and reduce the losses. Simple adaptations such as change in planting dates and crop varieties could help in reducing impacts of climate change to some extent. An Indian Council for Agricultural Research (ICAR) study indicates that losses in wheat production can be reduced from 4-5 million tons to 1-2 million tons if a large percentage of farmers could change to timely planting. This may, however, not always be possible due to constraints in the cropping systems.

3.2.2 Water Resources

It has been predicted that the drought-affected areas will likely increase, creating more stress on already stressed ecosystems of India. Such a situation, in conjunction with manmade interventions, can cause a situation of river system closure. Such a situation could arise due to the tendency of utilising/exploiting every bit of the available flow without bothering for any environmental flow left in the river system other than present surplus flow. Any reduction in future flow shall be taken from this available surplus and shall, thus, encroach upon the environmental flows.

There are also some areas predicted to experience extreme precipitation events, with increased frequency and intensity, thus causing enhanced flood risk. In India, the northeastern systems of Mahanadi and Baitarni rivers are expected to come under this category (Gosain et al., 2006). Increase of frequency and severity of floods and droughts will have implications on the functioning of the ecosystems.

Water volumes stored in glaciers and snow cover are very likely to decline, reducing summer and autumn flows in the Himalayan river systems in the long run. This shall be a major impact on the breadbasket of India since the Himalayan glaciers feed many major systems of India. There shall be a large number of implications such as glacier lake bursts, structural safety of the existing structures, etc. The climate change impacts are expected to influence the resilience of many ecosystems due to climate related disturbances such as wildfire, insects etc.

Climate change will affect the water balance, and particularly the amount of runoff and recharge, which in turn determines the water resources available for human and ecosystem uses. Some parts of the world will experience a reduction in resource availability, while others will see an increase. The impacts of climate change on the major sectors and on the region of Asia have been predicted in the Fourth Assessment Report of the IPCC (SPM, 2007) made public in April 2007 in Brussels. Some relevant findings of the Fourth Assessment Report of IPCC are:

- Runoff and water availability are very likely to increase at higher latitudes and in some wet tropics, including populous areas in East and Southeast Asia, and decrease over much of the mid-latitudes and dry tropics, which are presently water-stressed areas. (High confidence)
- Drought-affected areas will likely increase and extreme precipitation events, which are likely to increase in frequency and intensity, will augment flood risk. Increase of frequency and severity of floods and droughts will have implications on sustainable development. (High confidence)
- Water volumes stored in glaciers and snow cover are very likely to decline, reducing summer and autumn flows in regions where more than one sixth of the world population currently live (High confidence)

3.2.3 Ecosystems

- The resilience of many ecosystems is likely to be exceeded this century by an unprecedented combination of climate change, associated disturbances (e.g. wildfire, insects), and other global change drivers. (High confidence).
- In the second half of this century, terrestrial ecosystems are likely to become a net source of carbon, especially from previously under-estimated carbon stocks, thus amplifying climate change. (High confidence)
- Roughly 20-30 percent of species are likely to be at high risk of irreversible extinction if global average temperature exceeds 1.5-2.5°C. (Medium confidence)
- For increases in global average temperature exceeding 1.5-2.5°C and in concomitant atmospheric CO_2 concentrations, there are very likely to be major changes in ecosystem structure and function, species' ecological interactions, and species' geographic ranges, with predominantly negative consequences for goods and services. (High confidence)

3.2.4 Coastal Systems and Low-lying Areas

- Coasts are very likely to be exposed to increasing risks due to climate change and sea-level rise and the effect will be exacerbated by increasing human-induced pressures on coastal areas. (Very high confidence)
- It is likely that corals will experience a major decline due to increased bleaching and mortality due to rising seawater temperatures. Salt marshes and mangroves will be negatively affected by sea-level rise. (Very high confidence)

How Climate Change Impacts Coastal Zones in India

- All coastal states and territories in India are affected by coastal erosion.
- About 26 percent of the mainland coastline is already seriously eroded and much of the coastline is actively retreating. In the state of Karnataka, for example, erosion has affected 249.6 kilometers of the state's total coastline of 280 kilometers.
- Rising sea levels and storms that are likely to increase in frequency and intensity will aggravate erosion — with serious consequences for the economy and the environment in the coastal states.
- By the middle of the century, the sea level in the Indian subcontinent will have risen 15-38 centimeters.
- A 1-metre rise in sea level would displace 7.1 million people in India as 5,764 square kilometers of land and 4,200 kilometers of roads would be lost.

(Source: adapted from ADB 2010)

- Hundreds of millions of people are vulnerable to flooding due to sea-level rise, especially in densely populated and low-lying settlements where adaptive capacity is relatively low and which already face other challenges such as tropical storms or local coastal subsidence. The numbers affected will be largest in the mega-deltas of Asia but small islands face the highest relative increase in risk. (Very high confidence)

3.2.5 Health

There is a growing concern in both medical and climatological communities that global climate changes are likely to affect human health. Global climate changes may adversely affect mortality and morbidity rates through the global warming. Rich countries produce most of the world's greenhouse gases, but it is the health of people in poor countries that suffers the most from global warming. The World Health Organization (WHO) estimates warming and precipitation changes due to climate change claim 150,000 lives every year. The WHO warns that the risk of death and disease from climate change will double in the next 20 years. Thus, global warming is no longer an environmental problem, but has become a threat to public health. Diseases such as malaria, yellow fever, dengue and cholera are all sensitive to climate change, many spread by insects like mosquitoes, which prefer a wetter and warmer environment. Deaths from heart diseases and respiratory illness during heat waves and malnutrition from crop failures add to the toll.

A growth in population in the last few decades coupled with the rapid growth in industry and consequent higher energy consumption has led to the depletion of forest cover for converting into agricultural land, encroachment for settlement and increased harvesting of forest for biomass fuel. Similarly, in developing country such as India, rapid population growth, industrialisation, increased energy consumption and degrading air and water quality may lead to major health impacts due to resulting climate change.

Increase in temperature, precipitation and extreme events is predicted to have an effect on the viability and the geographical distribution of the mosquitoes that transmit malaria. Global warming is anticipated to increase the mosquito survival rates especially in temperate areas. In developing countries like India, rapid population growth and low incomes have resulted in large-scale rural urban mitigation resulting in chaotic and unplanned urbanisation. Besides,

the combustion of fossil fuel and biomass will continue to be the dominant source for energy in India even in late 21st century. The combustion of these fuels result in the emission of such as CO_2, CO, NO, SO_2, hydrocarbons, etc. The exposure to these pollutants can have a wide range of health effects. In metropolitan cities such as Delhi, with increase in the number of vehicles and subsequent release of pollutants cause considerable damage to the respiratory system. Complex effects such as bronchitis, pulmonary edema, chronic bronchitis, cancer and eye related diseases are reported at higher doses.

The health status of millions of people is projected to be affected through, for example, increased malnutrition; increased deaths, diseases and injury due to extreme weather events; increased burden of diarrhoeal diseases; increased frequency of cardio-respiratory diseases due to higher concentrations of ground-level ozone in urban areas related to climate change; and the altered spatial distribution of some infectious diseases. Climate change is projected to bring some benefits in temperate areas, such as fewer deaths from cold exposure, and some mixed effects such as changes in range and transmission potential of malaria in Africa. Overall, it is expected that benefits will be outweighed by the negative health effects of rising temperatures, especially in developing countries. The change in stratospheric ozone and corresponding change in ultra violet radiation over the years are correlated with eye diseases. Critically important will be factors that directly shape the health of populations such as education, health care, public health initiatives, and infrastructure and economic development.[10]

3.2.6 Forest and Environment

Impacts of climate change on forests have severe implications for the people who depend on forest resources for their livelihoods. India is a mega-biodiversity country where forests account for more than one-fifth of the geographical area. With nearly 173,000 villages classified as forest villages, there is a large dependence of communities on forest resources in India.[11] India has a large afforestation programme of over 1.32 Mha per annum,[12] and more area is likely to be afforested under programmes such as Green India Mission and Compensatory Afforestation Fund Management and Planning Authority (CAMPA). Thus, it is necessary to assess the likely impacts of projected climate change on existing forests and afforested areas, and develop and implement adaptation strategies to enhance the resilience of forests to climate change.

Forests in India are already subjected to multiple stresses including over-extraction, insect outbreaks, livestock grazing, forest fires and other anthropogenic pressures. Climate change will be an additional stress. Disturbed and fragmented forests and monoculture forests are likely to be more vulnerable to climate change.[13]

3.2.7 Infrastructure

Infrastructure assets are exposed to natural weather conditions and face challenges due to increased frequency and variability of climate-induced natural disasters. Infrastructure has a pivotal role to play in development and therefore, the large investments planned for future have to be protected against climate-induced risks. These span beyond physical risks as strict mitigation regimes could jeopardise their profitability and even future existence.

[10] Pachauri, R.K. and Reisinger, A. (2007). IPCC Fourth Assessment Report, Geneva, Switzerland. pp 104

[11] Kishwan et al. (2009). India's Forest and Tree Cover: Contribution as a Carbon Sink. Indian Council Of Forestry Research And Education.

[12] Ravindranath et al. (2008). Impact of climate change on Indian forests: a dynamic vegetation modeling approach. Mitigation and Adaptation Strategies for Global Change February 2011, Volume 16, Issue 2, pp 119–142

[13] Ravindranath et al. (2008). Impact of climate change on Indian forests: a dynamic vegetation modeling approach. Mitigation and Adaptation Strategies for Global Change February 2011, Volume 16, Issue 2, pp 133–142

Energy infrastructure such as thermal, hydroelectricity and renewable generation is susceptible to temperature change and extreme events. Extreme events are associated with physical damage to infrastructure. Temperature changes are likely to bring demand side variation in terms of space heating and cooling requirements. Variability in water availability and excessive siltation in river systems due to landslides in catchment areas will affect the hydropower potential. Brazil, where 85 percent of all electricity consumed comes from hydroelectricity, faced a major power crisis during the 2001 drought. Similar impacts would be associated with water supply and infrastructure assets.

Enhanced landslides, vegetation cover, excessive siltation in river systems and soil erosion are the possible direct impacts, while groundwater table depletion, energy-demand changes and migratory traffic could be the possible indirect impacts. Additional risks could also be due to strict global regimes for greenhouse gas emission mitigation that could severely constrain operations of some existing infrastructures and could even jeopardise their future existence. For instance, a severe carbon constraint could alter the standardised cost of power production across various fuels and technologies, relatively increasing the production costs from carbon-intensive plants such as coal-based power plants.

3.2.8 Tourism

With its close connections to the environment and climate, tourism is considered to be a highly climate sensitive economic sector, similar to agriculture, insurance, energy and transport. Indeed, climate change is not a remote future event for tourism as the varied impacts of a changing climate are becoming even more evident at destinations around the world. According to the world travel report, the natural features of some of the wonders of the world will be damaged by global warming, while other resorts will become seriously overcrowded by 2020.

Change is already influencing the travel demand in terms of decision-making in the tourism sector. A key element in the demand for leisure travel is the degree of comfort (or discomfort) to be experienced at the traveler's destination. This comfort factor is affected by many factors such as humidity and precipitation, disease risk, extended rainfall etc. These factors affect the choice of destination by the leisure travelers.

There are direct, indirect and secondary impacts of climate change on the tourism sector. Direct impacts relate to the loss of human, natural and capital stocks, damage to tourism infrastructure, the environment and ecotourism resources such as reefs, mangroves, wildlife habitats and other natural attractions.

3.2.9 Industry

Climate change will have an impact on both industrial raw material supplies and processes. Although the greatest effect will most likely be via global market development, climate change can have notable impacts to those industrial sectors in India whose raw materials are heavily dependent on weather and other changes in the natural environment.

Climate change can pose new challenges to the construction industry with changing weather conditions demanding the implementation of new type of construction materials and plans. For example, the changing damp conditions, frequency of storms and thawing of ground frost require attention. Basic work during the winter may become easier due to warmer weather, although rainy weather increases the risk of damage to the structures and increases drying costs. In addition, construction work can be strenuous to the health during extreme hot weather in the summer. If the current legislation remains in force, the rising temperatures will most likely also mean an increase in the time used for mandatory breaks during work.

On a general level, the industry is partially affected by the same factors as residential areas. Although air-conditioning will consume more

and more energy, the heating need in facilities will be reduced. Problems may also be caused by water bodies becoming warmer, which may impede the use of water for cooling industrial processes. Moreover, industrial plants handling flammable substances, in the chemical industry for example, can be faced with a higher risk of fire as the climate becomes warmer. On the other hand, as rainy weather increases, industrial plants may also be impeded by floods and accelerated corrosion of metal structures. Weather disruptions can also harm industrial logistics.

3.2.10 Education

According to two recent publications, Save the Children's (2008) *Legacy of Disasters* and UNICEF UK's (2008) *Our Climate, Our Children, Our Responsibility*, it is children who will be hardest hit by the effects of climate change. These impacts will be seen, for instance, in the direct effects on educational provision associated with increasing incidence of severe weather events (e.g. drought, flooding, cyclones, heat waves). Over the longer term, incremental environmental changes (e.g. sea level change, salination, changes in season patterns, desertification, soil erosion, species loss, etc.) are also likely to result in deteriorating livelihoods, which impact upon both household expenditure on schooling and the nutritional status of children.[14]

Evidence of the supply side consequences of extreme weather events is already emerging. The aftermath of Cyclone Sidr, which struck Bangladesh in November 2007, left 74 government primary schools destroyed and another 8,817 damaged. An estimated 103,664 children were affected as a result. The estimated cost of reconstruction and refurbishment was more than US$82 million (Das, 2008). Similarly, the 2000 flood in Cambodia destroyed approximately 18 percent of the country's schools, impacting the education of 500,000 children and costing US$1.6 million in rehabilitation costs. Subsequent research in Cambodia has also demonstrated that school absenteeism and drop out are higher in flood-prone areas. Moreover, there is evidence that flooding inhibits completion of school programmes, with schools located in flood-prone areas subject to at least one and a half months of closure due to flooding (ADPC, 2008).

The cumulative effects of extreme weather events on both initial enrollment and longer-term educational performance are not well known. Research in India, however, concludes that women born during flood years in the 1970s were 19 percent less likely to have attended primary school (UNDP, 2007). It would also seem safe to conclude that interrupted and/or impeded access to education has a detrimental impact on learning outcomes, reducing the likelihood that children and young people – especially girls – will be able to break the cycle of poverty (Elimu Yetu Coalition, 2005). A further and important implication that the Cambodia and Bangladesh examples demonstrate is the significant financial burden that rehabilitation costs exert on constrained education budgets. Emergency responses to extreme weather events and their aftermath, thus, have the potential to undermine investment in improving the quality of education.

3.2.11 Animal Husbandry/Fisheries

Climate change poses formidable challenge to the development of livestock sector in India. The anticipated rise in temperature between 2.3 and 4.8°C over the entire country together with increased precipitation resulting from climate change is likely to aggravate the heat stress in dairy animals, adversely affecting their productive and reproductive performance, and hence reducing the total area where high yielding dairy cattle can be economically reared. Given the vulnerability of India to rise in sea level, the impact of increased intensity of extreme events on the livestock sector would

[14] Bangay and Blum, (2010). *Education responses to climate change and quality: Two parts of the same agenda?*. International Journal of Educational Development 30(4):359-368 · July 2010

be large and devastating for the low-income rural areas. The predicted negative impact of climate change on Indian agriculture would also adversely affect livestock production by aggravating the feed and fodder shortages.

The organ systems of animals respond to physical, chemical, biological and climatic stimuli from their surroundings and work in concert to perform the essential body functions. The performance (e.g., growth, milk and wool production, reproduction), health and wellbeing of the livestock is strongly affected by climate both, directly and indirectly.

Livestock are homeotherms, which means, that they must regulate their body temperature within a relatively narrow range to remain healthy and productive. The ambient temperature below or above the thermoneutral range creates stress conditions in animals. The approximate thermal-comfort zone for optimum performance of adult cattle is reported to be 5–15°C (Hahn, 1999). However, significant changes in feed intake or in numerous physiological processes will not occur within the range of 5–25°C (McDowell, 1972). The upper critical temperature of dairy cattle is lower than other livestock species (Wathes et al., 1983). Hot and humid environmental conditions cause heat stress in cows. For air temperature below skin surface temperature of an animal, increasing ambient temperature decreases the gradients driving convective, radiation and conductive heat loss and consequently increases reliance on evaporative cooling (sweating and panting) to dissipate body heat. However, high relative humidity reduces the effectiveness of evaporative cooling and during hot, humid summer weather the animal cannot eliminate sufficient body heat and body temperature rises. Heat stress induces behavioural and metabolic changes, which include reduced feed intake and metabolic activity and thereby a decline in their productivity (e.g., cattle: NRC 2001). In fact, when the magnitudes (intensity and duration) of adverse environmental conditions exceed threshold limits with little or no opportunity for relief (recovery), animal functions can become impaired by the resulting stress, at least in the short term (Hahn and Becker, 1984; Hahn, 1999). Short-term extreme events (e.g., summer heat waves and winter storms) can result in the death of vulnerable animals (Balling, 1982; Hahn and Mader, 1997), which can have substantial financial impacts on livestock producers.

Although the vulnerability of the farm animals to environmental stress varies with the genetic potential, life stage and nutritional status of the animals, the studies unambiguously indicate that the performance of farm animals is directly sensitive to climate factors. Klinedinst et al. (1993) combined previously developed and evaluated biological response functions with three widely known Global Circulation Models [GCMs] (Goddard Institute for Space Studies [GISS], Geophysical Fluid Dynamics Laboratory [GFDL] and United Kingdom Meteorological Office [UKMO]) and found substantial reductions in dairy cow performance with projected climate change. Hahn et al. (1992) point out that,in the United States, summer already reduces production of high-producing dairy cows and beef animals in feedlots. Also, the conception rates of dairy cows are reduced by as much as 36 percent during summer. With global warming as predicted by these GCMs, an additional decline in milk production of about 5-14 percent (beyond expected summer reductions) may occur particularly in the hot/hot–humid southern regions of the United States.

Besides the direct effects of climate change on animal and animal production, there are profound indirect effects as well, which include climatic influences on quantity and quality of feed and fodder resources such as pastures, forages, grain and crop by-residues, and the severity and distribution of livestock diseases and parasites.

3.2.12 Glacial Lake Outburst Flood (GLOF)

The acronym GLOF is used for glacier floods caused by the drainage of naturally dammed lakes in the glacier, on or at the margin of glaciers. GLOFs are not a new phenomenon,

but with the worldwide receding of glaciers and rising temperature, the probability of their occurrences has risen in many mountain ranges. *"Glacier floods represent in general the highest and most far reaching glacial risk with the highest potential of disaster and damages".* [15]

A lake outburst can be triggered by several factors: ice or rock avalanches, the collapse of the moraine dams due to the melting of ice buried within, the washing out of fine material by springs flowing through the dam (piping), earthquakes or sudden inputs of water into the lake, e.g. through heavy rains or drainage from lakes further up-glacier. Self-destruction is caused by the failure of the dam slope and seepage from the natural drainage network of the dam.[16]

The climatic change/variability in recent decades has made considerable impacts on the glacier lifecycle in the Himalayan region. The Himalayas are geologically young and fragile and are vulnerable to even insignificant changes in the climatic system.[17] Studies confirm that many glaciers of the Sikkim Himalayas are leaving glacial lakes with increasing intensity, which in fact corroborates with the agreed upon intermediate effects of long term climate change by a majority of scientists.

Glacier thinning and retreat in the Sikkim Himalayas has resulted in the formation of new glacial lakes and the enlargement of existing ones due to the accumulation of melt-water behind loosely consolidated end-moraine dams. Such lakes are inherently unstable and subject to catastrophic drainage, they are potential sources of danger to people and property in the valleys below them (ICIMOD, 2011). Local communities living in the region are dependent upon the lakes for their livelihood regardless of whether they are settled or nomadic (SAC, 2011).

Recent studies being carried out by Centre for Development of Advanced Computing (C-DAC), Pune jointly with Sikkim State Council of Science & Technology, Gangtok, have shown that many glacial lakes in Sikkim Himalayan region have grown over the years revealing the impact of climate change on glacial lakes and associated hazards.

The state of Sikkim shelters many glaciers, mainly Zemu Glacier, Rathong Glacier and Lhonak Glacier. The status of these glaciers has become a measuring stick of climate change (SAC, 2010). The East Rathong Glacier is one of the important glaciers of Sikkim affected by climate change. The glacier has retreated significantly since 1965 and a marked shift in its snout position has been observed. A glacier terminus, or snout, is the end of a glacier at any given point in time, the position of which is impacted by localised or regional temperature change over time (NSIDC, 2007).

3.2.13 Gender Risks in Climate Change

Adaptation, vulnerability and resilience of people to climate change depend upon a range of conditions. These vary from their degree of exposure and dependency upon weather patterns for livelihoods and food security, to varying capacities in adaptation, which are influenced by gender, social status, economic poverty, power, access, and control and ownership over resources in the household, community and society. Mountain-dwelling people are especially vulnerable since climate impacts and changes are predominantly acute in mountainous regions. This is particularly true in the Andes, Africa and Asia. Put all cross cutting issues in one section

Women in India are particularly vulnerable to the impacts of disasters due to skewed power relations and inequitable cultural and social norms. At the same time, women are essential for

[15] Richard et al. (2007). Early recognition of glacial lake hazards in the Himalaya using remote sensing datasets Global and Planetary Change Volume 56, Issues 1–2, March 2007, Pages 137–152

[16] WWF Nepal Annual report, 2005-06

[17] Lama et al. (2009). Vulnerability of Mountain Communities to Climate Change and Adaptation Strategies. The Journal of Agriculture and Environment Vol:10, Jun.2009 Page: 76-83

developing sustainable adaptation options due to their knowledge, multiple and simultaneous responsibilities and as well as roles in productive areas. These include all sectors from agriculture, rangelands, biodiversity and forests, to households, income-generation, livelihoods and other socio-cultural and political-economic institutions and relations. Worldwide, women are an estimated 43 percent of the work force in agriculture. In Asia and Africa, this proportion is higher, often above 50 percent, especially in mountain regions. Hence, women play a key role in adaptation efforts, environmental sustainability and food security as the climate changes.

However, several dynamics make adaptation more difficult for some women due to a lack of access to formal education, economic poverty, discrimination in food distribution, food insecurity, limited access to resources, exclusion from policy and decision-making institutions and processes and other forms of social marginalisation. These dynamics put women at a distinct disadvantage, and few programmes include or focus on them for adaptation.

Women generally have far less access to and control over the resources they depend upon. Nor do they have opportunities for direct governance and effective influence in politics from the household to community, national, regional and international levels. In some contexts, women are often subject to gender based violence, harassment and psychological violence within the household. Some studies suggest that 95 percent of women and girls surveyed reported first-hand knowledge of violence with 77 percent by family members. Such situations affect women in negative ways, and further impede women's ability to adapt to extreme events and changes in their environment.

During extreme events such as drought, floods and other climate-related disasters, women face additional risks, due in large part to gender inequities that result in women bearing the disproportional brunt of disaster impacts. Moreover, women are often discouraged from learning coping strategies and lifesaving skills, such as how to climb trees or swim. Both factors put them at a disadvantage when floods hit. Often women are not permitted to evacuate their homes without consent from their husbands or elder men in their families or communities. Gendered cultural codes of dress may inhibit their mobility during crises, resulting in higher disproportionate mortality during many disasters. During such events, women and girls are frequently subjected to intimidation, gender-based violence, sexual harassment and rape. Women and girls also face an even more serious risk with the onslaught of climate-induced disasters: organised trafficking.

Organised trafficking of women is emerging as a potentially serious risk associated with environmental problems. Climate-related disasters such as flood, drought or famine may disrupt local security safety nets, leaving women and children unaccompanied, separated or orphaned due to the erosion and breakdown of normal social controls and protections. This makes them especially vulnerable to the exploitation of human trafficking.

4 Prevention and Mitigation Measures

Today, there is a paradigm shift in the approach to disaster management from a culture of relief and rehabilitation to that of preparedness and mitigation.

Mitigation is the effort to reduce loss of life and property by lessening the impact of disasters. In order for mitigation to be effective, we need to take action now—before the next disaster—to reduce human and financial consequences later (analyzing risk, reducing risk, and insuring against risk). It is important to know that disasters can happen at anytime and any place and if we are not prepared, consequences can be fatal.

Effective mitigation requires that we all understand local risks, address the hard choices, and invest in long-term community well-being. Without mitigation actions, we jeopardise our safety, financial security and self-reliance.

In the face of increasing menace of various hazards, mitigation would remain the key and the most effective strategy to reduce the risks of various hazards. **Structural mitigation** measures generally refer to capital investment on physical constructions or other development works, which include engineering measures and construction of hazard resistant and protective structures and other protective infrastructure. **Non-structural mitigation** measures refer to awareness and education, policies, techno-legal systems and practices, training, capacity development, public commitment, and methods and operating practices, including participatory mechanisms, and the provision of information, which can reduce risk with related impacts.

4.1 Structural Mitigation Measures

- All public buildings like schools, hospitals, and health centres should be multi hazard resilient, built on raised grounds and platforms with retrofitting and having adequate exit gates and fire extinguishers in place.
- Multipurpose community shelters should be constructed in all vulnerable areas.
- Houses built in the area should have multi-hazard resilient features keeping in tune with cultural housing practices.
- Watershed management:
  - A study can be conducted by the District Administration to assess the existing structures and system in place for watershed management and recommend best options for effective watershed management.
  - Periodical cleaning, de-silting and deepening of natural water reservoir and drainage channels

- Construction of irrigation channels - Sluice gates may be linked with ponds, which could be used as a water resource for enhancing livelihood.

Retrofitting of key structures/ buildings

Retrofitting reduces the vulnerability of damage of an existing structure during a future earthquake. It aims to strengthen a structure to satisfy the requirements of the current codes for seismic design. In this respect, seismic retrofit is beyond conventional repair or even rehabilitation. The principles of seismic retrofit refer to the goals, objectives and steps. The steps encompass condition assessment of the structure, evaluation for seismic forces, selection of retrofit strategies and construction. The applications include different types of buildings, industrial structures, bridges, urban transport structures, marine structures and earth retaining structures.

The benefits of retrofitting include the reduction in the loss of lives and damage of the essential facilities, and functional continuity of the life line structures. For an existing structure of good condition, the cost of retrofitting tends to be smaller than the replacement cost. Thus, the retrofitting of structures is an essential component of long term disaster mitigation.

The current earthquake codes of practice are applicable to new buildings and cannot be applied to these existing buildings that do not have earthquake resistant features. Thus, the existing stock of important lifeline buildings is vulnerable and need to be retrofitted to raise their level of performance in earthquakes. This has to be taken up by the administration as a long term mitigation measure.

Many buildings are considered critical or 'lifeline' buildings based on their role in a post disaster scenario as hospitals, command centres for relief operations, emergency shelters etc. In the 2001 Kachchh earthquake in Gujarat, India, the main health facilities in the district of Kachchh collapsed, leaving thousands of people without access to immediately required medical attention. Improved seismic performance of these buildings both protects the occupants of these buildings and enables them to respond more effectively to an earthquake disaster.

The retrofitting of lifeline buildings should be taken on in a campaign mode and should be incremental. Institutions and NGOs working on shelter and housing may be asked to demonstrate retrofitting models for various buildings and learning may be disseminated to key stakeholders for scaling up.

4.2 Non-structural Mitigation Measures

- Risk transfer mechanisms should be created, i.e. establishment and strengthening of insurance schemes and policies, which would transfer losses due to hazard to a third party. Insurance schemes for crop, cattle, small businesses and life should be strengthened and promoted to minimise economic losses.
- Groups of architects, engineers and masons should be formed and trained on building safe infrastructure.
- Alternate safe housing technology along with rainwater harvesting structures should be constantly encouraged and mainstreamed for long-term vulnerability reduction. Policies and bye laws could be developed for the same.
- Continued awareness campaign and encouragement for disaster-proof habitat planning at community level including shifting/relocating from hazard prone areas to safer places (with some incentives, if feasible).
- Disaster management may be included as a part of school, college, curriculum starting from primary level.
- The DDMA may suggest conducting research on alternative cropping to reduce adverse affect due to flood, water logging or drought.

Sector Specific Preparedness Measures & Mitigation Strategies

DEPARTMENT OF ENVIRONMENT

- Conduct Environmental Impact Assessment (EIA) for all programmes/projects
- Ensure integration of Disaster Impact Assessment (DIA) in EIA for all projects/ programmes
- Eco-system conservation must be considered as part of all developmental activities, particularly in environmentally sensitive areas such as coastal and hill areas etc
- Integrate DRR and Climate Change Adaptation in programmes at all levels
- Ensure that the schemes takes all reasonable steps to protect the environment
- Ensure that the emissions, surface discharges and effluent from the activities does not exceed the values indicated in the specifications, and must conform to the laws
- Conduct regular monitoring checks on the appointed Contractor's work to ensure strict adherence to the rules and regulations

DEPARTMENT OF AGRICULTURE

Undertake risk assessment for drought, flood, pest attacks, hailstorms etc.

Set up hazard monitoring system and strengthen weather information dissemination to farmers

Execute the schemes to combat the effects of drought

Assist farmers in implementing innovative techniques such as sowing of less time-period crop

Take effective mitigation measures. Set up mechanism for Integrated Pest Management

A functional mechanism such as Flood Forecasting System to advise farmers for appropriate crop selection

Estimate the requirement of seeds and other material to mitigate the loss

Assess the crop-loss and identify measures to undertake to mitigate the impact of losses

Adopt locally appropriate solutions such as construction of check-dams and irrigation tanks etc

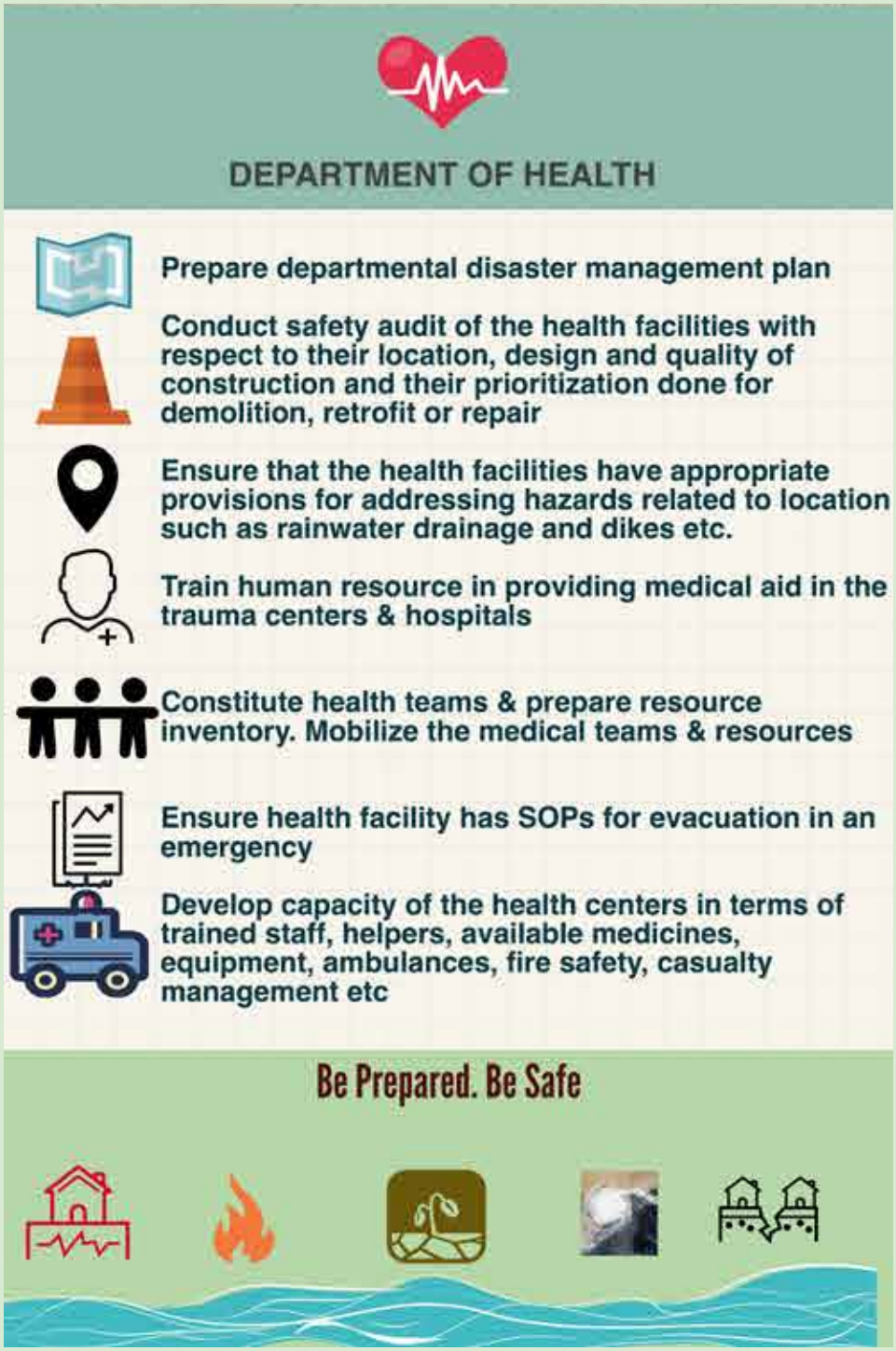
Procure resources required for response & relief operation. Identify & prepare resource inventory

Conduct Awareness generation programmes for farmers on Do's & Don'ts

Establish a functional system to preserve animal stock and provision for their health management

DEPARTMENT OF HOUSING & PUBLIC WORKS DEPARTMENT

- Ensure that the building or infrastructure consider appropriate measures of earthquake safety and resilience as per the BIS codes
- Adopt innovative technology and designs for low-cost, eco-friendly and hazard resistant housing with locally available materials
- Conduct Social Impact Assessment (SIA) and Environment Impact Assessment for the building or infrastructure
- Take appropriate measures to mitigate the negative impacts on the environment
- Organize trainings and capacity building initiatives on latest techniques of safe building codes, practices for the architects, engineers and masons
- Site selection must take into account the disaster history and past hazard assessment reports
- Ensure compliance of building codes, land use regulations and other byelaws for developmental projects
- Incorporate DRR measures in sewerage/drainage construction to mitigate the impact of urban flooding
- Prepare a relocation plan to shift the slums located in the vulnerable areas to safer places


DEPARTMENT OF HEALTH
Prepare departmental disaster management plan
Conduct safety audit of the health facilities with respect to their location, design and quality of construction and their prioritization done for demolition, retrofit or repair
Ensure that the health facilities have appropriate provisions for addressing hazards related to location such as rainwater drainage and dikes etc.
Train human resource in providing medical aid in the trauma centers & hospitals
Constitute health teams & prepare resource inventory. Mobilize the medical teams & resources
Ensure health facility has SOPs for evacuation in an emergency
Develop capacity of the health centers in terms of trained staff, helpers, available medicines, equipment, ambulances, fire safety, casualty management etc
Be Prepared. Be Safe

4.3 Hazard-specific Mitigation Measures

In addition to the multi-hazard mitigation actions, the following hazard specific mitigation actions should be taken depending on the vulnerability of the village/block/district:

Table 4.3 Hazard-specific Mitigation Actions

Hazard	Structural Mitigation	Non-structural Mitigation
Flood	• Construction, maintenance and protection of flood control structures like embankments, ring bunds, etc. • Dams and levees can also be constructed which can be used as temporarily storing space which reduce the chances of lower plains getting flooded. • Critical buildings as well as private houses in flood-prone areas should be constructed on an elevated area and if necessary on stilts and platform. • Construction of tube wells on raised platforms • Construction of seed bank on higher ground	• Well maintained boats available at all times at Gram Panchayat level • Crops that can be harvested before the onset of monsoon/flood season and crops that are flood friendly should be grown in the region. • Awareness on flood-proof habitat planning with long term goal of flood plain zoning and rehabilitating all to safer zones.
Earthquake	• All buildings especially public building must have earthquake resilient features. • Building bye laws applicable for the specific earthquake zone of the region should be followed.	• Awareness on building bye laws applicable for the specific earthquake zone should be followed.
Drought	• Construction of irrigation channels. • Existing ponds to be cleaned and more ponds to be dug as part of MGNREGA activities in village • Sluice gates to be linked with ponds • Tubewells and borewells to be built in village • Construction and maintenance of grain banks on safer locations	• Promotion and support for rainwater harvesting • Awareness on government subsidy on borewells and tubewells for irrigation purposes
Fire	• Establishment of fire stations as per Fire Safety Bye laws	• Promotion of usage of fuel blocks during summers to minimise cases of fire during summer • Awareness campaign on fire hazard and strategies to prevent fire incidents

Mainstreaming of DRR and CCA in District Level Planning

5

CCA and DRR, while not the same, have significant overlaps, including their need for mainstreaming into broader development. Moreover, it is increasingly recognised that 'there is a real opportunity to reduce current and future vulnerabilities to climate risks by building on and expanding existing disaster risk management.'[18]

As such, it is widely acknowledged that the two issues should not be tackled in isolation, with the growth of two parallel agendas, a greater likelihood of mainstreaming fatigue and competition for funding and policy space.[19] Instead, the issues should be brought closely together, in particular via institutional, policy and research coordination and the development of joint strategies, to exploit synergies, share experiences, lessons learned, tools and methodologies and consolidate the political voice for change. This joint approach would ensure a more efficient use of efforts and resources and greater effectiveness of achievements.

[18] Sperling and Szekely (2005:7). Disaster Risk Management in a Changing Climate. Vulnerability and Adaptation Resource Group (VARG).

[19] Jon Barnett et al (2008:3). Disaster Risk Reduction, Climate Change Adaptation and Human Security. Report prepared for the Royal Norwegian Ministry of Foreign Affairs by the Global Environmental Change and Human Security (GECHS) Project

What is mainstreaming?

This word obviously derives from the metaphor of a small, isolated flow of water being drawn into the mainstream of a river where it will expand to flow smoothly without loss or diversion. Therefore 'mainstreaming risk reduction' describes a process to fully incorporate DRR into relief and development policy and practice. It means radically expanding and enhancing DRR so that it becomes a normal practice, fully institutionalised within the departments' relief and development agenda.

Mainstreaming has three purposes:

- To make certain that all the development programmes and projects are designed with evident consideration for potential disaster risks and to resist hazard impact
- To make certain that all the development programmes and projects do not inadvertently increase vulnerability to disaster in all sectors: social, physical, economic and environment
- To make certain that all the disaster relief and rehabilitation programmes and projects are designed to contribute to developmental aims and to reduce future disaster risk

Mainstreaming climate change concerns in planning

While the issues of climate change cripple formulated climate action in the country, civil society initiatives have developed innovative

ways to address this development challenge. Mainstreaming climate change adaptation has emerged as a new area of focus for building resilience of vulnerable communities. Climate adaptive planning spans across departments (agriculture, water resources, rural development etc.) and vertical bureaucratic levels (national, state, district, block and village).

CCA, i.e. adjustments in human and natural systems in response to actual or expected climatic variation, with a view to moderating harm or exploiting beneficial opportunities (IPCC 2007), is an area of growing concern and engagement for many developing countries. The myriad and uncertain effects of a changing climate pose significant risks for development and achievement of the Millennium Development Goals (MDGs).

5.1 Procedure/Methodology for Mainstreaming of DRR and CCA in District Level Planning

Project appraisal

Consideration of disaster risk concerns as part of the project appraisal process is an essential step in:

- ensuring that development gains from individual projects are sustainable;
- ensuring that potential disaster risk reduction benefits of both dedicated risk reduction projects and other development projects are optimised; and
- highlighting related issues of responsibility and accountability.[20]

Disaster risk concerns should be considered in all components of project appraisal analysis – financial, economic, environmental, social, institutional and technical – reflecting the fact that vulnerability to natural hazards is complex and multi-faceted and so needs to be viewed from all angles, incorporated into broader planning tools, such as logical framework analysis and results-based management frameworks, and reflected in the development of monitoring and evaluation indicators.

Monitoring and evaluation of projects from DRR/CCA angle

The capacity to monitor and evaluate DRR initiatives, generate hard evidence on related inputs, outputs, results and impacts and learn lessons for the future is an essential component for mainstreaming. In practice, the use of benchmarks and indicators to monitor and evaluate DRR initiatives is not very common anywhere.[21] This partly reflects an inherent challenge relating to the fact that the success of a DRR initiative is ultimately measured in terms of something – a disaster or a particular form or level of loss – that does not happen as a consequence of a hazard event. There are further complications relating to the fact that a particular hazard event may not occur over the life of a project, implying that the benefits and impact of related DRR activities may not be directly measurable within the normal evaluation timeframe.[22] Moreover, no two hazard events are ever the same, implying that the precise nature and scale of any benefits may vary between events. Nevertheless, DRR initiatives can and should be monitored and evaluated. Problems relating, for instance, to potentially lengthy time lags in the realisation of benefits can be overcome to some extent by using leading or process indicators that provide a measure of progress towards the achievement of project objectives (e.g., the number of schools constructed to withstand earthquakes of a particular magnitude).

The UNDP guidelines on integrating disaster risk concerns in planning processes also provide little

[20] Benson and Twigg (2007). Tools for Mainstreaming Disaster Risk Reduction: Guidance notes for Development organisation. Provention Consortium.

[21] ISDR System Joint Work Programme (2008 – 2009). For the Implementation of the Hyogo Framework for Action 2005-2015:Building the Resilience of Nations and Communities to Disasters

[22] Benson and Twigg (2007). Tools for Mainstreaming Disaster Risk Reduction: Guidance notes for Development organisation. Provention Consortium.

guidance on monitoring and evaluation beyond stating the need to perform the following steps in undertaking the logical framework analysis for all programs, projects and activities:

- Include relevant indicators to monitor and evaluate any disaster risk reduction components
- Consider disaster-related factors in identifying critical risks and assumptions, developing a risk management plan and establishing risk indicators
- Monitor and assess performance of any disaster risk reduction components, the impact of any disaster events and implications of any changes in vulnerability to natural hazards and modify project activities, targets, and/or objectives accordingly where necessary
- Assess disaster risk reduction achievements and shortcomings and adequacy of the initial disaster risk assessment

Few key actions for mainstreaming of DRR and CCA in development planning

- Adequate budget, dedicated staff, capacity development, a monitoring framework, and interdepartmental cooperation need to be in place for effective mainstreaming.
- The funding gap between implementation of NAPCC and current scenario is huge. Ability to access and leverage climate change finance is important.
- More attention needs to be paid to the monitoring and measuring of mainstreaming. This should include an assessment of inclusion of gender issues and Below Poverty Line families in climate change planning.
- Risk diversification in the context of unpredictable climate patterns is necessary. The options need to include effective programmes of contingency crop planning, crop diversification including the use of hazard resistant crops as well as promoting supplementary income generation from off-farm and non-farm activities.
- The main obstacle in the path of government departments being able to address climate change concerns is dedicated personnel. Officials need to be highly skilled and trained. Additional qualities that an official needs to have in order to function effectively include empathy and communication.
- Detailed procedures that list the precise steps that are to be implemented in case of an emergency and by whom need to be put into place. This will ensure that systems work irrespective of the caliber of the individual official in position at that time.
- Preparation for a disaster as well as risk reduction should be incorporated into school and college curricula. This step will ensure that citizens who are usually the first on the scene of a disaster are well-equipped to deal with emergencies and also reduce dependence on the National Disaster Response Force.

Key Actions for Mainstreaming

Disaster Risk Reduction and Climate Change Adaptation in to Development Planning

Checklists

6

Mainstreaming is a dynamic process with a dual purpose, (1) ensuring that development is protected through DRR and CCA elements, and (2) ensuring that development does not increase people's vulnerability to disasters.

A set of checklists are given in the following sub-sections for vetting different projects/ developments through the lens of DRR and CCA as well as to check that they protect the communities from future disaster risks and do not increase their vulnerabilities to disasters. Each question is to be answered in Yes or No with specific remarks for the answer, if required. For details on the concepts, the previous chapters may be referred to.

6.1 Checklist for Community Physical Infrastructure, Shelter and Settlement

Sl.	Description/Checklist	Yes	No	Remarks
1.	Does the infrastructure/building involve any new construction or setup of infrastructure or building?			
2.	Does the site lie in an earthquake zone of IV or V?			
3.	Is there any known geological fault line near the site?			
4	Are the designs suitable to local environment and customs?			
5.	Does the map of the building or infrastructure consider appropriate measures of earthquake safety and resilience as per the National Building Codes 2005, BIS codes and NDMA guidelines (or any state level guidelines if issued)?			
6.	Is the map of the building or infrastructure approved by competent authority?			
7.	Do the shelters and buildings demonstrate technology and designs for low-cost, eco-friendly and hazard resistant housing with locally available materials?			
8.	Has the building or infrastructure ensured latest multi-hazard specific techniques used for retrofitting?			
9.	Is the Social Impact Assessment (SIA) conducted for the building or infrastructure?			
10.	Does the infrastructure project have a Social Impact Management Plan (SIMP) approved by the Gram Sabha?			

Sl.	Description/Checklist	Yes	No	Remarks
11.	Is the Environmental Impact Assessment (EIA) conducted for the infrastructure project?			
12.	Does the infrastructure project consider appropriate measures to mitigate the negative impacts on the environment?			
13.	Does the site lie in a flood prone or waterlogging zone (low-lying area)?			
14.	Does the building or infrastructure consider appropriate flood safety measures in its design?			
15.	Does the building or infrastructure lie in a cyclone prone zone?			
16.	Are appropriate measures taken in place in the design as per the norms and guidelines?			
17.	Does the building or infrastructure lie in a landslide, flashflood zone or any other hazards?			
18.	Are appropriate measures taken in place to negate the impact of the possible hazards on the building or infrastructure, as per the norms and guidelines?			
19.	Is there any dam or barrage upstream the site?			
20.	Is the dam breach effect considered on the building or infrastructure?			
21.	Are appropriate measures taken to negate the impacts of dam breach, as per norms/guidelines?			
22.	Does the building or infrastructure comply with the land use directives/ regulations?			
23.	Does the building or infrastructure consider Indian Road Congress Manual, Ministry of Road Transport, Highways and Shipping manual, Railway Board manual, Central Public Health Engineering Organisation (Min. of Urban Development) manual, Central Electricity Authority manual and Central Water Commission manual etc. where applicable?			
24.	Does the infrastructure project consider organising trainings and capacity building programme on latest techniques of safe building codes, practices for the people to be involved in the project execution (especially construction of the building/infrastructure etc.)?			
25.	Does the infrastructure project have dedicated budgetary and resource allocations for the measures of disaster risk reduction, mitigation and management of any negative impacts?			
26.	Has regular monitoring and inspection visits to check the safer building codes in the community done?			
27.	Is the Hazard Risk Vulnerability mapping of the community around the infrastructure project site done?			
28.	Has the building or infrastructure identified the sites which need hazard proofing, and sites for re-siting etc.			
29.	Does the infrastructure project ensure that the re-siting sites don't fall in hazard prone area?			
30.	Are their appropriate plans available in the project and measures taken to ensure hazard proofing as per the national and state guidelines?			
31.	Has the infrastructure project ensured that the site selection for development was done by local government taking into account the disaster history and past hazard assessment reports?			

Sl.	Description/Checklist	Yes	No	Remarks
32.	Do the new critical infrastructure projects (like roads, bridges, power, water, communication etc.) comply with the safety standards of disaster risk reduction?			
33.	Are the debris dumping sites of the proposed infrastructure project identified?			
34.	Are the debris dumping sites of the proposed project away from water bodies, stream or river, and probably near depressions that need filling?			
35.	Are DRR measures considered in sewerage/drainage construction planning so as to mitigate the impact of urban flooding?			
36.	Does the design of road or bridges etc. obstruct the natural flow of water?			
37.	Is there a relocation plan to shift the slums to safer places which are situated in vulnerable areas?			

6.2 Checklist for Water Resources

Sl.	Description/Checklist	Yes	No	Remarks
1.	Is the hazard risk assessment of Water, Sanitation and Hygiene systems and water points done to check whether they fall in a hazard prone area?			
2.	Did the WASH initiative consult the hydrologists, hydro-geologists and water & sanitation engineers to finalise a site for WASH structures?			
3.	Are the locations of new WASH installations hazard safe?			
4.	Is the water testing done for the water sources to mark the safe or unsafe water sources?			
5.	Is the gradient of the river or stream beds appropriate so that it allows for movement of aquatic fauna?			
6.	In case of culverts, does the design and site allow free movement of water and avoid water logging?			
7.	Do the designs of water installation follow the standard codes, norms and guidelines?			
8.	Do the diversion bunds constructed in the streams allow proper flow of water?			
9.	Are the dug wells, open wells, and bores etc. tested for water safety as per the approved standards?			
10.	Are the dug wells, open wells, and bores etc. located at a distance of less than 10m from a sewerage or waste disposal point?			
11.	If the dug wells, open wells, and bores etc. are located at a distance of less than 10m from a sewerage or waste disposal point, is a proper safety wall constructed around it?			
12.	Does the design/structure of water ponds/lakes etc. consider the available slope and quantity and duration of rainfall so that it does not lead either to flash floods in case of breach or blockage of downstream flows in case of less water availability?			
13.	Are there steep slopes in the designs of water ponds/lakes etc., which may lead to excessive land and soil disturbance, and subsequently may lead to soil erosion?			
14.	Embankments/bunds: Does the design ensure that water flows are not obstructed but only the banks are protected?			

Sl.	Description/Checklist	Yes	No	Remarks
15.	Are the flood protection spurs constructed on both the sides of the waterways? (If only on one side, they may redirect water flow to the other side and thus may lead to banks cutting on the opposite side of the rivers and streams)			
16.	Are the existing breaches in the embankments repaired?			
17.	Have WASH committees been formed in the villages?			
18.	Are the WASH committees in the villages given orientation and capacity building on management and maintenance of WASH resources and systems?			
19.	Does the implementation of modified sanitation systems ensure use of less volume of water and are less prone to blockages?			

6.3 Checklist for Educational Infrastructure

Sl.	Description/Checklist	Yes	No	Remarks
1.	Does the location of school/educational institution lie at the edge of a slope, near the foot of a mountain vulnerable to landslides, near creeks, rivers or bodies of water that could erode its foundation, on top of or in proximity to active fault lines (less than 10 meters away), near the river banks and areas prone to storm surges?			
2.	Is the safety audit of all existing school buildings carried out with respect to their location, design and quality of construction and their prioritisation done for demolition, retrofit or repair?			
3.	Does the map of the school or educational institution consider appropriate measures of earthquake safety and resilience as per the National Building Codes 2005, BIS codes and NDMA guidelines (or any state level guidelines if issued)?			
4.	Is the map of the school or educational institution approved by competent authority?			
5.	Does the construction/design of school or educational institute focus on the use of low cost and environment friendly construction material that is locally available?			
6.	Has the school or educational institution ensured latest multi-hazard specific techniques used for retrofitting?			
7.	Does the school or educational institution lie in a flood prone or water logging zone (low-lying area)?			
8.	Does the school or educational institution consider appropriate flood safety measures in its design?			
9.	Does the building have appropriate provisions for addressing hazards related to location such as rainwater drainage and dikes etc.?			
10.	Are flood protection bunds constructed around facilities that lie in a flood or water-logging prone area?			
11.	Is there any dam or barrage upstream the school or educational institution site?			

Sl.	Description/Checklist	Yes	No	Remarks
12.	Is the dam breach effect considered on the school or educational institution?			
13.	Are appropriate measures taken to negate the impacts of dam breach, as per norms/guidelines?			
14.	Does the facility have ramps and features to facilitate use of the structures for people with disabilities?			
15.	Does the building have multiple emergency exits?			
16.	Do the doors open outwards?			
17.	Have the school and educational institutions laid down standard operating procedures (SOPs) for evacuation in an emergency?			
18.	Do they have provisions for rehearsal of evacuation in an emergency?			
19.	Are the structures built with fire-resistant and nontoxic materials?			
20.	Has a Fire Suppression System with alarm, detection and extinguishing systems been installed?			
21.	Is there a provision and mechanism for training of HR for proper maintenance and use of fire alarm and firefighting equipment?			
22.	Is there a system for education and training of the staff and the students about possible hazards and required risk reduction measures?			
23.	Are the parents-teachers committees involved in DRR awareness and capacity building?			
24.	Is there a functional system of micro planning for school development at the village or village cluster level, with the formation of a core group comprising of teachers and parents, community leaders and NGOs?			
25.	Are the School Safety Weeks (or any other means of awareness through competition, workshop etc.) organised in the school?			
26.	Does the school/educational institution have a school preparedness/ response plan?			
27.	Do the educational institutes conduct half yearly multi-hazard preparedness/response mock drill exercises?			
28.	Is the DRR subject/module part of education curriculum at all levels?			
29.	Is there a community level committee (including school/college director, community leaders) constituted to monitor the school maintenance?			
30.	Is the awareness and capacity building of these committees ensured in terms of local hazard conditions and needs for safe development?			
31.	Are functional trainings undertaken for teachers and other stakeholders (PRI Members) involved in managing the school?			
32.	Are trainings in basic first aid and selected search & rescue methods undertaken for children and school staff?			
33.	Do the school buildings have necessary facilities (water, sanitation, electricity, etc.) for use as an emergency/relief shelter during emergency situations?			

6.4 Checklist for Health Infrastructure

Sl.	Description/Checklist	Yes	No	Remarks
1.	Does the location of the hospitals and health facilities lie at the edge of a slope, near the foot of a mountain vulnerable to landslides, near creeks, rivers or bodies of water that could erode its foundation, on top of or in proximity to active fault lines (less than 10 meters away), near the river banks and areas prone to storm surges?			
2.	Is the safety audit of the health facilities carried out with respect to their location, design and quality of construction and their prioritisation done for demolition, retrofit or repair?			
3.	Does the health facility have good accessibility through roads (preferably more than one well-paved access roads that are cemented or asphalt and are properly identified and labeled), and adequate means of transportation readily accessible to the community?			
4.	Is the site of health facility reasonably free from undue noise, smoke, dust, foul odours, floods etc.?			
5.	Is the health facility located adjacent to railroads, freight yards, children's playgrounds, airports, industrial plants, disposal plants etc.?			
6.	Does the map of the health facility consider appropriate measures of earthquake, fire, flood & cyclone safety and resilience (multi-hazard) as per the National Building Codes 2005, BIS codes and NDMA guidelines (or any state level guidelines if issued)?			
7.	Is the map of the health facility approved by competent authority?			
8.	Has the project ensured latest multi-hazard specific techniques used for retrofitting?			
9.	Is regional application of secondary covers ensured so that the glass walls, doors and windows may resist basic wind speeds of 200-250 km/h?			
10.	Does the health facility building have appropriate provisions for addressing hazards related to location such as rainwater drainage and dikes etc.?			
11.	Are flood protection bunds constructed around facilities that lie in a flood or waterlogging prone area?			
12.	Is there any dam or barrage upstream the health facility site?			
13.	Is the dam breach effect considered on the health facility?			
14.	Are appropriate measures taken to negate the impacts of dam breach, as per norms/guidelines?			
15.	Does the health facility have ramps and features to facilitate use of the structures for people with disabilities and patients?			
16.	Does the health facility building have multiple emergency exits?			
17.	Are there gathering grounds identified and marked?			
18.	Does an emergency Exit System with directions at all points including angles and intersections of corridors and passageways, landings of stairs and exit doors etc. exist?			
19.	Has health facility laid down SOPs for evacuation in an emergency?			
20.	Do the health facilities have provisions for rehearsal of evacuation in an emergency?			

Sl.	Description/Checklist	Yes	No	Remarks
21.	Are the health facility building and hospitals built with fire-resistant and nontoxic materials?			
22.	Is there a Fire Suppression System with alarm, detection and extinguishing systems available in the health facility?			
23.	Has a Fire Suppression System with alarm, detection and extinguishing systems been installed?			
24.	Is there a provision and mechanism for training of human resources for proper maintenance and use of fire alarm and firefighting equipment?			
25.	Is there a system for education and training of the staff and the students about possible hazards and required risk reduction measures?			
26.	Is the capacity assessment of the health centres conducted in terms of trained staff, helpers, available medicines, equipment, ambulances, fire safety, casualty management capacity etc.?			
27.	Is the development of preparedness/response plan for each hospital/ nursing home/dispensary is ensured?			
28.	Are the roofing materials in the health facility completely and securely fastened, welded, riveted or cemented, and the roof is leak-proof insulated (where possible)?			
29.	Are the door materials wind-and fire-resistant, and are securely attached to jambs?			
30.	Are the main doors double swing; bathroom door is swing out; emergency room doors are swing in and out, fire exit doors fire-resistant; swing out; with self-enclosing device and panic bar etc.?			
31.	Are the corridors double swing, per groups of rooms or sections, for compartmentalisation?			
32.	Do the windows have wind and sun protection devices, and features to secure the safety of the patients (e.g. grilles, railings)?			
33.	Are the rooms subdivided provided that the arrangement allows for direct and constant visual supervision by nursing personnel?			
34.	Are the exterior elements (cornices, ornaments, facade, plastering) securely fastened to walls, hanging light fixtures properly anchored, electrical wires and cables properly fastened and secured, non slip floor materials without crevices provided in all clinical and service areas and easy-to-clean floor materials in all other nonclinical areas?			
35.	Is there an emergency generator provided with the capacity to meet priority hospital demands (provision for backup electrical system to include operating room, intensive care, pathways)?			
36.	Are there functional electrical and emergency lights with battery backup in all critical areas?			
37.	Is there a water tank storage having sufficient reserve to satisfy the hospital demand for three days at all times?			
38.	Are medical gases properly stored and secured in well-ventilated areas or compartmented storage areas and secured from theft and vandalism?			
39.	Is there a logistic system in place for estimating drug requirement, maintaining an inventory, storing and stocking and issuing and controlling the use of drugs, stockpile of emergency medicines and supplies, special arrangement with vendors and suppliers for emergency purchases in times of disaster?			

Sl.	Description/Checklist	Yes	No	Remarks
40.	Are there linkages established with telemedicine to reach out to villages/ households that are difficult to access?			
41.	Is a training module on disaster management prepared for PHC staff, ASHAs and ANMs?			
42.	Are regular trainings imparted to Primary Health Centre (PHC) staff, community workers such as ASHAs, ANMs and community members on first aid and emergency health response?			
43.	Is there a mechanism in place for surveillance, detection and reporting outbreaks of diseases and issuing alerts and response tracking?			
44.	Have IEC materials been prepared and distributed among communities, which show the links between health aspects and DRR & CCA?			

6.5 Checklist for Agriculture, Food Security and Livelihood

Sl.	Description/Checklist	Yes	No	Remarks
1.	Is the mapping of land use pattern conducted at district level?			
2.	Are the different land use zones identified in the district?			
3.	Are the types, frequency and severity of potential disasters identified in the area?			
4.	Are bunds constructed along arable lands of villages to prevent river ingression and soil erosion?			
5.	Are locally appropriate solutions such as the construction of check dams/ minor irrigation tanks etc. undertaken to regulate flow of rain water?			
6.	Are there safe and appropriate storage facilities available for quality/ hazard-resistant seeds?			
7.	Can the farmers easily access the quality/hazard-resistant seeds?			
8.	Are there extension activities undertaken for training farmers?			
9.	Are there mechanisms set up for integrated pest management?			
10.	Is there a regular and functioning system existing to advise farmers on various agricultural issues free of cost in the local language?			
11.	Is there a regular and functioning system for training of farmers on creation and maintenance of grain and seed banks?			
12.	Is there a supportive, accessible and functional system present to ensure remunerative prices to farmers?			
13.	Is there an accurate, reliable and functional system present to track changes in weather patterns and their impact on agriculture, and further document it and disseminate among farmers?			
14.	Are farmers linked with risk sharing and transfer instruments like crop/ livestock/fishery insurance, compensation and calamity funds, micro/ credit and cash transfers etc.?			
15.	Are there enough seeds, fertilisers and pesticides available in the market? (may be done by establishing agriculture input hubs)			
16.	Is there a system for quick dewatering and clearing of cultivable lands at priority?			
17.	Is there a provision of cash support/interest free loans for farmers for sowing of crops in a post-emergency situation?			

Sl.	Description/Checklist	Yes	No	Remarks
18.	Is there a functional mechanism (such as Flood Forecasting System) to advise farmers for appropriate crop selection (testing and introducing new varieties, drought/saline/flood resistant crops, quick crowing crops) and animal breeding; Improved cropping systems and cultivation methods (crop diversification, intercropping, adjustment of cropping calendars, soil conservation); and Post-harvest management (storage, food drying, food processing) etc.?			
19.	Is there a functional system present to preserve animal stock by supplying supplementary feed, vaccination and standard medication such as de-worming for cattle, sheep, goats and other such livestock?			
20.	Is there well defined and efficient coordination mechanism established at village level, block level, district level, state level and national level?			
21.	Is there a functional mechanism available to improve the communication and coordination between the various stakeholders within the agriculture sector, as well as outside this sector?			
22.	Are workshops/seminars/sharing forums organised for demonstration and sharing of good practices for DRR from sectoral/cross-sectoral perspective to increase the resilience of existing farming systems?			
23.	Do functional systems and mechanisms exist to promote livelihood diversification, which may include small-scale enterprise development, introducing new farming activities (small-scale livestock, fish ponds, new crops of higher market value etc.)?			

6.6 Checklist for Animals and Fisheries

Sl.	Description/Checklist	Yes	No	Remarks
1.	Are the animal treatment centres and medicine storage etc. multi-hazard resistant (for flood, earthquake, fire, cyclone etc.)?			
2.	Are the veterinary hospitals constructed at strategic locations and away from flood prone areas?			
3.	Are the artificial insemination centres constructed at strategic locations and away from flood prone areas?			
4.	Are the fodder-banks established at safe places with multi-hazard resistant features (for safety against flood, water logging, earthquake, cyclone, fire etc.)?			
5.	Is earthquake and flood resistant renovation done for the fishponds and ox-bow lakes?			
6.	Are trainings and awareness programs conducted for fish farmers in scientific aquaculture?			
7.	Is renovation of water bodies done through village level committee comprising of PRIs, fish-farmers etc.?			
8.	Is there a mechanism of cross-learning, sharing and exposure visits etc. for farmers (cattle, fish, goat, poultry farmers etc.)?			
9.	Are regular awareness building processes conducted among the departmental staff, communities and the key stakeholders engaged with the department on potential disaster risks and measures to reduce the risk?			
10.	Are funds year-marked for mitigation measures (such as reconstruction work) in the sector?			

6.7 Checklist for Rural Roads

Sl.	Description/Checklist	Yes	No	Remarks
1.	Has a hazard risk vulnerability and capacity assessment (HRVCA) been conducted for the villages?			
2.	Is road connectivity established for critical village facilities such as PHCs, schools and Panchayat offices within the villages?			
3.	Are localities and households identified within the villages, which are disconnected, particularly during disasters such as a flood or earthquake?			
4.	Is there a plan to construct all-weather road to such localities and households for their connectivity and accessibility?			
5.	Keeping in view the hazard proneness of the villages, does the construction of roads in the villages meet the technical specifications and geometric design standards given in the Rural Roads Manual of the Indian Roads Congress (IRC:SP20:2002) and the Hill Roads Manual (IRC:SP:48)?			
6.	Does the road design for villages consider soil type and rainfall as well as by the technical specifications laid down in the Rural Roads Manual (IRC: SP20: 2002)?			
7.	Are the rural roads constructed with cement road or with paved stones (all-weather roads)?			
8.	Do the rural roads have appropriate side drains and cross drainage so that improper drainage does not damage the road or the dwelling units alongside?			
9.	Are the roads constructed keeping in view the hazard profile of the village so that they are resistant to the specific hazards of the village such as floods, landslides and snowfall, among others?			
10.	Are the Village/Panchayat level functionaries, PRI representatives and community- level resource persons oriented on DRR and involved to enhance the effectiveness of the PMGSY?			
11.	Is there a plan formulated by the Gram Panchayat to bring convergence of the PMGSY with the MGNREGA and other schemes?			
12.	Are regular awareness building processes conducted among the departmental staff, communities and the key stakeholders engaged with the department on potential disaster risks and measures to reduce the risk?			

6.8 Checklist for Environment

Sl.	Description/Checklist	Yes	No	Remarks
1.	Is Environmental Impact Assessment (EIA) being conducted for all programmes/projects?			
2.	Is Disaster Impact Assessment (DIA) integrated in EIA for all projects/ programmes?			
3.	Is eco-system conservation considered as part of all developmental activities, particularly in environmentally sensitive areas such as coastal and hill areas etc.?			
4.	Is DRR integrated in CCA programmes at all levels?			

Sl.	Description/Checklist	Yes	No	Remarks
5.	Does the concerned project or the Contractor take all reasonable steps to protect the environment (both on and off the site) and to limit damage and nuisance to people and property resulting from pollution, noise and other results of their operations?			
6.	Does the concerned project or the Contractor ensure that emissions, surface discharges and effluent from the activities does not exceed the values indicated in the specifications, and shall not exceed the values prescribed by applicable Laws?			
7.	Are regular monitoring checks done on the appointed Contractor's work to ensure that s/he is taking reasonable steps to protect the environment to limit the damage?			

6.9 Checklist for Migration

Sl.	Description/Checklist	Yes	No	Remarks
1.	Is systematic vulnerability capacity assessment (VCA) conducted in the villages to understand the livelihood patterns and seasonality?			
2.	Are migrant families able to access their entitlements and rights in their respective villages?			
3.	Are there programmes/schemes in the villages to build capacities of the migrant families in their respective skills so that they may earn better?			
4.	Are there measures taken to raise the community's awareness on migration choices and alternatives?			
5.	Are the urgent and long term needs of migrants identified?			
6.	Is there a mapping done for keeping record of individual migrant's skills and experience?			

6.10 Checklist for Gender Issues in DRR and CCA

Sl.	Description/Checklist	Yes	No	Remarks
1.	Has a mapping been done to understand the gender specific issues that may arise out of disaster and climate change?			
2.	Is a systematic gender analysis carried out for different roles, responsibilities and socio-economic status of men, women and other household members?			
3.	Does the analysis include a focus on diversity issues, such as the situation of men and women who are poorer, ethnic minorities, elderly, disabled, etc.?			
4.	Are there gender sensitisation programmes conducted for local government officials and community leaders to fully involve women and men, as well as marginalised groups, in disaster risk management activities and decision-making?			
5.	Have activities been undertaken to strengthen both male and female capacity in activities such as risk mapping to enable gender perspectives of risks and vulnerabilities to be identified through processes such as VCA?			

Sl.	Description/Checklist	Yes	No	Remarks
6.	Do the decision-making processes of Community Based DRR and preparedness activities promote proportional representation of women and men from diverse groups?			
7.	Do local organisations participate in the promotion, planning or implementation of the programme?			
8.	Do the men and women fully participate in the risk analysis and in developing community-based early warning systems that use the local tools and knowledge of both men and women?			
9.	Do both genders actively engage in community-based early warning systems to ensure that procedures are sensitive to both female and male needs?			
10.	Are safety-net cash transfers for household food security and basic needs provided directly to women?			
11.	Do women and men both have access to appropriate credit facilities and training for adapting their livelihoods to changing conditions?			
12.	Are women and men both involved in the development of land-use policies?			

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Annexures

Annexure-1: Case Studies for Reference

Annexure-2: Sectoral Responses in Various Impact Scenarios

Annexure-1

Case Studies for Reference

Case studies, innovative programmes and experiences on impact of climate change, and related adaptation measures are dealt with in following sections.

1. Impact of Climate Change on Sorghum in India

A study carried out on sorghum, one of India's most important crops, helped to give insights into the possible impact of climate change. The study focused on winter and monsoon crops of sorghum in three different climate zones of India: central (CZ), south-central (SCZ) and south-west (SWZ). According to the findings, an increased temperature will most likely lead to an overall decrease in crop production. By 2020, monsoon sorghum production is predicted to decrease by 14 percent in CZ and SWZ and by 2 percent in SCZ, whereas winter sorghum production is estimated to decrease by up to 7 percent by 2020. However, the authors mention that very low cost adaptation strategies, like changing variety and sowing date, could reduce the impact and vulnerability of winter sorghum and help maintain the productivity of sorghum under changing climatic conditions.

Source: Srivastava, et al. (2010)

2. Adapted Varieties Preventing Starvation – An Example from Karnataka, India

Sankappa is a small farmer owning three hectares of dryland in the village of Vittalpura in Bellary district, Northern Karnataka, India. This village is situated on the semi-arid Deccan Plateau and receives annual rainfall of 500 mm over a three-month period, which allows just one generation of millet to be grown between July and October. The amount of rainfall in this part of the country has dropped continuously over the last years; rainfall was below 300 mm in 2003.

Like his forefathers and other farmers of the village, Sankappa grows foxtail millet (*Setaria italica*). The millet varieties grown and conserved by the farmers of Vittalpura over the years have excellent drought resistance. 'All other crops failed due to extreme drought, and my family and livestock were saved from starvation only by the foxtail millet harvest,' said Sankappa.

Source: Bala (2004)

3. Community-based Adaptation – An Example from Eastern India

Background: Kodikitunda is a very small village in the Indian state of Odisha. The population consists mainly of farmers of tribal origin who have small landholdings and depend on rain-fed agriculture as one of their main sources of livelihood. Lately, due to heavy rainfall and longer dry spells, communities have faced shortages of water for irrigation and problems like dropping crop yields and soil erosion. Furthermore, the lack of financial resources often limits farmers' access to better farming technologies.

Approach: A non-governmental organisation (NGO), Agragamee, has been active in helping farmers in Kodikitunda cope with changing climatic conditions since 1994. The measures taken by the NGO with the involvement and help from the villagers include construction of check dams, field ponds and wells, contour bunding and gully plugging. Tree plantations were also created at strategic locations. Local institutions like water user societies and women's self-help groups were established and received support.

Outcome: The farmers have benefited most from increased tree cover, as it has reduced soil erosion to a great extent and also helped in groundwater restoration. Not only are the farmers continuing to plant trees in order to maintain the tree cover, they are also imposing fines on anyone violating regulations designed to protect the trees. Apart from improving the agricultural land, the efforts have helped farmers to diversify their income, e.g. through selling timber and non-timber products.

Source: Pande & Akermann (2009)

4. Biodiversity Erosion in the Sundarbans

The Sundarbans, an eco-region that covers the southern tip of India's West Bengal and Bangladesh's South, is both unique, and uniquely fragile. It is one of the most extensive mangrove forests in the world, with very high species diversity (18 major mangroves, 22 minor mangroves and 36 mangrove associates). These mangrove forests are one of the most significant strongholds of the Royal Bengal Tiger, an endangered species and the national animal of India. In addition, the mangroves presents a natural buffer against coastal erosion and seawater ingress into one of the most densely populated regions of the world where about 4.5 million Indians and about 7.5 million Bangladeshis live.

The Sundarbans are characterised by developmental constraints in terms of rapidly growing population on the one hand and a lack of appropriate transportation, modern energy services, adequate healthcare delivery, and education on the other hand. Global climate change is making matters worse for the region and its inhabitants, both human and wildlife. Sea levels are rising faster than the global average and high intensity events such as severe cyclones and tidal surges are becoming more intense. Loss of land is now a reality. As land-based livelihood activities get impacted due to rising sea levels, coastal erosion, loss of mangrove cover, and saltwater incursion, more and more people are exploiting the living resources of the ecosystem in a manner that will be difficult to sustain over the long term. The situation has the potential to erode ecosystem integrity due to overexploitation

of natural resources. For these reasons, climate vulnerability assessments are being carried out in the region and adaptation measures are undertaken by various Indian and international organisations.

Panchanan Gayen, 60 years old, lives in a village called Beguakhali on Sagar Island. He is one out of millions in the Sundarbans who depends on the land and the sea for his and his families' livelihood. Agriculture is his primary occupation. But he also tried his hand as fish whole seller, wood whole seller, and as medicine supplier in the past. Panchanan Gayen says: 'I am witness to immense changes which took place during the last three decades. Our village had huge stretches of sandy beaches and dense mangrove jungles along the coast. These jungles were stocked with a variety of mangrove species and wildlife. We lost these unique vegetative features and wildlife after 1980. In the past, Beguakhali was quite a big village. It is located at the south western side of Sagar Island. The river is fast eroding our village and it has already lost 26 hectares of land in the last three decades. The river has already washed away 35 houses in the recent past. My house was almost one kilometre away from the river, but now it is on the river side. Affected families have been relocated and resettled on the northern part of this island.'

Source: WWF (2010)

5. Payment for Ecosystem Services (PES) – An Example from Himachal Pradesh, India

Palampur town is situated in the foothills of Dhauladhar range in Kangra district of Himachal Pradesh in India. The Palampur Municipal Council (PMC) is responsible for drinking water supply in the town comprising of 852 households, 168 commercial establishments and 78 public enterprises. Bohal spring, situated upstream in Bohal village has been one of the major four sources of drinking water for the PMC and of superior quality as compared to others. Over the last few decades discharge from Bohal spring has declined substantially, from about 7-8 litres per second to 3-4 litres per second. This has been a major concern for the PMC.

The GIZ project 'Capacity building of Panchayati Raj Institutions in Himachal Pradesh' conducted a geo-hydrological survey of the area to delineate the infiltration zone for the Bohal spring system in the water management plan. The pilot project brought together key upstream and downstream stakeholders - the local communities of two villages in the Bohal spring catchment, the Forest Department, the Irrigation and Public Health Department, and the PMC. Together, they prepared a catchment protection, forest management and water management plan for the Bohal spring system.

The process led to the signing of a 20-year lasting agreement between the PMC and the Village Forest Development Society (VFDS) of Bohal outlining the Payment for Ecosystem Services (PES) arrangement. The PMC would pay to the VFDS Rs. 10,000 per annum with a provision of 10 percent increment every five year for source protection. The VFDS agreed to completely stop open grazing of livestock in the catchment area, control lopping and fodder harvesting, and implement a forest management plan in the catchment area. The VFDS and PMC agreed to jointly monitor the provisions of the agreement twice every year. There is also a provision to review the PES agreement every five years.

(Source: GIZ)

6. Maintaining Agricultural Biodiversity – An Example from the Himalayas

In many areas of India people grow different crop combinations in order to minimise the risk due to harvest failure and at the same time maintain agricultural biodiversity.

Farmers in the cold deserts of the Indian Himalayas have developed a number of traditional cropping practices to adapt to the harsh climatic conditions. The cold desert areas of Indian Himalayas are characterised by fast-blowing winds that erode the immature sandy soils and extreme variations in daily and seasonal temperatures. There is erratic precipitation during spring and summer, which marks a short growing season (spanning 25 months).

Farmers in such areas practice crop rotation, alternating paddy cultivation with wheat cultivation in the areas with irrigation, while wheat or barley is rotated with maize or mash in areas without irrigation. However, in cold reaches where paddy cannot be grown and two regular crops are not practicable, cultivation of wheat, barley, or *masur* (lentil) is followed by a fallow period during the winter. Crop rotation helps in maintaining soil productivity. Leguminous crops fix nitrogen. Intercropping maize, wheat, barley and millets conserves soil due to their different root systems, which extract nutrients from different layers of the soil. It also helps in crop diversification and control of any soil or crop residue-borne diseases and insect pests.

Source: Silori (2008)

7. Community-based Management of Genetic Resources in India

The need to replenish diversity in agricultural systems has encouraged communities to build up community seed banks that facilitate the revival and distribution of traditional and stress-tolerant crops and varieties.

In Uttar Pradesh, for example, the establishment of seed banks to facilitate the diversification of local food systems serves as a flood coping mechanism. In Bihar and Bengal, community seed banks with a focus on rice have been established to strengthen the community seed supply of flood-resistant varieties. In Odisha, saline-resistant varieties get the most attention from local communities in the hope that their efforts will result in increased productivity in a submergence-prone area.

Sources: Wajih (2008); Navdanya (2009); PAR (2010)

8. Adaptive Water Management – Examples from India

The **National Water Policy** of 2002 stresses the importance of multi-stakeholder participation and multi-sectoral analysis in planning and implementing water resource projects. It attaches great value to information systems that encourage knowledge generation, management and sharing as well as monitoring projects to ensure necessary corrective action has been mandated. The National Water Policy covers a broad array of water-related issues including groundwater development, drinking water, irrigation, resettlement, and land erosion. It places the stakeholders in the central role and is a good example of how the Government of India is trying to bring flexibility into the water management policy framework.

Another example of Adaptive Water Management being practiced intuitively in India is the **Common Guidelines for Watershed Development Projects** of 2008. The watershed guidelines have been modified over the past two decades, which shows the ability of India's political institutions, with the support of civil society, to adapt practices as circumstances change and people and institutions learn from experience. The most recent iteration, which is certain to be followed shortly by another, places a strong emphasis on the centrality of community participation and capacity development as well as on monitoring and evaluation. The guidelines have even mandated that 2 percent of the budget for watershed projects should be allocated to monitoring and evaluation and 5 percent to capacity building. The constant adaptation of the guidelines is not indicative of a trial and error process, but is rather the result of institutional learning by doing to adapt to changing requirements.

A practical example of Adaptive Water Management is the village of Hiware Bazar in the state of Maharashtra, known for its community-based initiatives in enhancing the resilience of communities to climatic variability and extreme weather conditions. From 1995 to 2005, the efforts of the local leadership were directed towards water conservation, which includes both replenishing the groundwater and creating a surface storage system. Since 2004, Hiware Bazar has been conducting an annual water audit, measuring the total availability of water. The implementation of these development programmes has to a large extent stopped the migration of the villagers. The village has introduced its own water regulations linked to its cropping plans. It began to base cropping patterns on water availability, despite a well-established market for the sugarcane crop. Decisions on cropping intensity are taken annually, ensuring efficient management of the resource and its equitable distribution.

9. Communities Engaging in Mangrove Restoration – An Example from Tamil Nadu, India

Background: Pichavaram mangrove wetland is located at the northernmost end of the Cauvery delta in Tamil Nadu. It covers a total area of about 1,470 hectares, consisting of about 50 small, yet inhabited islands. Due to extensive felling of mangrove trees to generate revenue, the whole area has experienced a number of problems like increased salinity, loss of biodiversity and complete degradation of the Pichavaram wetland.

Approach: The M.S. Swaminathan Research Foundation (MSSRF), supported by the State Forest Department (Government of Tamil Nadu) and the participation of local mangrove user communities, started a programme of mangrove restoration on a small area of 10 hectares. Artificial canal systems were built, enabling tidal water to flow freely to and from the degraded areas, increasing the soil moisture and decreasing soil and groundwater salinity. This made the area suitable for mangroves to be planted with good chances of survival.

Outcome: These efforts led to an increase in mangrove cover and a decrease in salinity of groundwater in the tested area. The success of this project led to a community-based joint mangrove management scheme being set up in this area and to the restoration of the Pichavaram wetland.

Source: Selvam et al. (2003)

10. Communities Replanting and Restoring Mangroves – An Example from Gujarat, India

Background: The Indian state of Gujarat has a 22.5 percent share in the country's total mangrove cover. In order to restore the declining mangrove cover, the state forest department started to support mangrove plantations in the districts of Kutch and Jamnagar. In 2001, the Gujarat Ecology Commission (GEC), which is an autonomous body under the state government, started a community-based project for mangrove restoration with financial help from the India-Canada Environment Facility (ICEF).

Approach: The project covered a total of 10 villages in Gujarat. Its key feature was building capacity in the communities to promote regeneration and sustainable management of the mangrove resources. In addition to mangrove plantation activities, awareness programmes were also conducted to educate people about mangroves and their ecological and economic importance. The state government had a very proactive role in this project.

Outcome: Under this project, which ended in 2007, a total of 4,000 hectares of mangroves were planted. The project also helped to establish a pool of local experts who are able to sustainably manage the restored mangrove forests and create large-scale awareness among local communities about the significance of mangroves.

Source: GEC (2010)

11. Towards Sustainable Water Management – An Example from Tamil Nadu, India

Background: Kadaikadu, a coastal town in the Nagapattinam district of Tamil Nadu, is home to 300 people. The town's close proximity to the sea and low-lying lands makes it vulnerable to sudden climatic changes. Lately, the town's freshwater supply has started to become scarce due to flooding and changing rainfall patterns as water storage ponds are either turning saline or running dry, which is threatening the livelihoods of the agriculture-based communities of Kadaikadu.

Approach: To address these challenges, GIZ Advisory Services in Environmental Management initiated the CapCoast pilot project for Kadaikadu with funding from the German Federal Ministry for Economic Cooperation and Development. One of its aims is to climate proof a fresh water pond in the village, i.e. anticipate climate impacts on its usage and respond in ways that minimise risk and utilise opportunities. The intention is to increase the capacity of water reservoirs and support groundwater recharge, which will in turn enhance well water sources. The technological interventions are accompanied by capacity development and knowledge transfer in water resource management, and include limiting groundwater extraction to an amount that can be replenished.

Outcome: These efforts made it possible to prevent salinisation of the water sources and nearby fields that provide the main source of livelihood. In addition, bunds were constructed to protect the pond from the intrusion of brackish water during cyclones and flooding. Under the notification, all development activities proposed in these zones are regulated according to specific guidelines. Special focus would be put on ecologically sensitive areas such as Sundarbans in West Bengal and on vulnerability and hazard mapping. This will be taken into consideration when framing coastal zone management plans for each state. Each coastal state has a designated coastal zone management authority under the Coastal Regulation Zone Notification and is responsible for implementing the regulation and drawing up a coastal zone management plan (MoEF, 2010).

Source: GIZ (2011)

Annexure-2

Sectoral Responses in Various Impact Scenarios

Impact of Climate Change				
Sector	**Drought**	**Flood**	**Increase in Sea Level**	**Health**
Land Use Planning	Include water efficiency in building codes and infrastructure plans	Include flood protection in building codes, zoning	Prevent new construction in vulnerable areas	Promote healthy lifestyles with walking/biking routes
Water Supply	Improve storage Reduce leakage Improve efficiency	Maintain quality Retain supply	Diversity forces Protect supply from saltwater intrusion	Improve potability and access
Sewerage	Adopt low water treatment options	Prevent overflow	Protect/relocate infrastructure	Improve coverage of sewage treatment
Storm Water Drainage	Harvest/store rainwater	Expand drainage capacity improve natural catchments	Protect/relocate infrastructure Protect natural coastal defences in delta regions	Improve drainage Prevent standing water
Solid Waste	Improve organic waste re-use, for compost and moisture retention Encourage low water processes	Improve containment Prevent release	Protect/relocate infrastructure	Improve collection services

Impact of Climate Change				
Sector	**Drought**	**Flood**	**Increase in Sea Level**	**Health**
Roads/Traffic	Use previous surfacing to allow for aquifer recharge	Improve road drainage Use previous surfacing to encourage runoff Establish/improve evacuation routes	Protect/relocate infrastructure	Establish/improve evacuation routes and accessibility of health services
Housing	Improve water use efficiency	Promote flood-resistant designs	Prevent new development in vulnerable areas Relocate highly vulnerable settlements	Prevent overcrowding
Housing for the Poor	Increase efficient water provision	Prevent settlement and improve resilience in vulnerable areas	Prevent settlement and improve resilience in vulnerable areas	Increase housing provision and quality
Pollution	Prevent high ozone levels	Prevent release of water pollutants	Prevent ocean pollution from land contaminants	Decrease pollution
Education	Increase water conservation education	Improve disaster response education, early warning systems	Increase education about impacts and responses to sea level rise	Increase health education
Health	Prevent dehydration and related conditions	Prevent drowning and flood-related diseases Relocate and fortify key health infrastructure	Relocate health infrastructure	Expand and improve rapid response and preventive care
Recreation/ Open Space	Employ water-efficient landscaping and maintenance techniques Encourage tree planting to reduce urban heat island	Increase water retention capacity in open space Manage flood-prone areas as green space to prevent settlement	Manage low-lying coastal areas as green space to prevent settlement	Promote healthy lifestyles

Impact of Climate Change				
Sector	**Drought**	**Flood**	**Increase in Sea Level**	**Health**
Governance	Strengthen capacity Improve transparency and inclusiveness	Strengthen capacity Improve transparency and inclusiveness	Strengthen capacity Improve transparency and inclusiveness	Strengthen capacity Improve transparency and inclusiveness
Finance	Improve financial resilience through efficiency measures	Flood-proof investments	Protect or reconsider investments	Ensure resilient health finances
Public Transport	Reduce water use for vehicle/system cleaning	Improve adaptive capacity of infrastructure Establish/improve evacuation routes	Protect/relocate infrastructure	Expand coverage and promote equal access to mobility options
Economic Development	Factor into commercial and industrial policy	Factor into commercial and industrial policy	Factor into commercial and industrial policy	Factor into commercial and industrial policy
Insurance	Protect against loss of livelihood	Protect citizens from loss of assets	Protect citizens from loss of assets	Expand access to healthcare for all citizens

Source: Mainstreaming Urban Resilience Planning in Indian Cities – A Policy Perspective, May 2011, Pp. 8-9 (TERI – 2009b)

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