Develop a baseline document to capture and analyse existing approaches and methodologies for Hazard Risk & Vulnerability Assessment

FINAL REPORT

WINROCK
INTERNATIONAL
INDIA

Contents

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List of Abbreviations/Acronyms

AAI	Aridity Anomaly Index
ANFAS	Data Fusion for Flood Analysis and decision Support
BMPTC	Building Materials Promotion Council
BPL	Below Poverty Line
CAZRI	Central Arid Zone Research Institute
CBO	Community Based Organisation
CD	Compact Disk
CDMS	Comprehensive Data Management System
CGWB	Central Ground Water Board
CWC	Central Water commission
CDMM	Centre for Disaster Mitigation & Management
CEO	Chief Executive Officer
CFM	Critical Facilities Map
CRED	Centre for Research on the Epidemiology of Disasters
CRIDA	Central research Institute for Dry land Agriculture
CRiSTAL	Community-Based Risk Screening Tool- Adaptation & Livelihoods
CVA	Capacities and Vulnerability Analysis
CVCA	Community Vulnerability and Capacity Assessment
CVCA	Climate Vulnerability and Capacity Analysis
CWSI	Crop Water Stress Index
DFID	Department for International Development
Defra	Department of Environment Food and Rural Affair
DGCA	Directorate General Civil Aviation
DM	Disaster management
DMC	Disaster Management Committees
DMI	Disaster Management Institute
DRI	Disaster Risk Index
DRM	Disaster Risk management
DRR	Disaster Risk Reduction
EDI	Effective Drought Index
EIA	Environmental Impact Assessment
EM&R	Ecosystem Management and Restoration
EM-DAT	Emergency Events Database
ESRI	Economic and Social Research Institute
FGD	Focus Group Discussion
FSI	Forest Survey of India
GDP	Gross Domestic Product
GEAG	Gorakhpur Environmental Action Group
GEF	Global Environment Facility
GSI	Geological Survey of India
GIS	Geographic Information System
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH
HDI	Human development Index
HH	House Hold
HIV/AIDS	Human immunodeficiency virus- Acquired Immunodeficiency Syndrome
HLS	Household Livelihood Security
HR	High Risk
HRM	Hazard Risk Management

HRV	Hazard Risk Vulnerability
HRVA	Hazard, Risk and Vulnerability analysis
HVCA	Hazard, Vulnerability ad Capacities Assessment
IARI	Indian Agricultural Research Institute
ICAR	Indian Council for Agricultural Research
ICMOD	International Centre for Integrated Mountain Development
IFRC	International Federation of Red Cross and Red Crescent Societies
IIASA	International Institute for Applied Systems Analysis
IIM-A	Indian Institute of Management – Ahmedabad
IISD	International Institute of Sustainable development
IIT	Indian Institute of Technology
IITM	Indian Institute of Tropical Meteorology
IMD	Indian Meteorological Department
IRS	Indian Remote Sensing
ISRO	Indian Space Research Organization
INSAT	Indian National Satellite system
IRDP	Integrated Rural Development Program
IRR	Internal Rate of Return
IRS	Remote Sensing Satellites
ISET	Institute of Socio Economic Transition
IT	Information Technology
IUCN	International Union for Conservation of Nature
IWD	Irrigation and Water department
LCILP	Local Climate Impacts Profile
LHEF	landslide hazard evaluation factor
LHAZ	Landslide Hazard Automated Zonation
LHZ	landslide Hazard Zonation
LIDAR	Light Detection And Ranging
LR	Low Risk
LSP	Local Strategic Partnership
LSV	Landslide Susceptibility Values
LULUC	land use and land use cover
MAI	Moisture Adequacy Index
MoEF	Ministry of Environment and Forests
MMI	Modified Mercalli Intensity Scale
MR	Medium Risk
MHM	Multi Hazard Map
NADAM	The National Agricultural Drought Assessment and Monitoring System
NAP	National Action Program
NAPA	National Adaptation Program of Action
NCA	National Commission on Agriculture
NDMA	National Disaster Management Authority
NGRI	National Geophysical Research Institute
NIDM	National Institute of Disaster Management
NIO	National Institute of Oceanography
NOAA-AVHRR	National Oceanic and Atmospheric Administration -Advanced Very High Resolution Radiometer
NRSC	National Remote Sensing Centre
NCMRWF	National Centre for Medium range Weather Forecasting
NDMA	National Disaster Management Authority
NDVI	Normalized Difference Vegetation Index

NDWI	Normalized Difference Wetness Index
NGO	Non Government Organisation
NPV	Net Present Value
NRSA	National Remote Sensing Agency
NRSC	National Remote Sensing Centre
PAR	Pressure and Release Model
PAR	Participatory Action Research
PADR	Participatory Assessment of Disaster Risk
PCVA	Participatory Capacities and Vulnerability Assessment
PDSI	Palmer Drought Severity Index
PGA	Peak Ground Acceleration
PLA	Participatory Learning and Action
PRA	Participatory Rapid Assessment
PRA	Participative Risk Analysis
PISFR	Pre investment Survey of Forest Resources
PRRA	Participatory Rapid Rural Appraisal
PVA	Participatory Vulnerability Analysis
RA	Risk Analysis
RADIUS	Risk Assessment Tool for Diagnosis of Urban areas against Seismic
RAM	Risk Assessment Matrix
RAT	Risk Assessment Tool
RH Model	Risk Hazard Model
RFA	Risk Factor Analysis
RMSI	Risk Management Software India
RRA	Rapid Rural Appraisal
RRI	Relative Risk Index
RTI	Right to Information
RVAT	Risk and Vulnerability Assessment Tool
SC	Scheduled Caste
CSSTEAP	Science & Technology Education in Asia and the Pacific
SHG	Self Help Groups
SLA	Sustainable Livelihoods Approach
SLF	Sustainable Livelihoods Framework
SAC	Space Application Centre
SDFs	Spatial Development Frameworks
SPI	Standardized Precipitation Index
SPOT	Satellite Pour l'Observation de la Terre
SPSS	Statistical Package for Social Sciences
ST	Scheduled Tribe
STATA	Data Analysis and Statistical software
SWI	Standardized water level Index
SWOT	Strength, Weakness, Opportunity and Threat
SWSI	Surface Water Supply Index
TEH	Total estimated hazard
ISRO	The Indian Space Research Organisation
ToR	Terms of Reference
UK	United Kingdom
UKCIP	United Kingdom Climate Impacts Programme
UN	United Nation
UNDP	United Nations Development Program
UNFCCC	United Nations Framework for Climate Change Convention

UN-ISDR	United Nations- International Strategy for Disaster Reduction
VCA	Vulnerability and Capacity Assessment
VCI	Vulnerability and Capacities Index
WiFS	Wide Field Sensor
WII	Winrock International India

Executive Summary

India is a vast country that is extremely vulnerable to a large number of natural as well as man-made disasters[1]. The quantum of landmass prone to earthquakes of moderate to very high intensity is 58.6 per cent of the total; the land prone to floods and river erosion amounts to over 40 million hectares (12 per cent of land); close to 5700 km of the 7516 km long coastline is prone to cyclones and tsunamis; the cultivable area vulnerable to drought forms 68 per cent of the total and the risk from landslides and avalanches makes the hilly areas prone to them.

Since the late 1990s, there has been increasing recognition of the need to 'mainstream' disaster risk reduction in order to plan for and address natural hazard risk in development planning at the national level. Hazard Risk and Vulnerability Assessment (HRVA) forms a critical part of the disaster risk reduction program and it has the potential to instruct the necessary authorities to prepare for emergencies. The primary objective of undertaking a HRVA is to anticipate the potential problems and possible solutions to help save lives, protect property, assets, reduce damage and facilitate a speedy recovery. The use of HRVA helps the policy makers, administrators and the community to make risk based choices to address vulnerabilities, mitigate hazards, and prepare for response to and recovery from hazard events. Currently, there are a number of institutions engaged in conducting risk mapping and vulnerability assessment, as well as developing broad frameworks for conducting hazard and vulnerability assessment, along with the risk analysis.

The objective of this baseline document is to develop a common understanding and shared knowledge about the various methods and technologies to conduct HRVA at different levels of governance. The methodologies and approaches for undertaking HRVA are very diverse and technical in nature; whereby the use of some requires specific knowledge of the subject. The use of some of these methods requires sound knowledge of various kinds of software such as those for data entry, data analysis, GIS software, remote sensing, etc. as well as an understanding of the different analytical models. The choice for selection of a particular method / approach is primarily guided by the nature of the hazard, the risk to be assessed, time and resources available, etc. It is always beneficial to induct a HRVA advisory committee at the state level consisting of experts with substantial technical knowledge, elected representatives, officials from the engineering and planning department and also with representatives from the emergency services like (police, fire, and health departments), so as to determine the appropriate approach to be implied while deciding on the hazard risk and vulnerability assessment of a particular area, making use of a single or a combination of the various methodologies discussed in this document.

[1] National Disaster Management Guidelines, 2007, NDMA

Although the baseline document has been developed taking care to provide an overview of the various methodologies for vulnerability and capacity assessment, hazard assessment and risk analysis, with particularly emphasis on including those methodologies that are relevant in the Indian context; however, there may be some more methodologies that may be applicable in particular regions with respect to some specific hazards that do not find a mention here. Therefore, a proper review of the area or region that is to undergo hazard risk and vulnerability assessment is proposed to be undertaken by the technical experts before any decision with regards to the selection of the methodology to be used for the same is taken.

The methodologies mentioned in this baseline document have been discussed briefly so as to provide a basic overview and understanding of the methodology to the users of this document. In case the details regarding any particular methodology are required, it can be sourced from the references provided for the same.

➲ *Analysis of the methodologies*

▪ Vulnerability and Capacity assessment methodologies

While the use of GIS techniques has substantially facilitated and improved the hazard mapping and physical aspects of vulnerability analysis, however the inclusion of social, economic and environmental variables into the GIS's conceptual models remains a challenging task. For some social/economic dimensions of vulnerability, the need to assign a quantifiable value to the variables analyzed in the spatial models used by GIS cannot always be necessarily fulfilled. Moreover, the diverse scales of operation of the social/economic vulnerabilities, i.e. individual, family, community, regional, also make the spatial representation through these techniques very difficult.

The quality and detail of information required by the analysis facilitated by GIS is difficult to source in many of the developing countries such as India. The non-availability or lower quality of the statistical data sets limits the GIS analysis to low resolution outputs. There have been several research initiatives aiming to provide solutions to the methodological constraints, especially the quantification of social aspects of vulnerability. Inspite of such efforts, the socio-economic vulnerability assessments rely on more conventional ways, which provide other opportunities and advantages with respect to the active involvement of community at risk in various community based vulnerability mapping and capacity assessment exercises.

The attempts towards assessment of the socio-economic aspects of vulnerability intend to answer the questions such as who is vulnerable, how they have become vulnerable, etc. The different attributes of groups and individuals such as socio-economic class, ethnicity, caste membership, gender, age, physical disability and religion correspond to some of the characteristics that have been linked to differential vulnerability to hazards.

- **Multi hazard assessment methodologies**

The methodologies for multi hazard assessment are diverse in nature and generally require a large pool of data, specific software, digital maps, satellite imageries and also skilled professional expertise to analyze and assess the scenario. Use of these methodologies generally requires pooling of data from diverse sources and also from different departments of the government. A multiple hazard map has serious implications in emergency preparedness planning and provides the policy planners with a more equitable basis for allocating disaster planning funds and facilitates support to efficient, integrated emergency preparedness response. Critical facilities map (CFM) facilitates to convey clearly and accurately to planners and decision makers the location, capacity, and service area of critical facilities. Effective use of CFM along with Multi Hazards Maps (MHM) can ensure that new critical facilities can be made less vulnerable by avoiding hazardous areas, designing for resistance, or operating with minimal exposure.

The Geographical Information System (GIS) can be used for hazards management at different levels of development planning. Proper selection of a system and its application can reduce the cost for hiring expensive experts and can also multiply the productivity of a technician. Aerial Photography and Satellite Imagery with different sensors form the two major components of remote sensing. Aerial Photography has a better spatial resolution and geometric fidelity than many ground-based sensing methods and has broader spectral sensitivity than the human eye. Satellites data/imagery are the best resources available to date for identification of hazards. The imagery can be obtained from different sources. However, the cost could vary to a considerable extent.

- **Risk assessment methodologies**

The disaster risk reduction process makes use of the risk analysis carried out through development of the risk function, making use of vulnerabilities and capacity assessment and hazards assessment. However, Operationalisation of these methodologies is fraught with a few constraints with respect to the use of the risk assessments in the process of decision making as well as the use of primary input in the form of terminology, data and methodology in the identification of trends in hazard, vulnerability and capacity.

In addition, there is an inherent need to bring into focus the various methodologies for risk assessment identified, into the mainstream as well as adapting them to address the newer emerging trends in hazard and vulnerability assessment.

Introduction

1.1 OVERVIEW

India is a disaster hotspot. Every year millions of people are affected by disasters causing loss of life, property and livelihoods. Some of these disaster events affect large number of people over a short period of time like the Tsunami of 2004, while others occur over several years, but may affect more number of people than these sudden events like the perpetual drought facing the central Indian region. Such events are likely to get more pronounced in the coming years with the increasing affect of climate change.

Evidences from the post hazard situations clearly indicate that the severity, damage and negative economic impacts of such disaster events have increased in the recent times. This can be attributed to the increasing vulnerabilities of individuals, communities and regions prone to such hazard especially due to poor living conditions, increasing poverty, low levels of literacy and awareness along with dwindling state of resources. Many disasters can be avoided, or at least made less destructive, by reducing the risks that people face. Disaster risk reduction has been effective in many countries around the world, by saving lives and protecting livelihoods. Risk reduction effort therefore makes a good economic sense as most of these efforts lead to many times higher returns than the cost of the project.

A disaster risk reduction strategy essentially includes a proper hazard, vulnerability and risk assessment. It also requires resources, institutional & operational capacities and infrastructural facilities like GIS tools & software to execute them. The essential features of such a strategy would require hazard mapping, assessment of hazard risks, and determination of probability of hazard event, vulnerability & capacity assessment on various environmental, social, economic and physical aspects followed by proper risk analysis.

The graphic representation in the figure below describes the main context and activities involved in disaster risk reduction strategization. For the development of any disaster risk reduction strategy, these are the elements to be taken into consideration. The sections of the global review have been organized around these issues, with exception of preparedness, response and recovery initiatives.

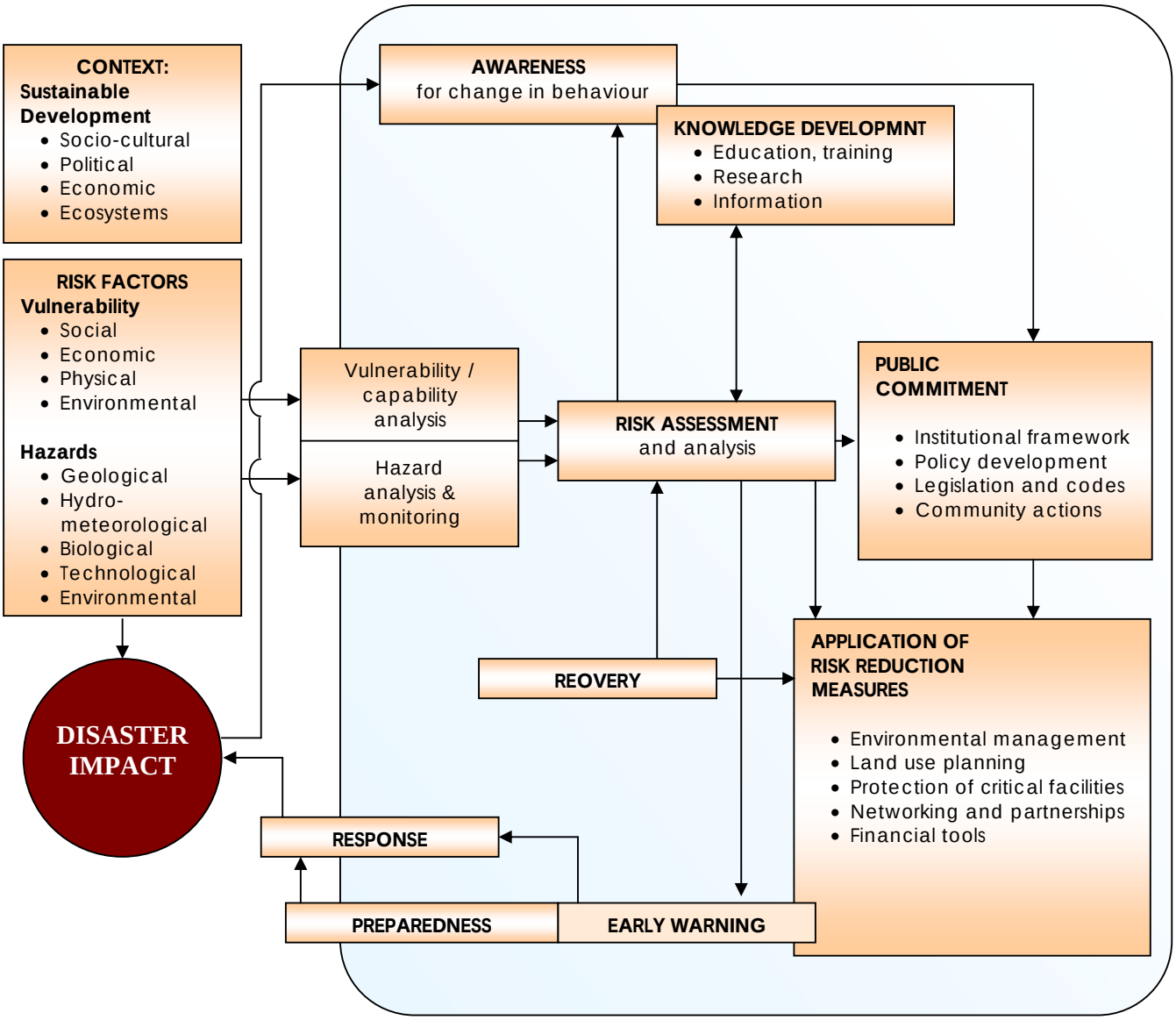


Figure 1.1: *Framework for disaster risk reduction*

1.2 ISSUES & CHALLENGES - HAZARD RISK AND VULNERABILITY ASSESSMENT

Hazard Risk and Vulnerability Assessment (HRVA) is one of the important and integral parts for disaster risk reduction. Currently several methodologies are being used worldwide for multi hazard risk assessment, vulnerability & capacity assessment and risk analysis for development of effective strategies for disaster risk reduction. However, when we consider them for application in Indian context it is marred by several issues and challenges, which have been discussed below:

- Limited agencies working in the field of HRVA, who can guide and advice development practitioners in selection, development and implementation of such methodologies suitable to the local context.
- Limited technical expertise in the form of resource agencies and individuals, who can help decision makers and government agencies in implementation.
- Lack of availability of time series and spatial database on various socio economic, environmental and infrastructural parameters along with demographic details on public domain/ public access that dissuades action research in this field.
- Hazard mapping and development of probability matrix of various hazard events necessitates use of advanced software like GIS, remote sensing and high resolution satellite imageries, which often has high cost implications and require high level of technical expertise for its application.
- Lack of historical legacy in the form of learnings that can be drawn from application of these methodologies in context of various hazards in India.
- Limited number of research agencies working in the field of development and application of new methodologies.
- Limited work on practical application of methodologies used worldwide in various hazard situations to assess its suitability and adaptation to Indian context.

In light of the above issues it becomes a challenge for policy/ decision makers, government & relief agencies, NGOs and other development practitioners to select a suitable methodology for assessment of hazard risks, vulnerability & capacity assessment and risk analysis to develop appropriate action plan for disaster preparedness and mitigation in a given local situation and need. Thus there is a need to take stock of the existing methodologies and review them in this context. The objective of this 'Baseline Document' is to develop a common understanding and knowhow about the various methods and tools available to conduct HRVA at various levels (national, state, district and community).

What do we mean by Hazard Risk and Vulnerability Assessment (HRVA)

The objective of undertaking a HRVA is primarily to anticipate the potential problems and possible solutions to help to save lives, protect property, assets, reduce damage and facilitate a speedy recovery. It is worthwhile to mention that HRVA is a means towards becoming disaster resilient and is not an end in itself. HRVA is a critical part of the disaster risk reduction program and it has the potential to help the necessary authorities to prepare for emergencies. Use of HRVA helps the policy makers, administrators and the community to make risk based choices to address vulnerabilities, mitigate hazards, and prepare for response to and recovery from hazard events. Apart from the central government, the state governments, district authorities and even the local level governance institutions (like municipalities and village panchayats) can undertake hazard risk and vulnerability analysis based on their respective locations vis-à-vis hazards.

1.3 KEY TERMINOLOGIES AND CONCEPTS

Before getting into the details of the document it is important to define the terminologies used within the baseline document. In order to have a common understanding and common usage of disaster the disk reduction concepts the terminologies have been used from UNISDRs 2004 and 2009 version of "Terminology on Disaster Risk Reduction". The most relevant definitions are as follows:

- **Hazard**

A potentially damaging physical event, phenomenon or human activity, which may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation

Hazards can include latent conditions that my represent future threats and can have different origins: natural (geological, hydro- meteorological and biological) and / or induced by human process (environmental degradation and technological hazards). Hazards can be single, sequential or combined in their origin and effects. Each hazard is characterized by its location, intensity and probability.

- **Vulnerability**

A set of conditions and processes resulting from physical, social, economical and environmental factors, which increase the susceptibility of a community to the impact of hazards

Positive factors, that increase the ability of people and the society they live in, to cope effectively with hazards, that increase their resilience, or that otherwise reduce their susceptibility, are considered as capacities.

- **Risk**

The probability of harmful consequences, or expected loss (of lives, people injured, property, livelihoods, economic activity disrupted or environmental damaged) resulting from interactions between natural or human induced hazards, and vulnerable / capable conditions. Conventionally risk is expressed by the equation Risk = Hazards x Vulnerability / capacity

Beyond expressing a probability of physical harm, it is crucial to appreciate that risks are always created or exist within social systems. It is important to consider the social contexts in which risks occur and that people therefore do not necessarily share the same perceptions of risk and their underlying causes.

- **Risk assessment / analysis**

A process to determine the nature and extent of risk by analyzing potential hazards and evaluating existing conditions of vulnerability / capacity that could pose a potential threat or harm to people, property, livelihoods and the environment on which they depend

> *The process of conducting a risk assessment is based on a review of both technical features of hazards such as their location, intensity and probability, and also the analysis of the physical, social and economic dimensions of vulnerability, while taking particular account of the coping capabilities pertinent to the risk scenarios.*

- **Coping capabilities / capacity**

The manner in which people and organizations use existing resources to achieve various beneficial ends during unusual, abnormal, and adverse conditions of a disaster event or process

> *The strengthening of coping capacities usually builds resilience to withstand the effects of natural and other hazards.*

- **Resilience / resilient**

The capacity of a system, community or society to resist or to change in order that it may obtain an acceptable level in functioning and structure. This is determined by the degree to which the social system is capable of organizing itself, and the ability to increase its capacity for learning and adaptation, including the capacity to recover from a disaster.

- **Disaster**

A serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community / society to cope using its own resources.

> *A disaster is a function of the risk process. It results from the combination of hazards, conditions of vulnerability and insufficient capacity or measures to reduce the potential negative consequence of risk.*

- **Risk management**

The systematic management of administrative decisions, organization, operational skills and responsibilities to apply policies, strategies and practices for disaster risk reduction.

- **Disaster risk reduction (disaster reduction)**

The systematic development and application of policies, strategies and practices to minimize vulnerabilities and disaster risks throughout a society, to avoid (prevention) or to limit (mitigation and preparedness) adverse impact of hazards, within the broad context of sustainable development.

- **Prevention**

Activities to provide outright avoidance of the adverse impact of hazards and related environmental, technological and biological disasters.

Depending on social and technical feasibility and cost/ benefit considerations, investing in preventive measures is justified in areas frequently affected by disaster. In the context of public awareness raising and education, prevention refers to attitude and behaviour leading towards a "culture of prevention".

- **Mitigation**

Structural and non-structural measures undertaken to limit the adverse impact of natural hazards, environmental degradation and technological hazards.

- **Preparedness**

Activities and measures taken in advance to ensure effective response to the impact of disaster, including the issuance of timely and effective early warnings and the temporary removal of people and property from a threatened location.

- **Early warning**

The provision of timely and effective information, through identified institutions, that allow individuals at risk of a disaster, to take action to avoid or reduce their risk and prepare for effective response.

Early warning systems consist of three elements (i)forecasting and prediction of impending events, (ii) processing and dissemination of warnings to political authorities and population, and (iii) undertaking appropriate reaction to warnings.

1.4 SCOPE OF THIS DOCUMENT

The present baseline document is a collection of various methods and techniques to conduct HRVA. It is based on the analysis of the various methodologies and will help the state, district disaster management authorities, development organizations and civil society organizations to develop a common understanding on the various methodologies. The document is expected to be used by state, district disaster management authorities, development organisations and civil society working on HRVA. Efforts have been made to simplify the methodologies to the best possible

extent. But since the methodologies and approaches are very diverse and technical in nature, the use of some would require basic knowledge on the subject. Use of some techniques would require knowledge of software and understanding of model. The choice for selection of a technique will primarily be guided by the nature of the hazard or the risk to be assessed. The other possible factors determining the choice would be the cost, kind of expertise and the software required. It is also important to note that while the document presents an extensive listing of the various methodologies in the context of hazard, vulnerability and risk assessment, it is nevertheless not an exhaustive document. The methodologies and approaches have been summarized in a particular format to ensure an easy understanding for the readers. It is always recommended to consult the resource agencies and review the references mentioned before undertaking any exercise. The format developed for the baseline document has been explained below:

Name of the method/ tool	
Brief Description	This section explains the objective, purpose and a brief summary of the method/tool (hazard analysis, vulnerability and risk analysis). Broad steps for undertaking the methodology are mentioned in this section. Flowcharts have been used wherever possible, to explain the steps involved.
Application/ Utility	Describes where the method or tool is applicable and suitable. In this case whether this is a multi hazard or single hazard assessment tool. This gives the user an idea of the stage at which it is appropriate to use.
Geographical Scope	This section mentions the geographical scale for which the method or tool is applicable e.g. city, district, community or country level.
Inputs/ Resources/data	Explains the nature (qualitative/ quantitative), scale, frequency/ periodicity, source etc. of data requirements for executing the methodology.
IT Infrastructure/ software required	Describes the computer hardware and software for eg. IT infrastructure, GIS software, manpower etc. necessary to use the framework or tool wherever applicable. This section also highlights the nature of training required and resource agency where it can be obtained for using the methodology.
Cost for resource input	Wherever possible it gives the approximate cost of technical data inputs such as resource/GIS maps and cost of software. Where the exact cost is unavailable, relative cost is used (e.g., high, medium, or low relative to other methods described).
Output/ outcomes	Explains the final and intermediate product of the method/tool (hazard map generation, probability matrix, Vulnerability chart etc)
Analysis	This section highlights the advantages & disadvantages of each methodology to help the user in decision making (in selection of a particular methodology over others).
Resource Agency/ Reference details	Provides information on who to contact for further information, documentation, and technical assistance. Generally the agency or firm that developed the framework or tool, or, for several of the tools applicable to multiple sectors, someone who can provide a reference to an expert for a particular application. Lists the citations for website, documents, articles, etc., from where the method/ tool has been mentioned

1.5 STRUCTURE OF THE REPORT

The report is divided into 5 main chapters apart from the introduction. Chapter 2 captures various methodologies for vulnerability assessment which can be used to assess the exposure of people, infrastructure, environment and economic activities to various natural hazards. Chapter 3 focuses on capturing the various methodologies/approaches for multi hazard risk assessments. This section is further classified into three groups: a) Hazard mapping, b) Hazard Risk Mapping and c) GIS Tools for Hazard Mapping and Remote Sensing. Chapter 4 analyses the various methodologies for undertaking risk analysis. Chapter 5 provides an inventory of the existing resources available on basic data sources, existing resources and applications of various softwares. Efforts have been made to make the inventory exhaustive. Chapter 6 provides some broad conclusions for effective and efficient use of HRVA methods and tools.

Methodologies for Vulnerability & Capacity Assessment

2.1 OVERVIEW

Vulnerability and capacity assessments complement the hazard assessment exercises, indispensably. The assessment methodologies for mapping the social, economic and environment vulnerabilities of the population are not equally developed despite considerable efforts and achievements reflected in improved quality and coverage of scientific data on different hazards. A different range of challenges to risk assessment is posed by some aspects of vulnerability / capacity assessment, especially those related to the social nature of these concepts. Often there exists a huge gap in the understanding and application of vulnerability / capacity assessment between the institutions undertaking these tasks, and of the local authorities and communities involved in the exercise.

This chapter provides an overview of various methods used for vulnerability and capacity assessment, which have been grouped into five broad sections as follows:

- Variables for vulnerability analysis.
- Methodology to conduct field assessment of physical vulnerability.
- Methodology to conduct detailed field assessment of social patterns of vulnerability.
- Methodology for assessment of economic vulnerability.
- Methodology to assess the capacity of the existing government institutions, emergency service providers and other social systems.

2.2 VARIABLES FOR VULNERABILITY ANALYSIS

Vulnerability is generally referred to as the inability of people, organizations, and societies to withstand adverse impacts of multiple stresses to which they are exposed. It is based on the premise that though different groups within a society may have the same level of exposure to a natural hazard, it may have a varying consequences for each of these groups, since they have diverging capacities and abilities to handle the impacts of such a hazard. Over the years several models of vulnerability analysis has emerged. Risk-Hazard (RH) model (diagram after Turner et al., 2003), considers the impact of a hazard as a function of exposure and sensitivity. The chain sequence begins with the hazard, and the concept of vulnerability is noted implicitly as represented by red arrows.

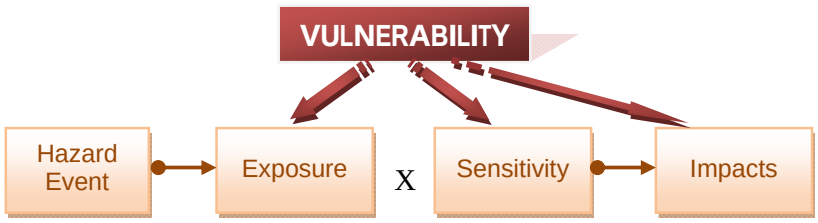


Figure 2.1: ***Risk-Hazard (RH) model***

Another model is the Pressure and Release Model (PAR) model. Pressure and Release (PAR) model after Blaikie et al. (1994) provides the progression of vulnerability. The PAR model considers disaster as a function of socio-economic pressures and physical exposures (natural hazards).

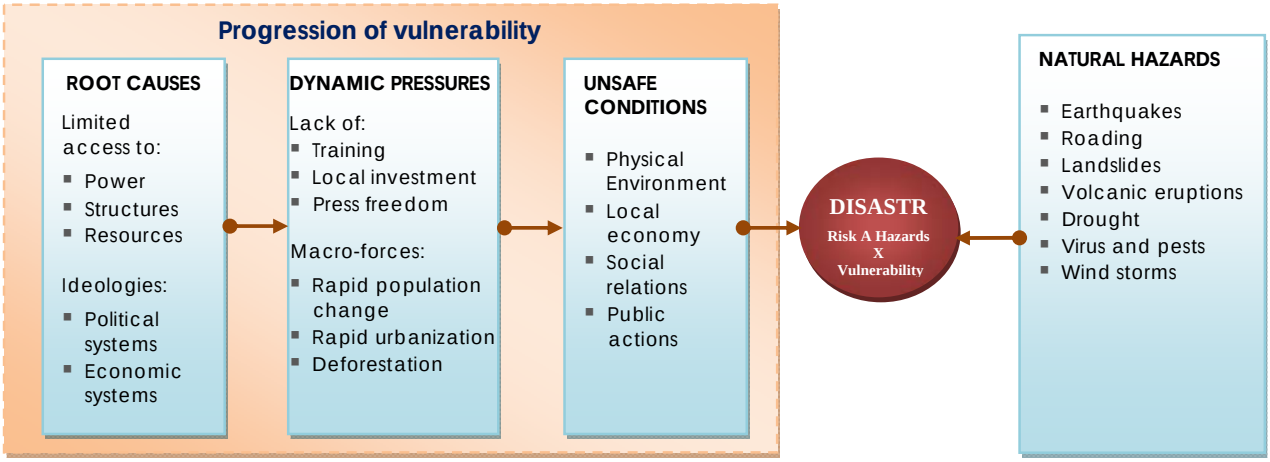


Figure 2.2: ***Pressure and Release (PAR) Model***

Therefore to assess vulnerability there is a need to understand the conditions that make exposure of an individual/ community/ region unsafe, leading to vulnerability and the causes leading to creation of these conditions. Thus vulnerability assessments would require systematic examinations of population groups, building elements, facilities, or components of the economy to identify features that are susceptible to damage from the effects of natural hazards. Keeping these in mind there are four broad areas in which different types of vulnerabilities have been grouped. These are shown as interacting spheres in the figure:

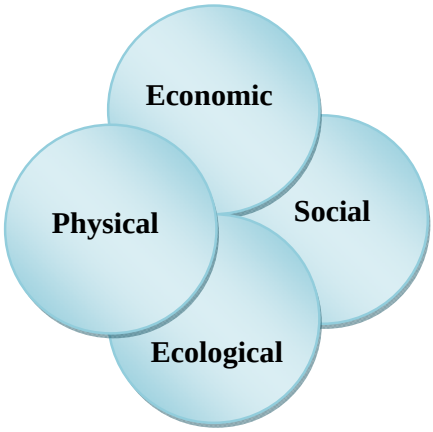


Figure 2.3: Factor affecting vulnerability

The key variables that constitute each of these vulnerabilities have been discussed below:

2.2.1 Physical Vulnerability

Physical factors to be considered for vulnerability assessment include the variables directly or indirectly related to the location and nature of the built environment. In case of natural hazards physical factors have direct impact on the structures and further define the vulnerability of the physical structures.

Physical vulnerability is determined by the aspects such as population density levels, remoteness of a settlement, the site, design and materials used for critical infrastructure and for housing.

Physical features in a community, such as insufficient basic infrastructure, especially water supply and sanitation, as well as inadequate health care facilities and supplies, are also expressions of increased vulnerability.

Physical factors as adopted by the BMPTC for Vulnerability Atlas of India.

- **Type of Roof:**
  - Pitched or sloping including tiles, slate; corrugated iron, zinc or other metal sheets; asbestos cement sheets; plastic polythene, thatch, grass, leaves, bamboo, etc.
  - Flat including brick, stone and lime; reinforced brick concrete/reinforced cement concrete.

- **Type of Wall:**
  - Mud, un burnt bricks, stone laid in mud or lime mortar
  - Burnt bricks laid in cement, lime or mud mortar
  - Cement concrete
  - Wood or Ekra wall
  - Corrugated iron, zinc or other metal sheets
  - Grass, leaves, reeds/bamboo/thatch, plastic polythene & others

- **Type of Flooring:**
  - Various types like mud, stone, concrete, wood or bamboo, mosaic floor tiles, etc.

A combination of local hazard intensity and vulnerability of existing house types is used for carrying out risk analysis of the village, block and district[2]. This index would

[2] Vulnerability Atlas of India, BMPTC,

help the village communities and house holders to develop village and district hazard maps; and village and district risk tables.

2.2.2 Social Vulnerability

Social Vulnerability is defined as "the exposure of groups of individuals to stress as a result of the impacts of hazards and related extremes[3]".

Social vulnerability is linked to the level of development in terms of human development indicators and well being of individuals, communities and society.

It includes variables measuring levels of literacy, the existence of peace and security, access to basic human rights, governance, social equity, gender issues, public health, population density, livelihood activities, traditional values, legal system, traditional knowledge, social networking of relatives and friends, political system, customs and ideological beliefs and overall collective organizational systems[4].

2.2.3 Economic Vulnerability

Economic status of households or individuals is directly related to the level of vulnerability due to natural hazards. Levels of vulnerability are highly dependent upon the economic status of individuals, communities and nations. The socially deprive groups female, children, SC, ST and minorities, are generally far more vulnerable than economically better off segments of the society. This would reduce the capacity of this group in case of natural hazards and therefore it will increase the vulnerability and risk.

Economic vulnerability is function of financial accessibility of individuals and communities, debt and the degree of access to credit, loans and insurance. The vulnerable groups are having inadequate access to critical and basic socioeconomic infrastructure, including communication networks, utilities and supplies, transportation, water, sewage and health care facilities, increase people's exposure to risk.

Economic Vulnerability Index is a composition of the following indicators:

- population size,
- remoteness,
- merchandise export concentration,
- share of agriculture, forestry and fisheries in gross domestic product,
- homelessness owing to natural disasters,

[3] Vulnerability: Conceptual and Methodology Review, Institute for Environment and Human Security
[4] Living with Risk: A global review of disaster reduction initiatives, Geneva, July 2002 ISDR

- instability of agricultural production, and
- instability of exports of goods and services

The **Economic Vulnerability**[5] is linked to the following parameters:

- Small size, which inhibits countries from taking advantage of the economics of scale
- Economic openness, which means lack of control of issues managed at a global level
- Export concentration narrowed to a few, selected products
- Dependence on strategic imports, particularly energy and raw materials
- Insularity and remoteness, leading to high transport costs
- Fragility of their ecosystems, which is exacerbated by natural phenomena

2.2.4 Ecological Vulnerability

The discussion of ecological aspects of vulnerability covers a wide portfolio of issues in the inter-acting social, physical, economic and ecological aspects of sustainable development as it relates to disaster risk reduction. The key aspects of ecological vulnerability could be the extent of natural resource depletion, the state of resource degradation, loss of resilience of the ecological systems, loss of biodiversity, exposure to toxic and hazardous pollutants.[6]

The social, economic/population, physical/Infrastructure and environmental/ ecological vulnerabilities are based on the development of different vulnerability indices. The variables of vulnerability analysis are divided into four major categories. These are: Environmental/Ecological Vulnerability Index, Population Vulnerability Index, Social Vulnerability Index and Infrastructure Vulnerability Index[7]. This has been represented in the figure below, which shows that the overall vulnerability index is a function of these vulnerability indices. This also involves prioritization by assigning weights to various indices depending upon scale and context of implementation.

[5] Vulnerability: Conceptual and Methodology Review, Institute for Environment and Human Security
[6] Sustainability and vulnerability indicators for decision making: lessons learned from Honduras, Manuel Winogard, European Environment Agency, Denmark (Sustainable development Vol. 10, Nos.1/2 2007)
[7] Sustainability and vulnerability indicators for decision making: lessons learned from Honduras, Manuel Winogard, European Environment Agency, Denmark (Sustainable development Vol. 10, Nos.1/2 2007)

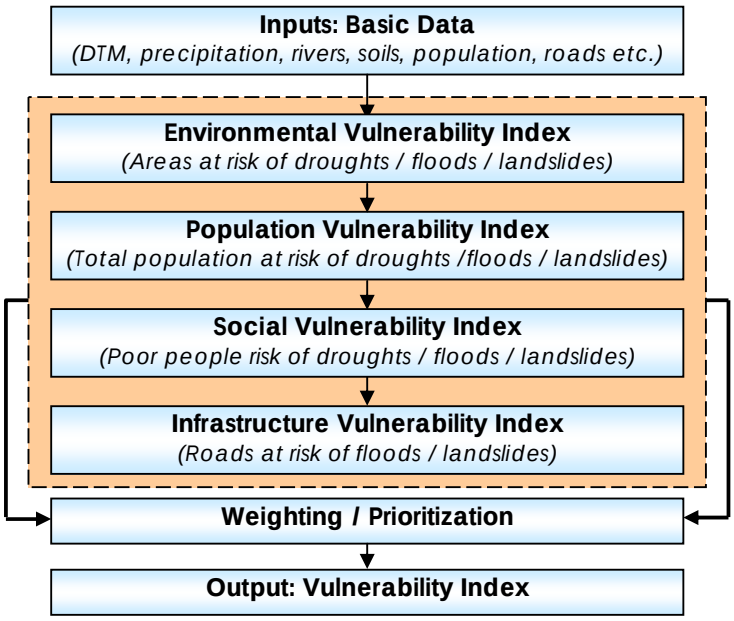


Figure 2.4: ***Vulnerability index model***

Source: Winograd et al. (2000b)

2.3 METHODOLOGY TO CONDUCT FIELD ASSESSMENT OF PHYSICAL VULNERABILITY

This section provides overview of methodologies used to conduct field assessment of physical vulnerability, which includes house types, critical infrastructure (particularly power and communication) and lifelines (drainage / water supply system etc.), and essential facilities such as, schools, hospitals, and public buildings, in view of structural aspects.

Name of the method/ tool: **Vulnerability Assessment Index: Megacity Scale**	
Brief Description	The method looks at calculating risks faced by the megacities due to the natural hazards. A combination of three parameters affects the calculation of vulnerability using this method, of which one parameter is hazard-dependent and the other two are hazard-independent. The three parameters comprise of: ➥ Physical *vulnerability of structures: dependent on the most prominent building classes* ➥ Level of *preparedness / safeguards: assessed in terms of existing building regulations, town and country planning with respect to hazards* ➥ *Construction quality and building density* Three of the parameters used in the methodology, i.e. Structural vulnerability, Preparedness, and Quality of Construction are assessed on a scale spanning four degrees (Very Good, Good, Average, and Below Average). For determining the last parameter, i.e. Building density, population density is used after normalisation in a range from 0 to 4 units. Equal weightage is assigned to each of the three parameters and a single indicator is generated for a particular city after combining the three parameters.

Application/ Utility	This methodology is applied for field assessment of physical vulnerability of various infrastructures for megacities, including houses, power and communication infrastructure, critical buildings, etc. In the Indian context, the method has been applied for the vulnerability assessment of Calcutta.
Geographical Scope	Applicable only for megacities
Inputs/ Resources/data	Population density data, Data on buildings in the city and their structural strength (materials used, architecture), data with respect to preparedness of the city in terms of structural modification, use of sturdy high-resistance materials, data on evacuation plans and safety measures
IT Infrastructure/ software required	The application of this methodology may require the use of data entry software like CS Pro and use of statistical packages like SPSS and STATA.
Cost for resource input	The tentative cost of inputs required for using the methodology are: 1. SPSS & STATA software : Ranging from Rs 2,00,000 (single user) to Rs. 5,00,000 (multi user) 2. CS Pro: Downloadable free of cost from the internet but may need customization as per needs of data entry. The consultant may charge Rs. 10,000 to 50,000 for making such changes. 3. Census data : Available in the census CD (less than Rs 1000 per CD) 4. Demographical Data : Available from Indiastat (Subscription more than Rs 50,000) 5. Other Secondary data : Various government department websites available free of cost 6. The above costs may vary with respect to the scale of application and data requirement
Output/ outcomes	Development of a combined Structural Vulnerability Index for the particular megacity under study
Analysis	The important points to be considered while applying this method are as follows: ➥ The information pertaining to the current infrastructure and population status of the city is utilized for developing this index. The historical outcomes of previous disasters cannot be used. ➥ Although several hazards are taken into account while developing the index, however the vulnerability index is expressed as a single indicator irrespective of the hazard ➥ The index captures only the physical vulnerability of the city directly or explicitly. It gives no reference to the dependence of vulnerability on the magnitude of the hazard. A single value of vulnerability is assigned to each city, irrespective of the hazard or its magnitude. ➥ The value of vulnerability indices calculated for the different cities cannot be linearly used for comparison of different cities using this method.
Resource Agency/ Reference details	Munich Re 2003 https://www.munichre-foundation.org/StiftungsWebsite/Pages/Contact_en.aspx

Name of the method/ tool: **Household Sector Approach**	
Brief Description	This method has been developed for assessing the structural vulnerability to different kinds of natural hazards such as landslides, earthquakes; associated with the housing sector at the local level. These include: physical or structural, functional, social, and economic income. The method makes use of different parameters that are directly related to housing sector vulnerability assessment. The different types of these variables are classified within three ranges: low, medium, and high. For example: while assessing vulnerability towards any natural hazard, five parameters are used for assessing the structural vulnerability of a house. These include: walls, roof materials, roof inclination, roof support material, doors, and windows. The construction material employed for each of these parameters are classified in terms of low, medium, and high classes; on the basis of an analysis of historical impacts of eruptions on houses. After assigning weights to each of these parameters, they are linearly combined. The overall vulnerability is presented in arbitrary units and classified in three ranges, as described in the table presented at the end of the description of this method.

	WEIGHT	LOW	MEDIUM	HIGH
		1	3	5
Walls	15	Block, brick metallic structure	Adobe	Cardboard, light wood, plastic, bamboo
Roof, materials	10	Concrete slab	Galvanized sheeting, cement tiles	Straw, plastic brick tiles
Roof, inclination	5	Very inclined	Moderately inclined	Low inclination
Roof, support material	5	Steel structure new, treated wood	Old, non-treated wood	Weights, stones
Doors	1	Metal, wood	Small windows	Large windows
Windows	1	Metal, wood	Small glass	Large glass d

$$V_{estruct} = 15 \times 5 + 10 \times 5 + 5 \times 5 + 5 \times 3 + 1 \times 1 + 1 \times 1$$
$$= 167$$

Degree of structural vulnerability	Numerical range
Low	37 - 80
Medium	81 -139 points
High	131 – 185 points

Application/ Utility	This methodology is used for conducting field assessment for assessing physical vulnerability of housing infrastructure at all levels, including the rural areas.
Geographical Scope	The method can be employed to assess the aggregated vulnerability at community, municipal, province and national level, as well as can be used to assess the vulnerability of a single house also. The method can be applied to the rural areas as well.
Inputs/ Resources/data	Data on construction material, structure architecture, historical data on impacts of past hazards in the area under assessment, Hazard maps in digital format
IT Infrastructure/ software required	GIS software like Arc GIS
Cost for resource input	The tentative cost of inputs required for using the methodology are: 1. The cost of GIS software like Arc GIS range from Rs 2,50,000 to Rs. 5,00,000 2. Census data : Available in the census CD (less than Rs 1000 per CD) 3. Demographical Data : Available from Indiastat (Subscription more than Rs 50,000) 4. Other Secondary data : Various government department websites available free of cost 5. The above costs may however vary with respect to the scale of application and data requirement
Output/ outcomes	Composite Structural Vulnerability
Analysis	Some of the important considerations with respect to this method include: ➥ This model expresses the physical or structural vulnerability according to the present condition of the house and addresses the elements that can cause damage or destruction during the event of a natural hazard ➥ To handle different hazards, the method requires adaptation on the basis of impacts of the hazard on various components of the house. ➥ The vulnerability of the household is directly depicted through various indicators, categorised into four types. However, there exists an assumption that the different options can be classified with higher or lower degrees of vulnerabilities, and a value computed according to the weights assigned to each parameter considered. ➥ The relationship between magnitude of the hazard with the vulnerability is not evident from these indicators, whereby the underlying assumption in the method is that it is based on the consideration of a very high magnitude event and cannot be appropriately applied in the case of small magnitude events. ➥ Although the method identifies options for reducing the degree of vulnerabilities, but it needs to be adapted for extrapolation to different regions. ➥ A specific household level survey is required to gather information on the four types of vulnerabilities within the housing sector for each house.
Resource Agency/ Reference details	*CIMDEN* *(Villagrán, 2004; 2005)*

Name of the method/ tool: **Local Climate Impacts Profile (LCLIP)**	
Brief Description	Local Climate Impacts Profile is a simple flexible methodology designed to help organizations like local municipal authorities to assess their exposure to weather and climate. The purpose of preparing a Local Climate Impacts Profile (LCLIP) is to raise awareness of current vulnerability to weather events in a particular locality. Understanding current vulnerability is an appropriate starting point for the preparation of an adaptation strategy. The LCLIP process highlights a localities vulnerability to several weather events and how these events affect local community and local authority's assets, infrastructure and capacity to deliver services. The principal objective of an LCLIP is to ascertain current vulnerability in a local area. LCLIPs provide a flexible methodology that can be adapted to match organisational objectives. This can be achieved by: ▪ **highlighting the most obvious examples** of the impacts and consequences of weather and climate ▪ **establishing comprehensive evidence** of the depth and breadth of these issues ▪ **looking for shocks** to/weak points in the system ▪ **cataloguing relatively low impact** but repeated weather events It might also indentify: ▪ threats that affect an organisation at the corporate level, (costs, insurance risks) ▪ common issues across several departments (risks to IT systems, threats to assets such as properties) ▪ common issues across partnership groups of local authorities/LSPs ▪ particularly vulnerable service areas or processes (social care, home-visit based services) ▪ locations that are repeatedly affected ▪ vulnerable groups within the local population or in particular locations
Application/ Utility	The aims of an LCLIP varies from one municipality to another but are likely to include the following: ▪ **raising awareness of specific weather and climate risks** and the need to consider adaptation, amongst municipal officers, particularly those in senior management, and those with responsibility for service delivery ▪ **raising awareness amongst elected members**, particularly those with portfolio responsibilities for vulnerable communities, critical infrastructure and service delivery ▪ **providing the catalyst for further action** within the authority and amongst Local Strategic Partnership (LSP) partners, specifically to encourage serious resource allocation to the development of an adaptation strategy **Steps for undertaking LCLIP :** Each organisation embarking on LCLIP will have its own starting point that will frame LCLIP work. For example, the primary purpose for undertaking an LCLIP might be to: • **take a first step** into adaptation activity • **consolidate existing but disparate evidence** available; where LCLIP is used as a focus to bring together evidence from different departments (insurance costs etc) and services in order to organise and share information about the consequences of weather events for an organisation and its partners • **To create a focus** for partnership work, with neighbouring municipal authorities.

	Timescale There can be no definitive statement on how much time should be allowed, but in principle, LCLIPs are short-term projects and 12 weeks allows enough time for basic coverage of the tasks involved. The different activities along with their respective time scales are as follows: ▪ Preparation 1–2 weeks ▪ Evidence gathering 2–3 weeks ▪ Interviews 2–3 weeks ▪ Writing up and reporting 2–3 weeks
Geographical Scope	LCLIP is a simple and flexible method which can be used by the local municipal council to assess current vulnerability. LCLIP has been designed as part of the UKLIP and has been used in several councils in UK. It has the potential for being used in municipalities in India too.
Inputs/ Resources/data	**Requirement of tools** In order to undertake LCLIP in an efficient manner both qualitative and quantitative data is required. The **LCLIP spreadsheet** has been designed to capture information that will provide useful messages for the local authority, and assumes that local newspaper reports are the principal source of data. It takes a weather-related news story and builds up information on the reported weather event and the consequences, i.e. what happened as a result, how organisations such as local authorities were affected and how various services responded. This detail is not generally recorded as part of routine service delivery, but it is the basis for building a picture of how local authorities currently deal with the impacts of weather events. The spreadsheet method has been chosen because it allows data to be sorted using different criteria, such as date, location, weather type, consequence, responsible agency, significance, etc. **Interviews with local authority staff** The purpose is to explore with selected service managers or other staff regarding further details of particular incidents or, events similar to those outlined in the spread-sheet. Interviews might shed light on: ▪ financial costs incurred ▪ additional staff resource required ▪ effects on service operation ▪ any ‘catch up’ period, i.e. time taken to re-establish normal routines ▪ effects on the community ▪ implications for service delivery ▪ • related services affected, i.e. referred actions
IT Infrastructure/ software required	The application of methodology would require the use of data entry software like CS Pro and use of statistical packages like SPSS and STATA.
Cost for resource input	The tentative cost of inputs required for using the methodology are: 1. SPSS & STATA software : Ranging from Rs 2,00,000 (single user) to Rs. 5,00,000 (multi user) 2. CS Pro: Downloadable free of cost from the internet but may need customization as per needs of data entry. The consultant may charge Rs. 10,000 to 50,000 for making such changes. 3. The spreadsheet and the other relevant documents can be downloaded free of cost from : www.ukcip.org.uk

	4. Census data : Available in the census CD (less than Rs 1000 per CD) 5. Demographical Data : Available from India stat (Subscription more than Rs 50,000) 6. Other Secondary data : Various government department websites available free of cost 7. The above costs may however vary with respect to the scale of application and data requirement
Output/ outcomes	The usual outputs from the LCLIP process are: Hard Outputs The *hard* outputs from an LCLIP can take a variety of different forms, including: • a short report highlighting key issues for the organisation • a briefing note (for elected members) • a PowerPoint (or similar) illustrating the main messages, to be shared within the organisation and partners (for workshops, briefings and other events) • an event or a series of events which share the outcomes with a variety of audiences both internal and external. • a spreadsheet plus report sheets that break the results down according to the service /responsible agency • bar charts, pie charts, graphs, photographs and other graphic material • an article in the local newspaper / in-house journal • a posting on the local authority website • an internal report which provides an agenda of issues that might improve current preparedness of the organisation and a suggested programme for further investigation **Soft Outputs** The LCLIP should help to: • Provide insights into current vulnerability and provide the platform from which to define further adaptation work • Raise the profile of adaptation within the organization The spreadsheet will yield the following: • A list of consequences that have occurred in the locality over the time frame covered. • A list of the organisations or responsible agencies required to make a response or affected by the consequences that occurred. (This might be the local authority as a whole, a local authority department or service area or another organisation such as an LSP partner.) • A qualitative assessment of the significance of the consequence according to risk criteria current within the local authority or by a simple grading (high, medium, low) for the organisation affected or required to act. In addition, the spreadsheet will also be able to sort data and report on: • the weather type (high temperatures, excessive rainfall), • the impacts as a result of the weather (flooding, heat wave, etc.), • detail of consequence (summary of what happened), • location of consequences (using a predefined list determined locally), • the date the consequence occurred. A LCLIP can deliver the following outcomes: ▪ **A schedule of consequences of weather events**, the responsible agencies and their experience in seeking to cope with and manage the consequences. This can

	be presented as quantitative data in graphs, charts or tables and qualitative headline findings. ▪ **An analysis of important variables**: date, location, weather type, impact type, consequences, responsible agency and perceived significance, (all derived from spreadsheet and presented as bar charts/pie charts etc.). This can be presented in the form of a report, presentation or webpage. ▪ **A summary of the discussion** and commentary on the significance of consequence, performance and preparedness (based on newspaper trawl, analysis, interviews and other inputs). This can be presented in a report or presentation and/or interview summaries. Together these provide insights into current vulnerability and provide the platform from which to define further adaptation work. The process of carrying out the LCLIP and the use of the outcomes can help to raise the profile of adaptation within the organisation.
Analysis	**Organizational approach through developing partnership:** There can be benefits in undertaking LCLIPs as part of a partnership with other developmental agencies on a district or even block wise basis. Collaborative projects allow better opportunities for learning from peers, comparing and discussing results, sustaining interest and momentum in the project and its outcomes can be used in defining further priorities and work arising from the LCLIP. A regional focus can further the engagement of regional bodies. Partnerships involving non-government organisations such as the local media, universities or community organisations can be effective in developing LCLIPs. **Timescale:** The timescale mentioned above is a tentative time scale and would differ based on the activities performed within LCLIPs. The task of undertaking LCLIP can be done either by a designated responsible officer from the particular municipal council or by an external researcher. Typically this involves payment for the employment of a researcher for a period of approx, 2–3 months. An important factor to be considered in this method is: whether to use (a) the external researcher, (b) a council officer, or (c) a combination of both, to carry out interviews. This value may be better realised if an officer can take some part in interviews rather than leaving the task to an external researcher. On the other hand, an external researcher may be regarded as a more impartial observer of the issues under discussion.
Resource Agency/ Reference details	UK Climate Impacts Programme UKCIP, 2009. A local climate impacts profile: how to do an LCLIP. UKCIP, Oxford. The document can be downloaded from : www.ukcip.org.uk

2.4 METHODOLOGY TO CONDUCT FIELD ASSESSMENT OF SOCIAL PATTERNS OF VULNERABILITY

Name of the method/ tool : **Participatory Vulnerability Analysis (PVA)**	
Brief Description	Participatory Vulnerability Analysis (PVA) is an analytical framework developed by ActionAid which involves communities, local authorities and other stakeholders in an in-depth examination of the factors which make them vulnerable to natural hazards. PVA helps in breaking down the complexity of vulnerability into manageable components by involving communities. The analytical framework is based on the fact that the local community knows the local condition much better than the project implementers and therefore, they are in the best position to plan for actions to reduce their exposure to hazards and shocks. PVA is essential in case of emergencies and conflict. In other words, PVA is a systematic process that involves communities and other stakeholders in an in-depth examination of their vulnerability, and at the same time empowers or motivates them to take appropriate actions. The overall aim of PVA is to link disaster preparedness and response to long-term development. PVA is a qualitative way of analyzing vulnerability, which involves participation of vulnerable people themselves. The analysis expects the project implementers to understand vulnerability, its root causes and most vulnerable groups, and agree on actions by, with and to people to reduce their vulnerability. PVA helps us identify critical gaps in people's infrastructure of protection. It may be lack of co-ordination, or the doings or neglect of unaccountable and corrupted governments, or the absence of effective enforcement instruments to protect people from violence and aggression, or a combination of all of them. PVA also invites us to explore ways to strengthen or improve people's infrastructure of protection. Broadly, there are three distinct stages for undertaking PVA: **Phase 1: Preparation Phase:** The preparation phase comprises awareness-raising at the country level, defining the purpose (TOR), and stakeholder analysis and team preparation. **Country programme level awareness raising** This stage involves liaison with departments and projects at country level to raise awareness and discussions about whether there is need for external support and where this support will be sought. **Purpose of conducting PVA (terms of reference)** This stage involves defining the terms of reference for the PVA exercise, i.e. why is PVA being conducted? It also involves analysing the background information. **Stakeholder analysis** This activity helps to identify the range of stakeholders that may be involved in the PVA process. It also suggests methods for working out how to involve them, at what stage etc. **Team preparation:** The aim of team preparation is to ensure common understanding of both the field exercise and the PVA process among team members. A preparatory workshop assists the team to prepare well. This workshop may take 2-3 days.

Phase 2: The analytical framework

The analytical framework uses a step-by-step guide. The steps include:

Step 1 — situation analysis of vulnerability

Information on vulnerability situation:

- prevalence/extent of vulnerability
- how different people are able to cope
- analyze present threats/ vulnerabilities
- characteristics of vulnerability

Step 2 — analysis of causes of vulnerability

Causes of vulnerability:

- unsafe conditions
- dynamic pressures
- root causes

Step 3 — analysis of community action

Community action and capacity:

- establish the sources, assets and entitlements used to reduce vulnerability
- external assistance used to reduce vulnerability

Step 4 — drawing action from analysis

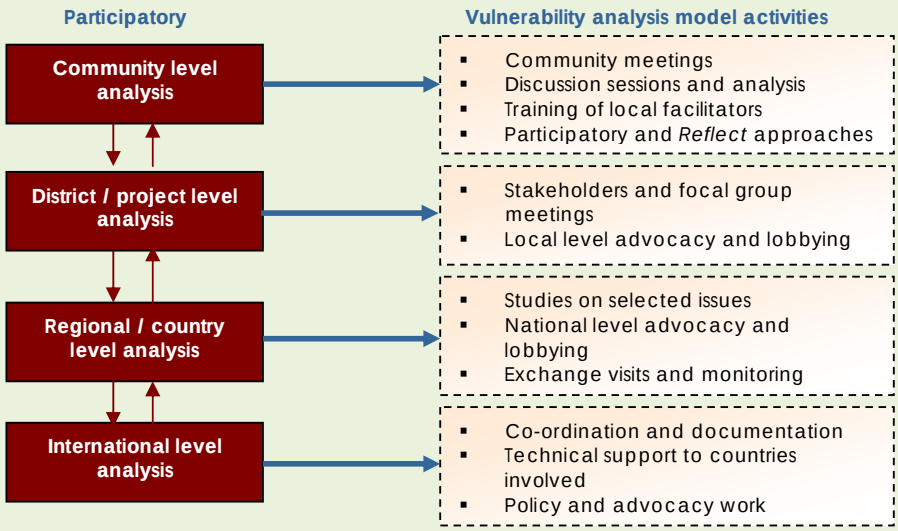
- Prioritize broad interventions
- Action plans including dates and responsibilities
- Scenario planning

Phase 3: The multi-levelled analytical approach

Using the step-by-step framework, analysis of vulnerability is conducted at three levels:

– community level analysis
– district level analysis
– national level analysis

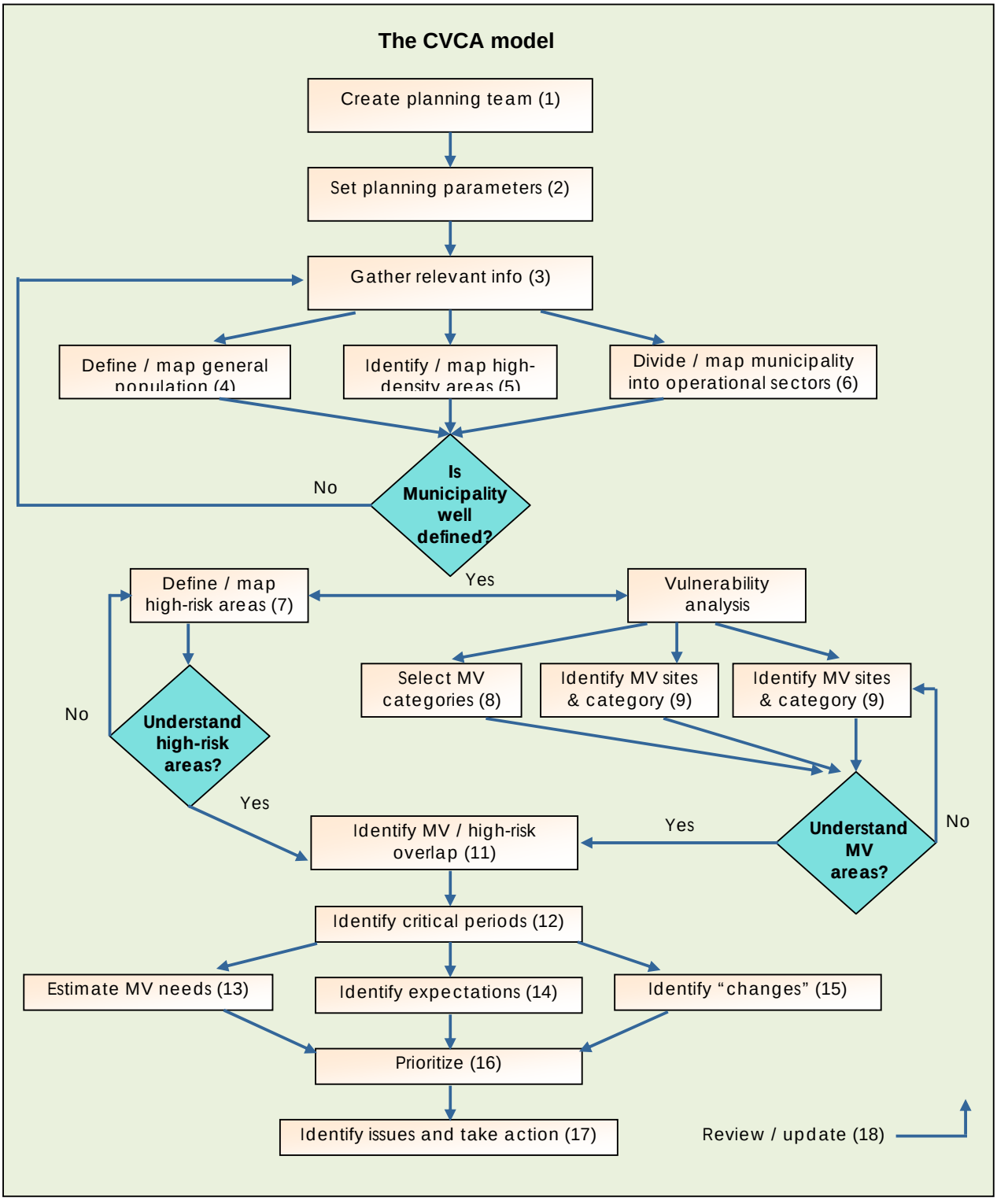
Summary of the PVA multi – levelled approach: what is involved at each level?



Application/ Utility	The purpose of this tool is to assist people to analyse their vulnerability, draw action plans, mobilise resources and enact appropriate policies, laws and strategies to reduce their vulnerability to disasters (both natural and man-made). End users intended are: emergency humanitarian fieldworkers, community development workers, NGOs, and community based organizations.
Geographical Scope	PVA itself focuses on communities, but the scale of assessment is multi-level that looks at vulnerabilities at the community, district, and at national level. PVA has already been used in different countries in Africa and Asia.
Inputs/ Resources/data	Historical profile/time line, Vulnerability map, Seasonal calendar, data for identification of vulnerable/levels/location, hazards/time they occurred / frequency, Trends/changes over time, Differences in vulnerabilities i.e. gender, age, ethnicity etc., data on unsafe conditions, Identification of dynamic pressures or determinants of vulnerability, data for assessment of capacities, Community action plan Data on most vulnerable groups, changes in vulnerabilities over time, underlying causes, Unsafe conditions (e.g. flow of information, coping mechanisms, level of assets etc), geographical location, access and control over resources, power, gender, economic etc; Underlying factors and trends (e.g. trade policies, land rights etc), livelihood options and protection measures, policies affecting poor people, sources of risk
IT Infrastructure/ software required	The application of methodology would require the use of data entry software like CS Pro and use of statistical packages like SPSS and STATA. The information gathered using PRA technique will require content analysis using N Vivo/ Atlas Ti software.
Cost for resource input	The tentative cost of inputs required for using the methodology are: 1. Questionnaire : Rs 250-600 per sample/ household + Consultancy fee of the data collection firm 2. PRA/ Focused Group Discussions (FGD) : Rs.1,00,000 per PRA / FGD exercise per village 3. Analysis using N Vivo/ Atlas Ti software: Up to Rs. 50,000 4. SPSS & STATA software : Ranging from Rs 2,00,000 (single user) to Rs. 5,00,000 (multi user) 5. CS Pro: Downloadable free of cost from the internet but may need customization as per needs of data entry. The consultant may charge Rs. 10,000 to 50,000 for making such changes. 6. Census data : Available in the census CD (less than Rs 1000 per CD) 7. Demographical Data : Available from Indiastat (Subscription more than Rs 50,000) 8. Other Secondary data : Various government department websites available free of cost 9. The above costs may however vary with respect to the scale of application and data requirement
Output/ outcomes	PVA exercise provides the following outputs: 1) **Actions to be taken at the community level:** How these actions will reduce their vulnerability. How will they know that the actions are reducing their vulnerability? 2) **Actions to be taken at the district level:** How these actions will reduce their vulnerability. How will they know that these actions are reducing their vulnerability? 3) **Actions to be taken at the national level:** How these actions will reduce their vulnerability. How will they know that the actions are reducing their vulnerability?
Analysis	The different aspects and causes of vulnerability are defined through PVA, along with provision of mechanisms for follow-up programmes.

	The effectiveness of emergency and development activities is increased in the long-term with vulnerability as an indicator by either categorising poor people into groups according to levels of vulnerability, thereby allowing better targeting, or being used to establish a baseline of new projects. Various cross cutting themes such as HIV/AIDS, gender, etc are catered to by PVA, thereby providing an in-depth understanding of vulnerabilities which unveils the dynamics of power, inequality and discrimination between men and women, girls and boys. The analysis through this method serves as a spring board for women's empowerment. The differences in approaches of locals and outsiders are reduced, merging them to create acceptability and ownership for both the community and development facilitators. PVA can make future vulnerabilities predictive, based on levels of skill and analysis, as such planning and mitigation efforts are made to offset potential future vulnerabilities.
Resource Agency/ Reference details	ActionAid International **Participatory Vulnerability Analysis : A step–by–step guide for field staff prepared by ActionAid International** Manual for undertaking PVA can be downloaded from http://www.proventionconsortium.org/themes/default/pdfs/CRA/PVA_ActionAid2005_meth.pdf Case studies on PVA are available from : http://www.actionaid.org.uk/_content/documents/pva_case_studies.pdf

Name of the method/ tool : Community-wide Vulnerability and Capacity Assessment (CVCA)	
Brief Description	The CVCA method intends to guide and enhance the assessment of hazard-risk vulnerability (HRV) at the municipal level and thereby to enhance the emergency planning process. It augments the existing assessment tools. The key principles and the assumptions that underlie its framework define the CVCA method. Initially, a step by step description of the overall process is provided, followed by illustration of key instruments. The method is based on a team approach, and involves emergency planners, municipal planners, public-service providers (e.g., social and health services), NGO representatives, and representatives of vulnerable groups or those who provide service to them. Without that degree of inclusion, of experience, information and linkages, the ultimate assessment may prove extremely weak. The Community-wide Vulnerability and Capacity Assessment (CVCA) is intended to help the emergency managers and municipal planners to understand the needs of their vulnerable populations in a better way, as well as meet the needs of the "most vulnerable". The process is designed to provide a comprehensive view of the population being assessed. The following steps outline the CVCA model: 1. Create the Planning Team 2. Set planning parameters 3. Gather relevant information 4. Define and map the general population 5. Define and map high-density areas 6. Divide and map the municipality into "Operational Sectors" 7. Define and map "high-risk" areas 8. Select applicable categories for the "most vulnerable" 9. Identify, categorize, and map sites related or specific to the identified "most vulnerable" groups 10. Identify and map other areas where each of the "most vulnerable" groups has significant numerical presence 11. Identify intersection or overlap of "most vulnerable" groupings or sites and "high-risk" areas 12. Identify critical periods when each group is particularly vulnerable 13. Estimate likely emergency needs 14. Identify realistic expectations regarding the capacity of each identified group 15. Consider conditions that change the presence or vulnerability level of the identified groups 16. Categorize sectors, facilities or community segments into relative levels of priority 17. Identify issues or groups for further consideration or action 18. Review and update information


The CVCA model
Create planning team (1)
Set planning parameters (2)
Gather relevant info (3)
Define / map general population (4)
Identify / map high-density areas (5)
Divide / map municipality into operational sectors (6)
Is Municipality well defined?
No
Yes
Define / map high-risk areas (7)
Vulnerability analysis
Select MV categories (8)
Identify MV sites & category (9)
Identify MV sites & category (9)
Understand high-risk areas?
No
Yes
Identify MV / high-risk overlap (11)
Yes
Understand MV areas?
No
Identify critical periods (12)
Estimate MV needs (13)
Identify expectations (14)
Identify "changes" (15)
Prioritize (16)
Identify issues and take action (17)
Review / update (18)

Application/ Utility	The CVCA method provides an analysis of a community's population, with focus on the "most vulnerable" groups amongst the current population. The method includes the process of 'Layering', whereby numerous perspectives or analyses are used to refine one's understanding of the current reality. There is a need to regularly review and update available information, especially in case of those environments where information changes quickly or profoundly. In such circumstances, the information needs to be reviewed and appropriately updated on a regular basis. Stagnation of meaning results from the failure to update information regularly. Successful application of the method is dependent on two key factors: • Team effort by a broad group of people representing the community and all its key stakeholders, especially the 'most vulnerable' • Patient effort to continue expanding one's understanding of 'vulnerability', the 'most vulnerable', and the reality of emergency situations
Geographical Scope	The method is applicable for vulnerability assessment at the community level. The CVCA method is intended to be applicable universally across diverse cultures, community sizes, geographic locations, or resource levels.
Inputs/ Resources/data	Forethought, planning, and layering of information is required at each step of the CVCA method. Data requirements include population, site, or risk-related information, community maps (with relevant natural or geographical barriers like lakes, rivers; key human-constructed structures; political or jurisdictional boundaries), Plastic overlays
IT Infrastructure/ software required	Simple analysis tools such as Tables, figures etc are required to be deployed in this method, making use of software packages such as MS Office itself. The application of methodology may require the use of data entry software like CS Pro and use of statistical packages like SPSS and STATA. The information gathered using FGD will require content analysis using N Vivo/ Atlas Ti software.
Cost for resource input	The tentative cost of inputs required for using the methodology are: 1. Questionnaire : Rs 250-600 per sample/ household + Consultancy fee of the data collection firm 2. Focused Group Discussions (FGD) : Rs.1,00,000 per FGD exercise per village 3. Analysis using N Vivo/ Atlas Ti software: Up to Rs. 50,000 4. SPSS & STATA software : Ranging from Rs 2,00,000 (single user) to Rs. 5,00,000 (multi user) 5. CS Pro: Downloadable free of cost from the internet but may need customization as per needs of data entry. The consultant may charge Rs. 10,000 to 50,000 for making such changes. 6. Census data : Available in the census CD (less than Rs 1000 per CD) 7. Demographical Data : Available from Indiastat (Subscription more than Rs 50,000) 8. Other Secondary data : Various government department websites available free of cost 9. The above costs may however vary with respect to the scale of application and data requirement
Output/ outcomes	Vulnerability mapping of the community being assessed in the form of maps, graphs, figures, tables and templates describing the overall vulnerability of the community towards the particular natural hazard in question.
Analysis	As is evident from the flow chart, the CVCA analysis is not such as to be conducted once, and then be discarded. The analysis is required to be implemented through action, followed by regular review and revision as deemed

	necessary. Although CVCA is a simple method, yet its utility is dependent on the information used during its process, the quality of which in turn is dependent on the team that strives to collect, analyze, communicate, and act on that information. The team developed ideally includes representatives of the agencies that service the vulnerable populations. CVCA proves to be most informative or useful when used as a component of a larger analysis. Conversely, its weakness is that it does not provide the complete picture by itself and needs to be augmented with data and analysis from other sources. Such a multi-pronged analysis could change the perspective towards the dynamic nature of life. Therefore, the process of gathering of *meaningful* information must involve layering, data richness, continual outcome review and update.
Resource Agency/ Reference details	Community-wide Vulnerability and Capacity Assessment, CARE International, 2001 (Office of Critical Infrastructure Protection and Emergency Preparedness) The document can be downloaded from: http://www.proventionconsortium.org/themes/default/pdfs/CRA/CVCA2001_meth.pdf

Name of the method/ tool: **Vulnerability and Capacity Assessment (VCA)**	
Brief Description	Vulnerability and Capacity Assessment (VCA) is a participatory investigative process for assessing the risks that people face in their locality, their vulnerability to those risks, and the capacities they possess to cope with a hazard and recover from it when it strikes. Vulnerability and capacity assessment is used to identify the strengths and weaknesses of households, communities and institutions. The VCA serves as an important tool in supporting decisions with respect to disaster preparedness and the development of mitigation programmes. The information included in VCA describes the risk people or institutions face while preparing for coping with natural hazards. VCA helps to raise public awareness with respect to hazards, vulnerabilities and capacities and the risk taken by society. Positive response by communities can be initiated through VCA towards programmes of mitigation against the 'shocks' to them that set back their development achievements. An understanding of the process of assessing the society's vulnerabilities and capacities offers options for initiating contribution to the empowerment of people at risk. Using VCA equips the institution/ development agency/ local government with the capacity to monitor and assess its impact on both disaster preparedness and disaster response events. VCA has been conceptualized and fine tuned by practitioners from International Federation of Red Cross and Red Crescent Societies. The assessment is undertaken in three steps, as described below: **Step 1: Identifying potential "threats"** These are defined within three basic categories of threats: ▪ *Those based in nature*; such as earthquakes, cyclones, droughts, floods, or pathogens. ▪ *Those based in violence*; such as war, intimidation, harassment, or sexual assault. ▪ *Those based in deterioration*; such as declining health, education and other social services, trade shifts, government policy or environmental degradation. Both historical and new threats of these kinds are assessed within this method. **Step 2: Identifying Vulnerabilities** Three basic characteristics are defined that make some groups more vulnerable than others: ▪ *Proximity and exposure*: people who live or work near hazard prone area are more vulnerable than those who don't. ▪ *Poverty*: people having fewer options, few resources and few reserves are pushed over the "edge" of survival more easily than the wealthier ones. ▪ *Exclusion / marginalisation*: People left out of economic and social systems or lacking access to social services due to religion, race, gender, class and other factors are vulnerable. **Step Three: Assessing People's Capacities to Prevent or Cope with Threats** Effective and efficient programme planning needs to focus on identification of both capacities and threats, although they are considered to be mirror images. An understanding of the useful capacities existing in a country or region, or within a National Society, community or individual, as well as the external resources needed to cope with threats, is important.

	People's capacities can be described within three categories: ▪ *Physical and material*: physical resources that people rely on to survive and to lead a satisfying and dignified life, such as cash, land, tools, food, jobs, energy sources or access to credit and borrowing capacity. ▪ *Social and organisational*: close-knit communities with social networks to support each other, good leadership, and sharing of the physical resources in times of need, are more likely to survive. ▪ *Skills and attitudes*: people with skills, knowledge and education have more choices and a greater ability to improve their conditions. People dependent on others and feeling victimized by events outside their control, have few attitudinal capacities. The completion of all three steps produces a Vulnerability and Capacity Assessment.
Application/ Utility	VCA contributes to a self-reflection process – defining the strengths and shortcomings of current activities and highlighting the unfulfilled needs of new vulnerable groups. VCA has been designed for used by all National Societies. VCA can be used: *1. As a diagnostic tool* ▪ Helps to understand problems (symptoms) and where they stem from (underlying causes) ▪ Helps to systematically look at what is available to alleviate the problem (resources, skills and capacities) and decide whether the Society should be involved and at what level ▪ Encourages focus on specific local conditions (specific threats and risks, most vulnerable groups, sources of vulnerability, local perceptions of risks, and capacities) ▪ Highlights different areas of responsibility for reducing vulnerabilities, including political inputs, technical, monetary or social *2. As a planning tool* ▪ Helps to prioritise and sequence both actions and inputs for determining who and what should be addressed at which stage ▪ Provides an opportunity for dynamic and realistic planning where changes can be monitored and single-solution programmes can be avoided ▪ Evaluating the impact of a project in terms of risks reduced, vulnerable conditions improved, capacities enhanced or new risks introduced *3. To assess risk in a single sector* To estimate the probability and the level of a particular risk from a specific threat. For example, VCA assesses the level of measles risk among children in a refugee camp; the probability of building collapse in a city from a certain scale of earthquake; or the relative risk of malnutrition from food shortage in different parts of a country. Application of VCA is broad in different ways at different stages of the disaster cycle. Vulnerability assessment is an ongoing process to be started ideally during the 'quiet times' between disasters, considering risk and other long-term factors that make people more vulnerable to a hazard. The intended end users of VCA are staff and volunteers with Red Cross and Red Crescent National Societies who work with branch and community members to increase their resilience and reduce disaster risk. However, VCA can be used by development practitioners from any other civil society organization.

Geographical Scope	The focus of the assessment is at the **locality, neighbourhood** and **community-level**. VCA can be used at the panchayat and municipal level.
Inputs/ Resources/data	Various techniques made use of for data collection include Rapid Rural/Urban Appraisal and Participatory Rural/Urban Appraisal; transect walks, physical maps and social maps; wealth ranking and mini-surveys; Venn diagrams, economic relationship charts and kinship charts; daily time use charts and seasonal calendars; production flow charts, impact flow charts and problem trees; matrix ranking and scoring; consensus panels, focus groups, questionnaires and semi-structured interviews.. **Sorting and analysis:** Data analysis starts with sorting. While sorting the data collected, it is important to recognize useful parts and discard the rest. Once sorted, the data analysis is initiated. **Participatory evaluation:** Monitoring and evaluation of both the VCA process and resulting projects are important components of community work. Participatory evaluation assesses and measures the quality and impact of interventions in consultation with the VCA team and community members. **Applying the VCA method principles:** While working with a community, especially in the initial phase of the process, it is critical to consider the community's perspective, rooted in its cultural identity, beliefs and values. Application of the VCA method principles enables for better understanding of the natural, social and political environment, encourages respect for a community's behaviours and capabilities within that environment and reduces the possibility of bias. **Better Programming Initiative:** The Better Programming Initiative provides a framework for impact assessment, to analyse the positive and/or negative impacts of aid programmes on communities recovering from violence, armed conflict or disaster. An analytical approach to programming is used that helps the programme staff avoid the possible negative consequences of aid in the contexts in which programmes are implemented and to strengthen collaboration with community groups. The various analytical methods included within VCA are as follows: *Disaster Risk Assessment Methods like:* • **Vulnerability Capacity Assessment (VCA)** *General Assessment methods include:* • Participatory Learning and Action (PLA) • Livelihoods and Coping Strategies Analysis • Institutional and Social Network Analysis • Assessing the Capacity of People's Organizations *The participatory tools which is used to undertake* **Vulnerability Capacity Assessment are as follows***:* • Mapping (Hazard & Risk, Spatial and Capacity Resource) • Focus Group Discussion • Transect Walk • Seasonal Calendar

	• Historical Profile • Problem Tree • Venn Diagram • Historical Visualisation • Community Meetings • Brainstorming • Ranking • Wall Methodology (participatory analysis of data) • Livelihoods and coping strategies analysis • Institutional and social networking analysis • Assessing the capacity of peoples' organizations *Technical tools include:* • GIS Mapping The detailed description with respect to the use and application of each of these tools is made available in the guidance toolkit for VCA, developed by IFRC (International Federation of Red Cross and Red Crescent Societies).
IT Infrastructure/ software required	The application of methodology would require the use of data entry software like CS Pro and use of statistical packages like SPSS and STATA. The information gathered using PRA technique will require content analysis using N Vivo/ Atlas Ti software. In case GIS mapping is to be included, it requires necessary IT infrastructure in the form of software such as Arc GIS
Cost for resource input	The tentative cost of inputs required for using the methodology are: 1. Questionnaire : Rs 250-600 per sample/ household + Consultancy fee of the data collection firm 2. PRA/ Focused Group Discussions (FGD) : Rs.1,00,000 per PRA / FGD exercise per village 3. Analysis using N Vivo/ Atlas Ti software: Up to Rs. 50,000 4. SPSS & STATA software : Ranging from Rs 2,00,000 (single user) to Rs. 5,00,000 (multi user) 5. CS Pro: Downloadable free of cost from the internet but may need customization as per needs of data entry. The consultant may charge Rs. 10,000 to 50,000 for making such changes. 6. If GIS will be used in analysis it will cost in range of Rs 2,00,000 to Rs 5,00,000 7. Census data : Available in the census CD (less than Rs 1000 per CD) 8. Demographical Data : Available from Indiastat (Subscription more than Rs 50,000) 9. Other Secondary data : Various government department websites available free of cost 10. The above costs may however vary with respect to the scale of application and data requirement
Output outcomes	VCA involves quality research to obtain data that can be analysed for the purpose of planning programmes and projects designed to reduce risk and vulnerability. The expected outcomes from a VCA process are as follows: ▪ A baseline assessment information that serves as the entry point for an emergency needs assessment following a disaster ▪ Community's understanding of its own environment in relation to known risks and hazards ▪ Community's realization of its own capacities to cope with those risks and hazards ▪ Agreement between the community and local authorities on actions needed to

	prevent or reduce the effects of hazards ▪ Development of relevant projects in prevention, preparedness and risk reduction VCA as a tool helps to assess the following: • identify vulnerable groups • identify the factors that make them vulnerable and how they are affected • assess their needs and capacities (and empower them to assess these) • ensure that projects, programmes and policies address these needs, through targeted interventions or prevention and mitigation of potentially adverse impacts
Analysis	The challenge of reducing vulnerability and enhancing capacity requires an intimate knowledge and understanding of the local reality. However, VCA is a broad, simple and flexible method that can be easily adapted to serve the needs of diverse societies with respect to the socio-cultural, economic, political, and natural environments in which they are located. **Limitations of the approach** Although being a highly valuable tool, there are certain design limitations within VCA: • *Lack of mechanisms for analysis*: Although identification of individual hazards, vulnerabilities, and capacities is important, but more importantly the factors identified have to be turned from raw data into useful information through an analytical process. The toolbox of this method, offers no means of analysing the relationships between sets of data. • *Offers no specific methods for data triangulation* • There are also possible negatives arising from VCA's broadness and high degree of flexibility, as the assessors need to 'pick and choose' between data collection methods and determine the level of study and what subjects to analyse. It implies that potentially critical issues or levels of inquiry can be inadvertently overlooked. • Although less critical, but another limitation of the high degree of flexibility in the VCA process is that the results from one assessment look different to those of another assessment. It implies that VCAs are not calibrated in form or content, thereby making it difficult to compare limiting the potential for regional or international analysis. **Usefulness to the Planning Process** VCA is used to inform decision-making processes, including small project preparation and wide-scale programming modification. The breadth of the VCA allows different societies to explore the area of mitigation most pertinent to them, as opposed to channelling all Societies in the same direction towards one or two specific goals. **Coverage of vulnerabilities and capacities** **Breadth and depth** Vulnerability and capacity are both extremely complex – cross-disciplinary, invariably multi-layered, and always dynamic. An exhaustive list of tools and techniques required for the collection and analysis of data cannot be prepared through any assessment methodology. **Coverage of livelihoods** VCA includes the key components of the livelihoods approach, including social, physical, financial, human, and natural capital and the vulnerability context.

	Positive implications of VCA The VCA process has a number of positive implications, as demonstrated from field level assessments include the following: • Significant impact on people's perceptions of disasters, vulnerabilities and capacities • Development of a common ground with respect to disaster, capacity and vulnerability • Critical look at the environment in which societies work provides a positive outcome in terms of an increased awareness of the other institutions, governmental and non-governmental alike.
Resource Agency/ Reference details	International Federation of Red Cross and Red Crescent : VCA Toolkit with reference sheets IFRC (International Federation of Red Cross and Red Crescent Societies), 1999, 'Vulnerability and Capacity Assessment: an International Federation Guide', Geneva. IFRC, 'Toolbox for vulnerability and capacity assessments', (no date), Disaster Preparedness Department, International Federation of Red Cross and Red Crescent Societies, Geneva. The document is available from the CRA toolkit at: http://www.proventionconsortium.org/themes/default/pdfs/CRA/VCA-toolbox-en_meth.pdf Cannon, Terry; Twigg, John and Rowell, Jennifer; Social Vulnerability, Sustainable Livelihoods and Disasters

Name of the method/ tool: **Participatory Capacities And Vulnerability Assessment (PCVA)**	
Brief Description	Participatory Capacities And Vulnerability Assessment (PCVA) is primarily based on the existing analytical method of Capacities and Vulnerability Assessment (CVA). PCVA was conceptualized in 1998 upon refining the limitations of CVA to involve local communities. In addition, the CVA framework was combined with participatory approaches, specifically with participatory rural appraisal (PRA) tools; with the objective of providing more opportunity for local communities and other stakeholders to participate in assessing the disaster scenarios. The local perception of disasters is important in understanding the behavior of poor people and their reaction during disaster situations. It is through their experiences and local belief systems that we understand how and why people develop certain attitudes towards disasters (e.g., passive, complacent, or fatalistic attitudes), or whether poor people really feel helpless in the face of disasters. People's experiences of disasters allow development practitioners to learn about how they assess disaster impacts. People have their own criteria in assessing disaster impacts. Through years of exposure to various disasters, the vulnerable people have also developed their own indicators to assess the intensity and magnitude of disaster. These local indicators become important in determining how and when local communities consider an event a disaster. The PCVA gives primary importance to participation of the vulnerable people in the research process, through following the principles of Participatory Rural (or Urban) Appraisal or PRA (now also known as Participatory Learning and Action or PLA). The PCVA was conceptualized as an enabling process where poor people can analyse their disaster experiences and take action to address their vulnerabilities. Through exploration of people's experience and perceptions of disasters, PCVA is capable of drawing a clear picture of local vulnerabilities and understanding them from the point of view of the people who live under the vulnerable conditions. The PCVA process not only allows people to perform analysis themselves, but also provides an opportunity for the different stakeholders to discuss community concerns together.
Application/ Utility	PCVA is intended and designed to be used by disaster risk management field practitioners, community development workers and for government officials at the local level.
Geographical Scope	The scale of assessment looks at community / local level. It can be used at municipality and village Panchayat level.
Inputs/ Resources/data	PCVA can be undertaken through three broad phases which are as follows: **1. Planning and designing phase:** During this phase the following activities should be undertaken – Formation of PCVA team consisting of local NGO, Government official other relevant stakeholders – Team orientation and familiarization – Designing of the PCVA research **2. Field work, consisting of the following activities:** – Courtesy call to local officials and relevant community leaders – Co-ordinating the actual workshop – Conduct team assessment – Triangulation of the data collected 3. **Synthesis of data and sharing of the data with the relevant stakeholders** *The participatory tools used for undertaking PCVA include:* ▪ CVA matrix

	▪ Gender desegregation matrix ▪ Resource mapping ▪ Community mapping ▪ Hazard mapping ▪ Transect walk ▪ Matrix ranking/scoring ▪ Wealth ranking ▪ Venn diagrams ▪ Community visioning ▪ Seasonal calendar ▪ Timeline ▪ Focus group interviews ▪ Role playing ▪ Household interviews The handbook developed by Oxfam for PCVA provides detailed guidelines for undertaking the same.
IT Infrastructure/ software required	The application of methodology would require the use of data entry software like CS Pro and use of statistical packages like SPSS and STATA. The information gathered using PRA technique will require content analysis using N Vivo/ Atlas Ti software.
Cost for resource input	The tentative cost of inputs required for using the methodology are: ▪ Questionnaire : Rs 250-600 per sample/ household + Consultancy fee of the data collection firm ▪ PRA/ Focused Group Discussions (FGD) : Rs.1,00,000 per PRA / FGD exercise per village ▪ Analysis using N Vivo/ Atlas Ti software: Up to Rs. 50,000 ▪ SPSS & STATA software : Ranging from Rs 2,00,000 (single user) to Rs. 5,00,000 (multi user) ▪ CS Pro: Downloadable free of cost from the internet but may need customization as per needs of data entry. The consultant may charge Rs. 10,000 to 50,000 for making such changes. ▪ Census data : Available in the census CD (less than Rs 1000 per CD) ▪ Demographical Data : Available from Indiastat (Subscription more than Rs 50,000) ▪ Other Secondary data : Various government department websites available free of cost ▪ The above costs may however vary with respect to the scale of application and data requirement
Output/ outcomes	PCVA provides an in-depth analysis of the local vulnerabilities of different sections of the population. It assists the local government/ NGO to assess the local capabilities to address disaster. It facilitates disaster management through local governance by undertaking micro planning exercise.
Analysis	The strength of PCVA is that it uses a community perspective for presenting the disaster concepts and experiences. It focuses on how people experience disaster impacts (post-disaster conditions) and how these shape their attitudes and belief systems towards managing disasters in their communities. Through the PCVA workshops, individual households and whole communities are given an opportunity for discussing how to respond to and cope with disaster impacts, and engage with different disaster management actors in their localities. By examining local concepts and experiences of disasters, we also learn how varying vulnerabilities of different groups of people determine different levels of

	disaster impacts. This is important in drawing up the context-specific nature of disasters. However, there exist three main aspects that the PCVA needs to improve. These are: ▪ **Strengthening analysis of local capacities and vulnerabilities:** PCVA requires to enhance the analysis of pre-existing conditions in the community, especially the social and economic vulnerability ▪ **Encouraging fuller participation**, so as to mobilise representatives of various stakeholders in the community ▪ **Maximising PCVA potential** as a tool for advocacy along with sustaining the process
Resource Agency/ Reference details	Lourdes Lasap, Oxfam UK, email : LLasap@Oxfam.org.uk Oxfam Great Britain - Philippines Programme Participatory Capacities And Vulnerability Assessment : Finding the link between disaster and development Published by: Oxfam Great Britain - Philippines Programme, Year: 2002, pp.1-82 Available for free download from: www.oxfam.org.uk/what_we_do/emergencies/how_we_work/emerg_prep.htm

Name of the method/ tool : Climate Vulnerability and Capacity Analysis (CVCA)	
Brief Description	The CVCA methodology provides a framework for analyzing vulnerability and capacity to adapt to climate change at the community level. Recognizing that local actors must drive their own future, the CVCA prioritizes local knowledge on climate risks and adaptation strategies in the data gathering and analysis process. The main objectives of the CVCA methodology include: ➥ To analyze vulnerability to climate change and adaptive capacity at the community level ➥ To combine community knowledge and scientific data to yield greater understanding about local impacts of climate change The analytical method of the CVCA is based on CARE's CBA methodology. It presents a range of "enabling factors" which must be in place at household/individual, community/local and national levels in order for effective community-based adaptation to take place. The CVCA process facilitates analysis of the existing situation with respect to these enabling factors. It helps to identify actions that can be taken to put the factors in place, creating an enabling environment for adaptation. Adaptation of the CVCA methodology can be carried out to gather and analyze information to design climate change adaptation initiatives, as well as to integrate climate change adaptation issues into livelihoods and natural resource management programs. It also provides practical evidence for advocacy on climate change issues.
Application/ Utility	The CVCA methodology involves engagement of stakeholders, assessing current vulnerability and understanding future climate risks. Its results provide an excellent foundation for designing, implementing and evaluating adaptation strategies through a participatory learning and planning process.
Geographical Scope	CVCA process can be undertaken at national, local government/community and household/individual level. The CVCA process can be implemented in any community whereby a deeper understanding of vulnerability to climate change is required, particularly for communities in areas or regions that have been identified as highly vulnerable.
Inputs/ Resources/data	The following is a list of the steps involved for undertaking CVCA: **Setting the scope and depth of analysis:** Adaptation of the CVCA process can be carried out to reflect specific needs and constraints. The objective is to develop a detailed understanding of the dynamics of vulnerability for different groups within the community. It involves significant engagement with communities and local stakeholders over a period of time to gather information, analyze the data, validate the analysis, and use it in a broader participatory planning process. **Selection of a suitable and capable team:** During planning for a CVCA, it is important to choose an analytical team with diverse backgrounds. A multidisciplinary team is better positioned to undertake a holistic analysis. To ensure appropriate entry points into communities and to increase trust during the field exercises, the team is required to include people who are known in the area, such as local NGO or CBO representatives. Team leaders are required to be aware of the fact that some people may have a vested interest in the outcomes of the analysis.

	For analysis at the National level: Some of the guiding questions for undertaking the analysis at the national level include: – Is the government monitoring and analyzing current and future climate information related to livelihoods? – If so, is this information being disseminated? How? To whom? – What are the observed and predicted impacts of climate change for the country? – What livelihood groups or economic sectors are most vulnerable to climate change? – Is climate change integrated into relevant sectoral policies? – Is climate change integrated into poverty reduction strategy and/or other development policies and programs? **Access to secondary Research:** Before initiation of work in communities, it is imperative to understand the overall picture. Scientific information on climate change is generally available at the country level. Helpful sources of information may include: ➥ National Communications to the United Nations Framework Convention on Climate Change ➥ National Adaptation Programme of Action (NAPA) documents ➥ National Action Programme to Combat Drought and Desertification (NAP) documents ➥ Meteorological data on current climate trends ➥ National census and poverty data **Institutional Mapping :** To understand the context at the national level, an institutional mapping exercise can be useful. The institutional analysis provides useful information to plan the scope of the policy analysis, and to identify key stakeholders at different levels. **Policy Analysis:** – Review of national level sectoral policies in the areas of water, agriculture health, economic development, infrastructure etc. – Review of local level/ district level plans **Key Informant interview** – Persons engaged in development of NAPAs or other climate change policies and plans – Persons engaged in development or implementation of disaster risk management policies – Persons leading decision-making in relevant sectors such as water, agriculture, economic development, etc. **For analysis at the local government/ community level:** Some of the guiding questions for undertaking the analysis at the local government/ community level include: – What social groups within the community are most vulnerable to climate change? – Are local planning processes participatory?

	– Do women and other marginalized groups have a voice in local planning processes? – Do local policies provide access to and control over critical livelihoods resources for all? – What are the other factors constraining adaptive capacity of the most vulnerable groups? – Do vulnerable communities and groups have any influence over these factors? **Secondary Research** An understanding of the livelihoods strategies, socio-economic situation, power dynamics and local governance within the target communities is critical to ensuring that facilitators are effective during the field work, and to identify focus groups within the community. Secondary sources for community-level information include: ▪ Assessment reports from NGOs or UN organizations ▪ Evaluations of past disaster response operations **Policy Analysis** Depending on the degree of decentralization of decision-making, local-level plans or policies serve as important sources for shaping adaptive capacity of vulnerable households and individuals. Regional or district plans and/or sector strategies also provide helpful information on priorities of local governments. Further, the process for developing these policies and strategies provides insights into the level of participation of vulnerable people in establishing these priorities. The status of implementation yields useful information on resource and capacity constraints faced by local actors. **Institutional Mapping** Institutions play a critical role in supporting or constraining people's capacity to adapt to climate change. In order to better understand which institutions are most important to people in the target communities, an institutional mapping exercise is useful. Institutional mapping involves examination of the following questions: ▪ Which organizations (governmental, non-governmental and community-based) are involved in addressing key issues and problems related to climate change? ▪ What do they do? ▪ Where do they work? ▪ How do they interact with the target population? ▪ Where are the overlaps with other organizations? **Key Informant Interviews** Key informants can provide useful insights into local governance structures and status of implementation of local policies and programs. Power issues within and between communities and other stakeholders are also assessed through interviews with key actors, however preserving their anonymity may allow them to speak more freely. Key informants at the local government/community level include: ▪ Local leaders (council officials, elected representatives, etc.) ▪ Representatives of community-based organizations (CBOs) such as farmer's groups, water and sanitation committees, savings and credit groups, etc.

	Some of the participatory tools that can be used for conducting CVCA include: • Group discussions • Focused group discussions • Interview with Key informant • Hazard Mapping • Seasonal Calendar • Historical Timeline • Vulnerability Matrix • Venn diagram The detailed description with respect to the use and application of each of these tools is made available in the guidance toolkit for CVCA, developed by CARE.
IT Infrastructure/ software required	The application of methodology would require the use of data entry software like CS Pro and use of statistical packages like SPSS and STATA. The information gathered using PRA technique will require content analysis using N Vivo/ Atlas Ti software.
Cost for resource input	The tentative cost of inputs required for using the methodology are: • Questionnaire : Rs 250-600 per sample/ household + Consultancy fee of the data collection firm • PRA/ Focused Group Discussions (FGD) : Rs.1,00,000 per PRA / FGD exercise per village • Analysis using N Vivo/ Atlas Ti software: Up to Rs. 50,000 • SPSS & STATA software : Ranging from Rs 2,00,000 (single user) to Rs. 5,00,000 (multi user) • CS Pro: Downloadable free of cost from the internet but may need customization as per needs of data entry. The consultant may charge Rs. 10,000 to 50,000 for making such changes. • Census data : Available in the census CD (less than Rs 1000 per CD) • Demographical Data : Available from Indiastat (Subscription more than Rs 50,000) • Other Secondary data : Various government department websites available free of cost • The above costs may however vary with respect to the scale of application and data requirement
Output/ outcomes	The results of the CVCA provide insights into the policy and institutional issues that constrain the ability of vulnerable communities to adapt to climate change. They help in understanding inequalities within communities and households that make certain groups or people more vulnerable. Finally, they provide “first-hand” accounts of the impacts of climate change on vulnerable people. CVCA also assists in developing solid foundation for the identification of practical strategies to facilitate community-based adaptation to climate change.
Analysis	A number of characteristics make the CVCA process different from other forms of participatory learning and analysis. These include: • **Focus on climate change**: CVCA focuses on understanding effects of climate change on the lives and livelihoods of target populations. It examines hazards, vulnerability to climate change and adaptive capacity with a view to building resilience for the future. • **Analyzing conditions and hazards**: CVCA combines good practices from analyses done for development initiatives, which focus on conditions of poverty and vulnerability, and those done within the context of disaster risk reduction (DRR), which focus on hazards. CVCA facilitates analysis of the information gained from both types of assessments from a climate change perspective. It

	examines both hazards and conditions, and analyzes the interactions between the two. • **Emphasis on multi-stakeholder analysis, collaborative learning and dialogue:** While CVCA is primarily used to analyze information, the methodology is designed to balance the research agenda with a process of learning and dialogue among local stakeholders. This yields a greater understanding within communities of the resources available to them to support adaptation, and can promote dialogue among stakeholders on adaptation actions that can be initiated. • **Focus on communities but also examines enabling environment**: Vulnerability to climate change varies within countries, communities and even households. Therefore, adaptation requires context-specific activities, with strategies targeted to meet the needs of different vulnerable groups. At the same time, local and national policies and institutions play a critical role in shaping people's capacity to adapt to climate change. Thus, the CVCA process focuses on the community level but incorporates analysis of issues at regional and national level in an effort to foster an enabling environment for community-based adaptation.
Resource Agency/ Reference details	Climate Vulnerability and Capacity Analysis Handbook Published by CARE International First Edition May 2009 The Handbook can be downloaded from CARE's climate change website at http://www.careclimatechange.org.

Name of the method/ tool : Assessment of Social Vulnerability to Drought	
Brief Description	This methodology can be used to assess social vulnerability of the community to drought. The method involves development of vulnerability index the is reflective of the level of social vulnerability of the community to droughts by following these steps: Step 1: Selection of proxy variables that reflect status of the natural resources available, the economic capacity of the community, the human and community resources available and level of agricultural innovation/ adaptation in the region. These variables will be reflective of factors that contribute to social vulnerability to drought. Step 2: This is followed by normalization of the proxy variables with respect to a common baseline to remove anomalies and avoid biases towards any particular pattern of querying. Step 3: Assign weighted averages to each category of proxy variable of (i) natural resources; (ii) economic capacity; (iii) human and community resources and (iv) agricultural innovation/ adaptation based on the frequency & extent of drought and socio economic status of the community. This is based on the premise that underlying cause of vulnerability may be related to structural issues, such as lack of water harvesting structures and soil & moisture conservation interventions, and also to management, economic and social features of the region. For example, the direct impact of drought may be reduction agricultural yield. The underlying cause of this vulnerability, however, may be that the farmers did not use drought-resistant seeds, either because they were not aware of it; their costs were too high, or because of some commitment to local cultural norms. Another example could be crop failure due to drought. The underlying cause of this vulnerability could be small farm size, lack of access to credit for crop diversification, farming on marginal lands, lack of agricultural extension services, lack of local industry for off-farm supplemental income among others. Based on these assumptions the weight assigned of each category of index becomes the key determinant of the final value. The results of the index are generally presented under two scenarios. Under first scenario all components are given equal weight. Under second scenario various category of proxy indicators are given differential weightages depending upon local situation. This reflects the assumption that a society with institutional structures and strengths for public participation is less vulnerable to drought and that agriculture is only one of the sectors affected by drought. Step 4: The final step would involve quantification of vulnerability as weighted average of each of the above components.
Application/ Utility	This methodology can be used to assess the overall social vulnerability due to drought, which can be obtained by combining vulnerability obtained from factors governing direct exposure to drought, and vulnerability to drought derived from social and economic aspects. For example, in case of a farmland, the vulnerability is directly related to the intensity of the drought event. On the contrary, for a given drought event, the most vulnerable farming system would be the one that has less social and economic resiliency; in general marginal and small farmers suffer the most impacts of drought.
Geographical Scope	The methodology can be applied spatially at village, block, district or national level with different aggregation levels of the input data. The methodology allows the indices to be evaluated separately for each level, allowing comprehensive interpretation at that level.

Inputs/ Resources/data	Data inputs on indicators of like Agricultural water use (%), Total water use, Average precipitation (mm/year) over a period of 30-40 year time scale, Area under irrigation (ha), Irrigated area (% of cropland), Agricultural value added/GDP (%), Energy use, Population below poverty line, Population density, Agricultural employment (% of total), Adult literacy rate, Life expectancy at birth, Population without access to water (drinking/ irrigation), Fertilizer consumption, use of agricultural machinery etc.
IT Infrastructure/ software required	The application of methodology would require the use of data entry software like CS Pro and use of statistical packages like SPSS and STATA. The information gathered using PRRA technique will require content analysis using N Vivo/ Atlas Ti software.
Cost for resource input	The tentative cost of inputs required for using the methodology are: 1. Questionnaire : Rs 250-600 per sample/ household + Consultancy fee of the data collection firm 2. PRA : Rs.1,00,000 per PRA exercise per village 3. Analysis using N Vivo/ Atlas Ti software: Up to Rs. 50,000 4. SPSS & STATA software : Ranging from Rs 2,00,000 (single user) to Rs. 5,00,000 (multi user) 5. CS Pro: Downloadable free of cost from the internet but may need customization as per needs of data entry. The consultant may charge Rs. 10,000 to 50,000 for making such changes. 6. Environmental Data: Available free for the use by government agencies from IMD and IITM 7. Census data : Available in the census CD (less than Rs 1000 per CD) 8. Demographical Data : Available from Indiastat (Subscription more than Rs 50,000) 9. Other Secondary data : Various government department websites available free of cost 10. Other Costs : Vary with respect to the scale of application and data requirement
Output/ outcomes	The application of this methodology will result in development of an index which will be reflective of the social capacity of the community to foresee, cope, manage and respond to drought situation.
Analysis	The methodology is useful for integrating both quantitative and qualitative aspects of vulnerability, permitting the involvement of stakeholders at all level in the process. This makes the methodology more grounded to the realities on the field and helps in eliminating the biases that may creep in due to use of only secondary data/ information that may at times be old or redundant due to introduction of new systems / policies/ programs/ infrastructure. The vulnerability index developed using the methodology will help in establishing robust conclusions as the range of values used in the methodology across regions does not change with the assumptions under the two scenarios.
Resource Agency/ Reference details	This methodology was practically applied in the Mediterranean region and is suitable for application in Indian context as well. Further information related to the methodology can be obtained from http://www.proventionconsortium.org/?pageid=43. A paper written by A. Iglesias, M. Moneo, S. Quiroga, Dpto. de Economía y Ciencias Sociales Agrarias, E.T.S. Ingenieros Agrónomos, Universidad Politécnica de Madrid, Avenida Complutense, s/n, 28040 Madrid, Spain gives an overview of practical approach of the methodology for assessing social vulnerability in drought situation. The authors can be contacted to provide further information on application of the methodology in Indian context specially in terms of assigning weightages to various categories of proxy variables.

Name of the method/ tool : Vulnerability and Capacity Index (VCI) Method	
Brief Description	The VCI method identifies and examines eleven critical indicators of vulnerabilities covering material, institutional and attitudinal drivers of social vulnerability. This methodology can be used at the household and community level covering both rural as well as urban areas. This method is different from other methodologies as it measures the prevalent conditions that drives vulnerability and does not measures them in relation to any thresholds levels of damage from specific hazards as some other vulnerability indices. The steps involved in using this methodology are: Step 1: Identify the key measures of vulnerability by defining and quantifying appropriate measures for the three key aspects of vulnerability, in terms of material covering income & education; institutional covering infrastructure & social capital; and attitudinal assessing the sense of empowerment. Step 2: Development of data collection tools covering all indicators. Here the data collection tools need to be simple and in local language to evince proper responses from the targeted stakeholders. Further they should be simple enough for community researchers to adopt so that they could repeat this exercise six months or one year down the line to look at the impact of the various adaptation or disaster risk reduction interventions. The survey tools generally used are household questionnaire and checklist for the focus group discussions. The data can also be used from secondary data sources like existing surveys. Step 3: Collection of data to compile the VCI from primary / secondary sources, e.g., household surveys or focus group discussions for the community level VCI. Step 2: Assigning weights to each category of indicator. The overall weight distribution of vulnerability drivers used for the three categories of material, institutional and attitudinal vulnerabilities are 35, 50 and 15, respectively. However, they may be modified depending upon local conditions. Step 4: The final step would involve quantification of vulnerability as weighted average of each of the three category of indicators.
Application/ Utility	VCI can be used by development practitioners and policy makers to examine and assess vulnerability at scale in disaster and extreme climate risk regions. The VCI can be implemented with the help of NGO teams and community animators to collect baseline information on vulnerability in a village or urban community not only to target specific interventions and limited resources at vulnerable households, but also to later monitor impacts and outcomes of the same.
Geographical Scope	VCI is a simple and comprehensive method which can be used for measuring differential vulnerability at the household and community level in both rural and urban areas.
Inputs/ Resources/data	**Data inputs that would be needed in the following categories of indicators primarily through primary surveys:** **Material Vulnerabilities** Income Source: Sources of livelihoods, local level asset for livelihood, e.g., land, tractor, fisheries etc. Educational Attainment: Literacy rates, Female literacy

	Assets: Exposure: Distance from the source of prime hazard, e.g., river, coastline, landslide zone; evidence of hazard proofing, e.g., building of a house on higher plinth for floods, light construction, low cost construction which could be rebuilt with local resources. **Institutional Vulnerability** Social Networks: Existence of equitable, democratic community organization. Extra-local kinship ties: Infrastructure: Status of all-weather road, electricity, clean drinking water, telecommunications (mobile coverage), medical facility Proportion of dependents in a household: Warning Systems: Status of warning system Community of disadvantaged lower caste, religious or ethnic minority **Attitudinal Vulnerability** Sense of Empowerment: Status of SHGs, Access to official levers of power, access to information on local hazards
IT Infrastructure/ software required	The application of methodology would require the use of data entry software like CS Pro and use of statistical packages like SPSS and STATA. The information gathered using PRRA technique will require content analysis using N Vivo/ Atlas Ti software.
Cost for resource input	The tentative cost of inputs required for using the methodology are: 1. Questionnaire : Rs 250-600 per sample/ household + Consultancy fee of the data collection firm 2. PRA/ Focused Group Discussions (FGD) : Rs.1,00,000 per PRA / FGD exercise per village 3. Analysis using N Vivo/ Atlas Ti software: Up to Rs. 50,000 4. SPSS & STATA software : Ranging from Rs 2,00,000 (single user) to Rs. 5,00,000 (multi user) 5. CS Pro: Downloadable free of cost from the internet but may need customization as per needs of data entry. The consultant may charge Rs. 10,000 to 50,000 for making such changes. 6. Environmental Data: Available free for the use by government agencies from IMD and IITM 7. Census data : Available in the census CD (less than Rs 1000 per CD) 8. Demographical Data : Available from Indiastat (Subscription more than Rs 50,000) 9. Other Secondary data : Various government department websites available free of cost 10. The above costs vary with respect to the scale of application and data requirement
Output/ outcomes	The application of this methodology will result in development of a vulnerability and capacities index which can provide a measure of the current factors that drives vulnerability in terms of material, institutional and attitudinal aspects. This can help the policy makers in designing appropriate packages/ programs for reducing the vulnerabilities of the targeted community/ households/ region.
Analysis	One of the key advantages of this method is its ability to provide a quantitative measure of vulnerability, which increases its communicative impact particularly with the policy makers who are not an expert in this sector specially relaying critical information in a comparative sense across rural and urban household and community level. However, while trying to quantify a complex and nuanced concept

	like vulnerability one needs to consider several competing criteria, scores and weights that can be ascribed to the index. In addition, as with any methodology or tool, the VCI cannot be used on its own without supporting narrative on the local context, hazards, risks and social relations. Therefore while using the index the reasons why certain households and communities are vulnerable or the rationale behind the numbers need to be explained briefly in order to develop a more complete analysis for designing policy and development interventions that can address vulnerability. One of the advantages of VCI is that it looks at the some of the common drivers of vulnerability across household and community level and across rural and urban divides, without changing drastically. Such simplicity can be helpful for medium to small NGOs and government line departments for monitoring vulnerability. More importantly, VCI can be used for mapping vulnerability for channelizing resources and policy interventions where the need for vulnerability mitigation and risk reduction is high.
Resource Agency/ Reference details	VCI has been effectively used in Indian context to analyze vulnerabilities in various hazard hazard risk conditions. VCI was used by ISET team to understand vulnerabilities in Eastern Uttar Pradesh and coastal Gujarat in India (rural household VCI) and seven urban communities in Rawalpindi, Pakistan (urban community VCI). In all these field areas adaptation pilots are ongoing with NGOs facilitating awareness on disaster risk reduction, particularly in the case of the Indian sites. Further Winrock International India has used VCI to assess the vulnerabilities of the forest dependent communities in central Indian Region. Further information on practical application of this method can be obtained from Daanish Mustafa (KCL) , Sara Ahmed, Eva Saroch (ISET-India) & The Risk to Resilience Study Team and Winrock International India (wii@winrockindia.org) **References:** Mustafa, D., Ahmed, S., E. Saroch and The Risk to Resilience Study Team, (2008): Pinning Down Vulnerability: From Narratives to Numbers, From Risk to Resilience Working Paper No. 2, eds. Moench, M., Caspari, E. & A. Pokhrel, ISET, ISET-Nepal and ProVention, Kathmandu, Nepal, 28 pp.

Name of the method/ tool : Capacities and Vulnerabilities Analysis (CVA) Method	
Brief Description	The CVA is a practical and diagnostic method, which is used to support policy planners and government agencies to help them direct their relief intervention in a manner that leads to socio economic development of the targeted community/ region, but at the practical level it has been more widely used for disaster preparedness and mitigation. CVA makes a distinction between vulnerabilities and needs of the community by considering vulnerabilities as factors that affects community's long-term ability to respond to a hazard or make it susceptible to an event, while needs as immediate requirements of the community for survival and or recovery after an event. CVA is based on a simple matrix for analyzing community's vulnerabilities and capacities in three primary interrelated areas covering: i. physical/ material; ii. social/ organizational; and iii. motivational/ attitudinal , shown in the figure below.

	Vulnerabilities	Capacities
Physical/material Productive resources, skills and hazards prevalent		
Social/organizational Relationships between organizations and people		
Motivational/attitudinal Community's perceived ability to create change		

Figure: CVA matrix

Each of the above categories comprises a wide range of indicators. The CVA matrix also helps in disaggregation of factors by gender, economic status, and changes over time as well as interaction between categories and different scales or levels of application (e.g. village or national levels).

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The basic premise behind successful application of CVA is active participation of targeted vulnerable group so that they can understand their own situation and capacities to effect desired change. Therefore this method is based on participatory approaches. Community members take an active role in participatory data gathering. In this process the community themselves analyze the factors that lead to their vulnerabilities and identify the resources and solutions needed to deal and respond to disaster events and other periods of stress. The most commonly used tools for participatory data collection include the following:

- Secondary data analysis to understand the situation and context, covering the community, threats, hazards, policies and legislation. This information can be obtained from government offices, universities, research centres and past programs.
- Semi-structured interviews with targeted groups and individuals to get information on the issues, vulnerabilities and capacities of the community.
- PRA and Focused Group Discussions to develop a historical profile and insight into hazards and links to vulnerabilities and to make people aware of changes for example, trends crop productivity and forest cover.
- PRA through community mapping of topography, houses, land use, hazards, elements etc. showing local resources and capacities, control over resources
- PRA through transect walks with key informants to visualise interactions between physical environment and human activities covering issues like land use and tenure, environmental changes and areas vulnerable to hazards.
- PRA through seasonal calendars identify periods of stress, hazards, disease, hunger, debt and vulnerability. This can also be used to identify the current coping strategies of the community.
- Combination of household interviews and PRA techniques for analysis of livelihoods and coping strategies by getting an understanding of perceptions, behaviour and decisions of the community related to livelihood strategies in event of a hazard.
- Institutional and social network analysis through PRA and Focused Group Discussions.
- Problem trees analysis through PRA to identify local issues, problems and vulnerabilities, including the root causes and their long-term effects.
- Semi-structured interviews, SWOT analysis and planning processes to assess

	the capacity of local institutions. • Direct observation to obtain a better picture and cross-check verbal information. Most of the methods deployed under CVA are derived from PRA techniques and therefore can be applied by many NGOs. However past experience show that it is important to have a clear plan for gathering data during a CVA covering the data to be collected, methods to be used for data collection, sources of information, the sequence of methods and a time schedule. **Hazards, Vulnerabilities and Capacities Assessment (HVCA)** is another methodology undertaken for counter disaster planning. HVCA is largely based on CVA but is carried out more rapidly. The difference in the approach used under these two methodologies is that HVCA includes a more detailed analysis of hazards and their likely impacts as compared to CVA.
Application/ Utility	CVA is a good method for the use of policy planner, government agencies and even NGOs to help them respond to a disaster by understanding the impacts of their interventions on capacities and vulnerabilities of targeted community. It was first applied by the IRDP to 30 projects in Asia, Africa and Latin America, implemented by a large number of NGOs covering different disasters (drought, flood, earthquake, typhoon, volcano, tsunami, refugees). The IRDP cases demonstrated that CVA could be applied in a wide variety of contexts and could generate valuable insights into vulnerabilities and capacities for use in planning and implementation of projects. CVA has been used mostly to identify appropriate effective strategies for rehabilitation and mitigation in a post disaster situation, however in the recent years it is also being increasingly used for pre-disaster planning. Its applicability to different stages and phases in project cycle and disaster is seen as one of its strengths.
Geographical Scope	The methodology can be applied at project and community level covering village, block, district or national level with different aggregation levels of the input data. The methodology allows the indices to be evaluated separately for each level, allowing comprehensive interpretation at that level.
Inputs/ Resources/data	Data inputs for using CVA are as follows: ***Data on Physical/material vulnerability and capacity***: This will include data on land, climate, environment, health, skills and labour, infrastructure, housing, finance and technologies. ***Social/organisational vulnerability and capacity***: This will cover information on institutional structures, prevalent conflicts and its redressal mechanism, political structures. ***Motivational/attitudinal vulnerability and capacity***. This will cover information on how people in society view themselves and their ability to affect their environment.
IT Infrastructure/ software required	The application of methodology would require the use of data entry software like CS Pro and use of statistical packages like SPSS and STATA. The information gathered using PRRA technique will require content analysis using N Vivo/ Atlas Ti software.
Cost for resource input	The tentative cost of inputs required for using the methodology are: ▪ Questionnaire : Rs 250-600 per sample/ household + Consultancy fee of the data collection firm ▪ PRA/ Focused Group Discussions (FGD) : Rs.1,00,000 per PRA / FGD

	exercise per village ▪ Analysis using N Vivo/ Atlas Ti software: Up to Rs. 50,000 ▪ SPSS & STATA software : Ranging from Rs 2,00,000 (single user) to Rs. 5,00,000 (multi user) ▪ CS Pro: Downloadable free of cost from the internet but may need customization as per needs of data entry. The consultant may charge Rs. 10,000 to 50,000 for making such changes. ▪ Census data : Available in the census CD (less than Rs 1000 per CD) ▪ Demographical Data : Available from Indiastat (Subscription more than Rs 50,000) ▪ Other Secondary data : Various government department websites available free of cost ▪ Other Costs : Vary with respect to the scale of application and data requirement
Output/ outcomes	The application of this methodology will result in development of Capacities and Vulnerabilities Assessment Matrix covering all dimensions of vulnerability, including interactions between the different factors.
Analysis	CVA is an effective method for covering vulnerabilities, capacities and livelihoods issues at an extensive level. CVA's strength is that it allows different organisations to use it in a variety of contexts and hazards according to local needs and capacities. However, its weakness is that the diversity of data sources and data sets used in it makes comparison between projects difficult and therefore limits the potential for drawing more general lessons. Excessive reliance on data collection under CVA can be expensive, redundant, ineffective and anti-developmental. Organisations often fail to use information collected, leading to a waste of effort and resources. Another aspect of CVA is that it does not define indicators. The user defines these and their respective weights depending upon local conditions and requirements. In one sense this makes the method open-minded and participatory but past experiences suggest that the lack of more specific guidance on appropriate indicators and weights can create problems for field staff who find it difficult to apply CVA as an analytical tool for identification of interventions. In such situation there is a risk that the projects that ensue from the CVA may be based on evidence that are subjective and too broad based. The CVA matrix is simple and this helps in remembering the data to be collected. It is comprehensive and covers most of the important variables affecting the community and gives equal consideration to different aspects of capacity and vulnerability. This approach in that sense is advantageous for ensuring that all relevant data are collected. Analysis of vulnerabilities and capacities, however, requires some kind of weighting of these different factors. CVA as generally practised does not weigh the different aspects of vulnerability, which are not all equal in their nature or consequences, which may not present a clear picture. Other aspect concerns cause-effect linkages and coverage of hazards under the methodology. Cause-effect relationships of vulnerabilities are specifically covered under CVA, however in relation to hazards, CVA and even HVCA as applied do not relate capacities and vulnerabilities well to the different kinds of hazard. With field staff often not having sufficient expertise in hazard and risk to fill this gap, there is the possibility that some hazards' significance may get underestimated.

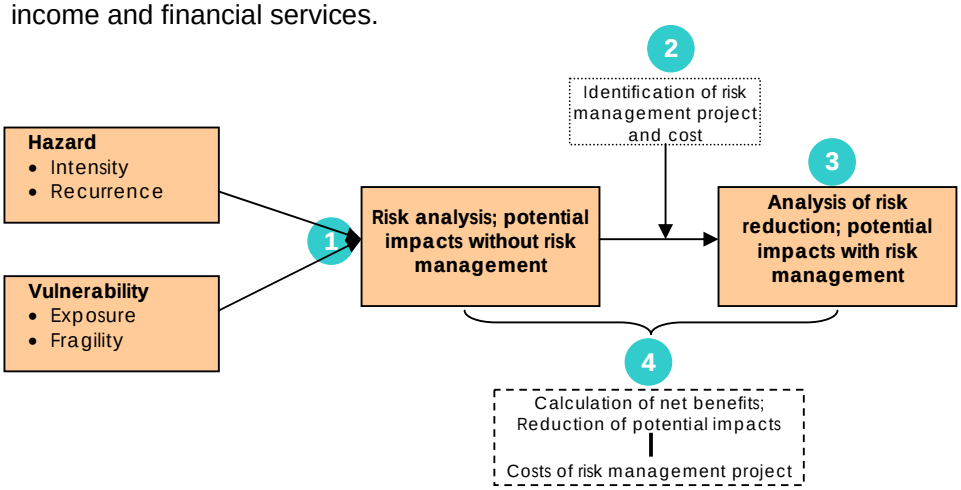
Resource Agency/ Reference details	A good analysis of the CVA method has been done by Terry Cannon, Social Development Adviser, Livelihoods and Institutions Group, Natural Resources Institute, University of Greenwich; John Twigg Benfield Hazard Research Centre, University College London & Jennifer Rowell, CARE International (UK) in their report on 'Social Vulnerability, Sustainable Livelihoods and Disasters' to DFID Conflict and Humanitarian Assistance Department (CHAD) and Sustainable Livelihoods Support Office. Further information on this can be obtained from: Terry Cannon, Livelihoods and Institutions Group, Natural Resources Institute, University of Greenwich, Central Avenue, Chatham, Kent ME4 4TB, 01634 883025, t.g.cannon@greenwich.ac.uk **References** (CVA theory) Mary B Anderson and Peter J Woodrow [1989](1998) Rising from the Ashes: Development Strategies in Times of Disaster. London: IT Publications. (CVA training materials) Mary B Anderson and Peter J Woodrow (1990) Disaster and Development Workshops: a Manual for Training in Capacities and Vulnerabilities Analysis. Harvard University Graduate School of Education: International Relief/Development Project. Citizens' Disaster Response Center, Children's Rehabilitation Center, Department of Social Welfare and Development (n.d.) Trainer's Manual on Disaster Management and Crisis Intervention, Module III: Disaster Management Framework. Quezon City, the Philippines: CDRC/CRC/DSWD. (application of CVA) Mary B Anderson and Peter J Woodrow (1998)[1989] Rising from the Ashes: Development Strategies in Times of Disaster. London: IT Publications. Annelies Heijmans and Lorna P Victoria (2001) Citizenry-Based & Development-Oriented Disaster Response: Experiences and Practices in Disaster Management of the Citizens' Disaster Response Network in the Philippines. Quezon City: Center for Disaster Preparedness. Victoria L, Delica Z (1998) untitled document on risk and vulnerability assessment methods used by Citizens' Disaster Response Centre and Center for Disaster Preparedness in the Philippines. Unpublished report for South Bank University study 'Improved Vulnerability and Capacity Analysis' Bellers R. (2000) 'Summary of CDP/CDRC Risk Assessment'. Unpublished report for South Bank University study 'Improved Vulnerability and Capacity Analysis'.

2.5 METHODOLOGY FOR ASSESSMENT OF ECONOMIC VULNERABILITY

Economic vulnerability is the function of financial accessibility of individuals and communities, debt and the degree of access to credit, loans and insurance. The vulnerable groups are having inadequate access to critical and basic socioeconomic infrastructure, including communication networks, utilities and supplies,

transportation, water, sewage and health care facilities, increase people's exposure to risk.

Economic Vulnerability Index is a composition of the following indicators: 1) population size, 2) remoteness, 3) market linkages, 4) share of agriculture, forestry and fisheries in local livelihood, 5) homelessness owing to natural disasters, 6) instability of agricultural production and other livelihood activities, and 7) instability of income and financial services.



The **Economic Vulnerability**[8] is linked to the following parameters:

- Small size, which inhibits countries from taking advantage of the economics of scale
- Economic openness, which means lack of control of issues managed at a global level
- Dependence on strategic supply chain, particularly energy and raw materials
- Insularity and remoteness, leading to high transport costs
- Fragility of their ecosystems, which is exacerbated by natural phenomena

Purposes, resource and time commitments and the expertise require differ significantly different analysis under the CBA.

The two sub sets under the CBA methodology is mentioned below:

Types of assessments in context of CBA under risk and related case studies

Types of assessment	Methodology	Data requirements	Costs and applicability
Forward-looking assessment – risk based	Estimate hazard, vulnerability, then combine with risk, combine with climate	Locale and asset specific data on hazards and vulnerability. Minimum	More accurate, but time and data-intensive (up to several person years). More applicable for small scale risk management measures, e.g. retrofitting

[8] Vulnerability: Conceptual and Methodology Review, Institute for Environment and Human Security

	modelling, e.g. regional to local climate downscaling	of three data points, Global or regional climate circulation modelling	a school/building against seismic shocks **Input to:** Pre-project appraisal or full project appraisal
Backward-looking assessment – impact based	Use past damages as manifestations of past risk, then update to current risk	Data on past events, information on changes in hazard and vulnerability. Minimum of three data points (past disaster events)	Leads to rougher estimates, but **more realistic and typical** for developing country context. More applicable for large scale risk management measures like flood protection for river basin with various and different exposed elements. Need experience with damages in the past. **Time effort:** in range of several person-months. **Input to:** Evaluation (ex-post) Informational study

Source: Mechler, R. and The Risk to Resilience Study Team, (2008): The Cost-Benefit Analysis Methodology, From Risk to Resilience Working Paper No. 1, eds. Moench, M., Caspari, E. & A. Pokhrel, ISET, ISET-Nepal and ProVention, Kathmandu, Nepal, 32 pp

2.5.1 Data Sources and Availability

Table below gives an overview of key data sources useful for estimating risk. Collecting data on the elements of risk can be time-intensive and difficult. Particularly, information on the degree of damage due to a certain hazard is usually not readily available. As a consequence, in some instances, estimates need to be based on past impacts.

Data sources for hazard, exposure, vulnerability and impacts information

Component	Data source
Hazard	Scientific publications and official statistics, post-disaster publications, geological meteorological and water authorities, local governments. Disaster management authorities. For climate change: global circulation models, regional downscaling.
Exposure	Statistical agencies, private firms. Disaster management authorities
Vulnerability	Specialized engineering reports. Disaster management authorities
Impacts of past events	Official post- disaster publications. Standardized databases. Local, regional and national governments, industry and commercial groups. Disaster management authorities

Name of the method/ tool: The Cost Benefit Analysis Methodology of Hazards and Vulnerability	
Brief Description	The cost benefit analysis is used for the assessment of economic vulnerability due to various hazards. This is undertaken through the weightage analysis of identified vulnerability variables and cost benefit analysis of disaster risk reduction measures. This methodology assesses the impact of hazards like flood, drought etc. on business, industries, handicrafts, agriculture and other source of livelihood in statistical and analytical terms. Where possible uncertainties should be assessed, caution is essential when using estimates of risk to evaluate the benefits of risk reduction. **Types of assessments in context of CBA** **Forward-looking assessment risk based:** ▪ Estimate hazard, vulnerability, then combine with risk, combine with climate modelling, e.g. regional to local climate downscaling ▪ Data requirement: Locale and asset specific data on hazards and vulnerability. Minimum of three data points, Global or regional climate circulation modeling ▪ More accurate, but time and data-intensive (up to several person years). More applicable for small scale risk management measures, e.g. retrofitting a school/building against seismic shocks Input to: Pre-project appraisal or full project appraisal **Backward-looking assessment impact based** ▪ Use past damages as manifestations of past risk, then update to current risk ▪ Data on past events, information on changes in hazard and vulnerability. Minimum of three data points (past disaster events) ▪ Leads to rougher estimates, but more realistic and typical for developing country context. More applicable for large scale risk management measures like flood protection for river basin with various and different exposed elements. Need experience with damages in the past. Time effort: in range of several person-months. Input to: Evaluation (ex-post) Informational study Uncertainties are inherent in : • **Hazard recurrence:** estimates are often only based on a limited number of data points. • **Incomplete damage assessments:** data will not be available for all relevant direct and indirect effects, particularly so for the non-monetary effects • **Vulnerability:** Information to construct vulnerability curves often does not exist • **Exposure:** the dynamics of population increase and urban expansion, increase of welfare need to be accounted for • **Benefits of risk management estimates:** often difficult to accurately measure the effects and benefits of risk management measures • **Discounting:** the discount rate used reduces benefits over the lifetime of a project and thus has a very important impact on the result • **Valuation issues:** exchange rates, deflators and different cost concepts (replacement, market values) used Three decision criteria are of major importance in CBA: • Net Present Value (NPV), Benefit/Cost Ratio, Internal Rate of Return (IRR)

Application/ Utility	Cost-benefit analysis (CBA) is an established tool for determining the economic efficiency of development interventions. CBA compares the costs of conducting such projects with their benefits and calculates the net benefits or efficiency (measured by the net present value, the rate of return or the benefit-cost ratio). While the benefits created by development interventions are the additional benefits due to, for example, improvements in physical or social infrastructure, in disaster risk management the benefits are mostly the avoided or reduced potential damages and losses, including the benefits of the primary development interventions. The economic vulnerability assessment of hazard and vulnerability is undertaken through the weightage analysis of identified vulnerability variables and cost benefit analysis of disaster risk reduction measures. These methods assess the impact of disaster on business, industries, handicrafts, agriculture and other source of livelihood in statistical and analytical terms. The CBA is applied for economic vulnerability due to various hazards on the below project cycle: • Project identification and specification • Appraisal: technical, environmental and economic viability • Evaluation
Geographical Scope	The CBA for assessment of economic vulnerability would be used in the disaster risk reduction project boundary, district and region scale
Inputs/ Resources/data	Scientific publications and official statistics, post-disaster publications, geological meteorological and water authorities, local governments. Disaster management authorities. For climate change: global circulation models, regional downscaling. Statistical agencies, private firms. Disaster management authorities For conducting economic vulnerability due to various hazards and vulnerability data based on the below heads would be required for analysis. This data is mainly defined under monetary and non-monetary in nature with direct and indirect impacts. • **Economic** ➥ *Private Sector*- Housing damaged or destroyed - Household - Livestock ➥ *Public Sector- Assets destroyed or damaged: buildings, roads, machinery etc* - Education - Health - Water and sewage - Electricity - Transport - Emergency spending ➥ *Economic Sectors-- Assets destroyed or damaged: buildings, roads, machinery etc* - Agriculture - Industry - Commerce - Services

	• **Environmental-** *Natural assets and common property resources destroyed or polluted* - Local natural Resources - Natural resource based livelihoods - Loss of natural habitats/biodiversity loss • **Social-Household** - Number of casualties - Number of injured - Number affected - Increase of disease stress symptom - Increase in HH poverty
IT Infrastructure/ software required	• Software packages for analysis SPSS 15.0, Microsoft Office
Cost for resource input	• Data from Indiastat – More than Rs 50,000 • SPSS for data analysis- Rs 100000 • Data from secondary sources from Government websites – Available for Free • The above costs may however vary with respect to the scale of application and data requirement
Output/ outcomes	Net present Value of the project, Cost of reduction of potential impacts, Cost of risk management project and economic vulnerability
Analysis	The CBA assessment is apply with clear objectives, information needs and data situation among different potential stakeholders. Such stakeholders may include representatives from local, regional and national planning agencies, NGOs working in development and disaster risk management, disaster risk managers, officials concerned with public investment decisions, development cooperation staff and local communities. The type of envisage product is closely link to its potential users. A CBA is conducted in Indian sub continent regions for following purpose: • Informational purposes (such as in the Lai Basin case9) • Pre-project appraisal (the India Uttar Pradesh flood study10) • Full-blown project appraisal (the India Uttar Pradesh drought study11) • Expost evaluation (touched upon in the India Uttar Pradesh flood study[12])
Resource Agency/ Reference details	Methodology is tested by ISET, Winrock International India, IIASA (International Institute for Applied Systems Analysis) and GEAG (Gorakhpur Environmental Action Group) Informational purposes (such as in the Lai Basin case[13]), Pre-project appraisal (the India Uttar Pradesh flood study[14]), Full-blown project appraisal (the India Uttar Pradesh drought study[15]), Expost evaluation (touched upon in the India Uttar Pradesh flood study[16])

[9] Risk to Resilience Working Paper, Evaluating the Costs and Benefits of Disaster Risk Reduction under Changing Climatic Conditions : A Pakistan Case Study, ISET

[10] Risk to Resilience Working Paper, Evaluating Costs and Benefits of Flood Reduction under Changing Climatic Conditions : Case of the Rohini River Basin, India, ISET

[11] Risk to Resilience Working Paper, The Cost Benefit Methodology, ISET

[12] Risk to Resilience Working Paper, Evaluating Costs and Benefits of Flood Reduction under Changing Climatic Conditions : Case of the Rohini River Basin, India, ISET

[13] Risk to Resilience Working Paper, Evaluating the Costs and Benefits of Disaster Risk Reduction under Changing Climatic Conditions : A Pakistan Case Study, ISET

[14] Risk to Resilience Working Paper, Evaluating Costs and Benefits of Flood Reduction under Changing Climatic Conditions : Case of the Rohini River Basin, India, ISET

[15] Risk to Resilience Working Paper, The Cost Benefit Methodology, ISET

Name of the method/ tool : **(HLS) Household Livelihood Security , CARE's basic Framework**	
Brief Description	Household Livelihood Security (HLS) has become CARE's basic framework for program analysis, design, monitoring and evaluation. HLS grows out of a food security perspective, but is based on the observation that food is only one important basic need among several, and adequate food consumption may be sacrificed for other important needs HLSA framework provides a framework for the disaster based analysis of vulnerability and livelihood security. This framework analyzes the issues of vulnerability and poverty with people's mechanism for dealing with it. **Assessments Based Upon the Evolving Household Livelihood Security Framework** HLS framework requires a desegregation of data by ethnic groups, gender, economic status, social strata, age, etc. in order to analyze: Division of labor within the family and the community, Access to goods and services, Control over resources, Exercise of rights and obligations analysis of capital (physical, natural, economic, human, social, political), Vulnerability and marginalization issues, Distribution of political and economic Power **Base level of Livelihood strategy** • Exposure to shock • Coping responses and institutional reactions to the shock • Vulnerability (individual, household, community level) as outcome • Identification of target populations for interventions. Vulnerability is then a consequence of the impact of shocks, and not a characteristic of particular sets of households that can be determined in advance of a hazard (or other type of risk) impact. ***Important area of descriptive information are as under:*** • **Physical and Environmental:** Types and distribution of communities, · Available services and infrastructure, History of natural disasters, Historical trends and policies, Agro-ecological conditions and seasonality, Historical "shocks" and "stresses", Demographic distributions • **Social and Political:** Local leadership and authority, Ethnic groups, Formal and informal social networks, Political systems, Personal security • **Economic Activities:** Major and minor livelihood strategies, Sources of income, Farm and off-farm employment, Seasonal and permanent migration • **Institutional Analysis:** Existing institutions (public, NGOs, CBOs, religious, trade and labor associations, industry, etc.), Nature of institutional programming and strategic plans, Interest in collaboration, Comparative advantages, SWOT analysis, Relations with governments and communities • **Outcome Indicators:** Health and disease, Nutritional status, Access to water and sanitation, Literacy, Access to infrastructure, public and productive • **Social Differentiation:** Levels of wealth and poverty, Livelihood profiles and categories, Social mapping

[16] Risk to Resilience Working Paper, Evaluating Costs and Benefits of Flood Reduction under Changing Climatic Conditions : Case of the Rohini River Basin, India, ISET, Winrock International India

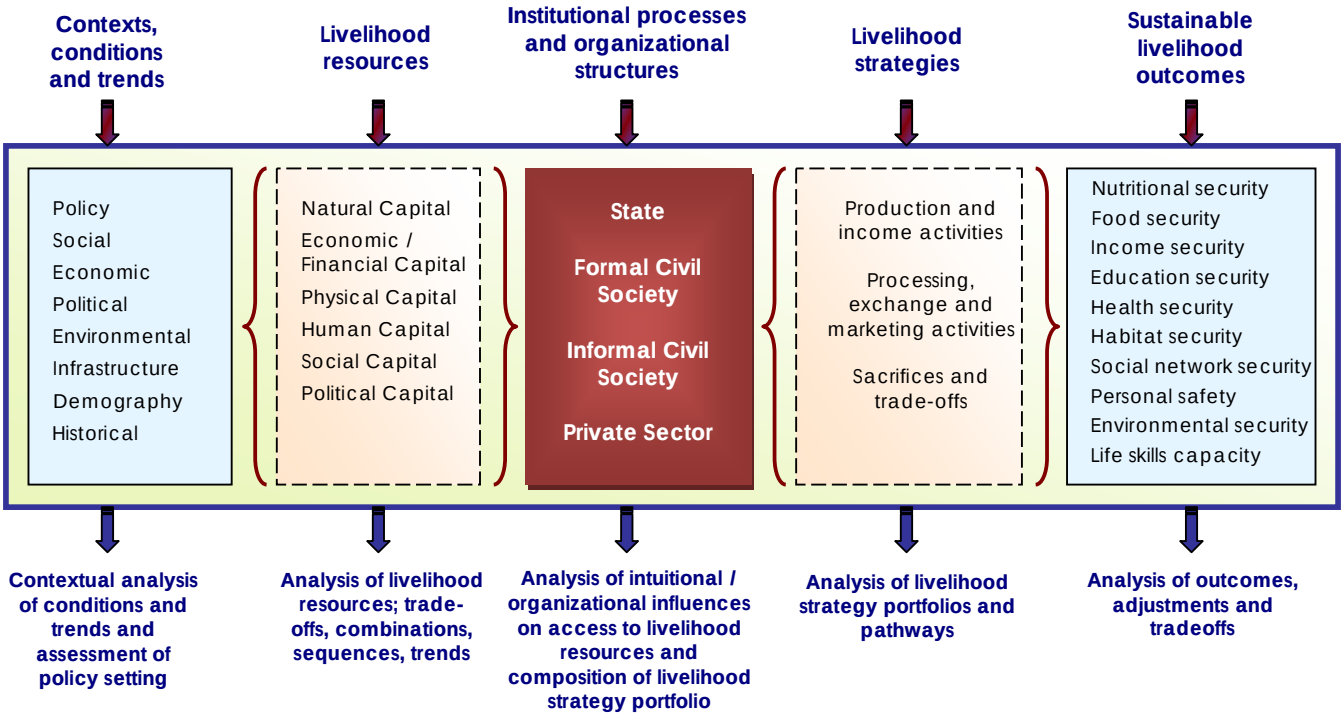
	In-depth analysis of HLS to assess vulnerabilities and livelihood security issues would be done by the following steps: Details of each step is given in the "***Tool Household Livelihood Security Assessments: A Toolkit for Practitioners, July***". : **I. HLS Diagnostic** ➥ Household Livelihood Security ➥ Rights-Based Approach to Household Livelihood Security ➥ Household Livelihood Security Assessment **II. Pre-Assessment Activities** ➥ Secondary Data Review ➥ Institutional Profiles/Mapping ➥ Stakeholders Identification and Participation **III. Target Area Selection** **IV. Creating Livelihood Security Profiles** ➥ Context, Conditions and Trends ➥ Livelihood Resources ➥ Institutional Process and Organizational Structures ➥ Livelihood Security Strategies ➥ Livelihood Security Outcomes ➥ Rights Realization ➥ Developing and Fine-Tuning Your Objectives **V. Survey Sample Selection** ➥ Purposive and Random Sampling ➥ Other Sampling Considerations ➥ Sampling in Urban Areas **VII. Survey Team** ➥ Survey Team Composition ➥ Key Training Techniques **VIII. Primary Data Gathering Methods** ➥ Qualitative Descriptive Information ➥ Quantitative Descriptive Information ➥ Analytical (Causal) Information – Collection Techniques – Types of Interviews – Group Interviews (GI) – Key Informant Interviews (KI) – Focus Group Interviews (FG) – Household Interviews (HI) ▪ *Transects* ▪ *Calendars* ▪ *Flow diagrams* ▪ *Venn diagrams* ▪ *Ranking and Scoring* – Importance of Mixed Methods for Triangulation – Procedures for Carrying out the Fieldwork **IX. Data Analysis and Interpretation** ➥ Institutional Strengthening through Interagency Workshops

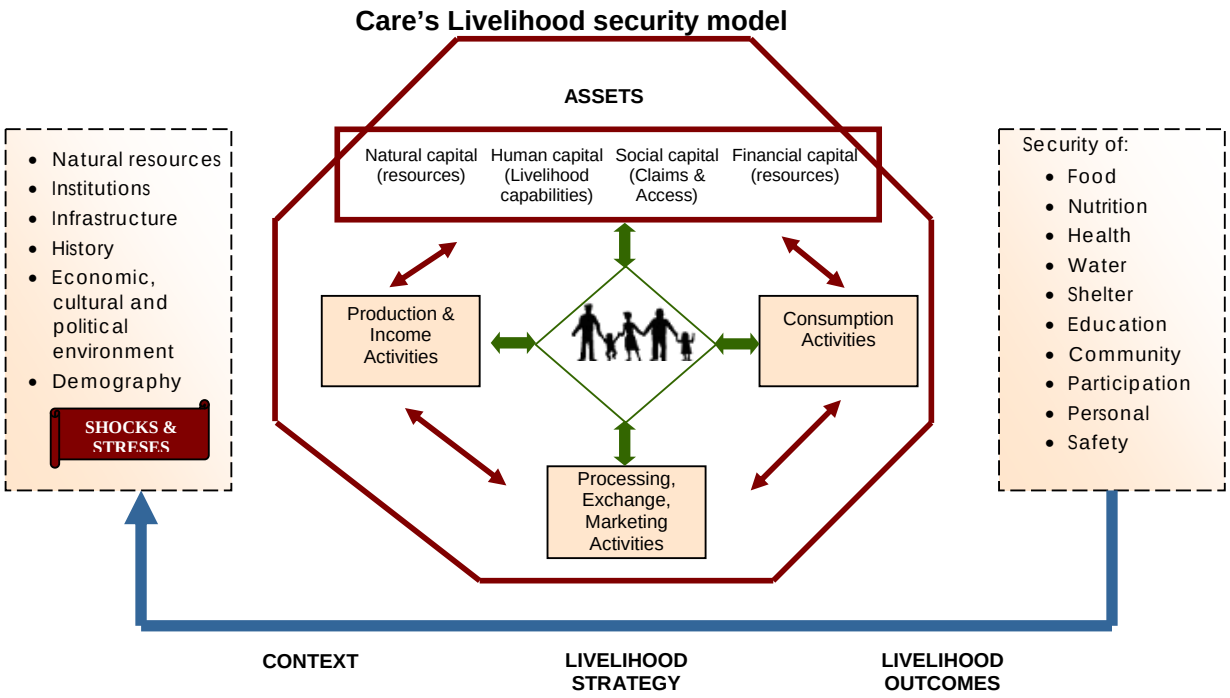
	➥ Suggested Analysis Instruments and Techniques – Consolidated Matrices of Community Livelihood Systems – Profiles of Livelihood Systems – Problem – Cause Trees – Analysis of Common Causes – Opportunities Analysis – Rights and Responsibilities Analysis – Gender Analysis – Stakeholder Analysis – Institutional Analysis – Institutional SWOT Analysis – RICO Strategy Analysis – Cross-Sectoral Strategy Analysis – Benefit-Harm Analysis
Application/ Utility	The approach is directly and indirectly related to the natural hazards, vulnerability and disasters. HLSA is an essential framework for analysing problems and designing interventions including disaster relief and reconstruction.
Geographical Scope	This methodology is applicable on clusters of villages sharing similar profile of problems and having similar socio-economic, socio-political, natural resource, vulnerability and disasters
Inputs/ Resources/data	**QUALITATIVE DATA** Household level: • Assets and how they are used to earn income (including productive assets, but also intangibles such as skills, capacity, social relations that underpin livelihood activities) • Resources allocation and outcome ➥ Food security, nutrition and health status ➥ Other basic needs like water, shelter, education • Capacity to cope with risks and crises Intra-household level: • Gender and generational roles and responsibilities • Power relations and differential access to resources and opportunities Community level: • Livelihood outcomes link with wider community, political and social context and the institutional environment. **QUANTITATIVE DATA** (much of it from secondary sources) that helps to target geographically and to identify vulnerable groups: • Nutritional status information • Health status • Access to services • Literacy levels • Access to water **ANALYTICAL (CAUSAL) INFORMATION** is designed to project the current status of target groups in terms of their exposure to risks (shocks): • Vulnerability and risk factors (ecological, economic, social, political) ➥ Coping, trends in livelihoods, household dynamics, networks and social

	capital ➥ Individual, household and community vulnerability • Opportunity analysis (this seems to be congruent with much of what is considered 'capabilities' in other models) **SECONDARY DATA:** Government documents, Municipal development plans, Official statistics, Technical reports, Project reports, Baseline studies, Project evaluations, Professional and academic journals, Reference books, Research organizations, Public and private universities, Public and private libraries, Computerized data bases, Internet web sites
IT Infrastructure/ software required	• Data Analysis will be through statistical packages such as SPSS 15.0 and STAT it will cost between Rs 200000 (Single User) to Rs 500000 (Multi User) • Data entry software CS Pro 4.0 is available for free in internet. But • If GIS will be used in analysis it will cost in range of Rs 200000 to Rs 500000
Cost for resource input	• Rs 500 to Rs 1000 per sample or per household as the primary data collection would be very intensive. • PRA exercise per village will cost in range of Rs 50000 to Rs 300000 • Consultant may charge Rs. 20000 to Rs. 50000 for designing CS Pro 4.0
Output/ outcomes	Context, conditions and trends will provide the understanding of the macro-level factors that influence the range of possibilities for livelihood systems and vulnerabilities due to natural hazards and disasters. Whereas, in-depth risk analysis would provide the basic support in designing risk mitigation measures with community and all integrated issues as the planning platform.
Analysis	HLSAs are intended to 'provide comprehensive socio-cultural, economic and ecological assessments of a given area for planning and project implementation HLSA uses the system approach with focus on socio economic, socio-political, livelihood, socio-cultural, constraints, vulnerabilities, risks and shocks due to various disasters and hazards. HLSA is a holistic and multi disciplinary approach with emphasis on Livelihood security and vulnerability assessment. An HLSA is formulated for a country or region by using Analytical lenses that is a cluster of : contexts, conditions and trends; livelihood resources (economic, natural, human and social capital); institutional processes and organizational structures (government, civil society and private sector); livelihood strategies (productive and exchange activities); and livelihood outcomes (e.g. nutritional security, food security, health security, habitat security, education security, income security, social network security, safety and environmental security) A Household Livelihood Security Assessment (HLSA) is a type of rapid rural appraisal (RRA) or participatory rural appraisal (PRA), but administered in a different manner as below: Interviews are administered by researchers and not by enumerators, Interviews are semi-structured with focus of on dialogue and probing for information, Informal purposeful sampling procedures are used in conjunction with formal random sampling from a sample frame, Data collection process is dynamic and interactive, where the researchers evaluate the data collected and reformulate data needs on a daily basis, In dealing with accuracy/timeliness trade-offs, triangulation diverse methods

Resource Agency/ Reference details	**M. Katherine McCaston**(Household Livelihood Security, Coordinator, CARE USA, PHLS Unit, mccaston@care.org) **Terry Cannon**(Social Development Adviser, Livelihoods and Institutions Group, Natural Resources Institute, University of Greenwich) **John Twigg** (Benfield Hazard Research Centre, University College London) **Jennifer Rowell** (CARE International (UK), previously Benfield Hazard Research Centre, University College London) **Terry Cannon (**Livelihoods and Institutions Group, Natural Resources Institute University of Greenwich, Central Avenue, Chatham, Kent ME4 4TB, 01634 883025, t.g.cannon@greenwich.ac.uk) T R. Frankenberger, Michael Drinkwater, Daniel Maxwell, 'Operationalizing household livelihood security: a holistic approach for addressing poverty and vulnerability', no date, probably 2000, available at: http://www.fao.org/docrep/003/X9371e/x9371e12.htm

The ***HLS Framework*** and ***Care's Livelihood Security Model*** is given in the below diagram**:**





After swift, 1989, Drinkwater, 1994, 1998, Frankenburger and Drinkwater, 1999

2.6 METHODOLOGY TO ASSESS THE CAPACITY TO RESPOND EFFECTIVELY TO DISASTER SITUATION AND UNDERTAKE FUTURE PROTECTION MEASURES

2.6.1 Effective Capacity Assessment for Non-Profit Organisations

➲ *Brief Description*

This tool has been developed by McKinsey and is used for capacity assessment of non profit organisation. Also known as the McKinsey Capacity Assessment Grid, the tool has been developed to assist non profit organisations for assessing their organizational capacities. The key features and uses of the tool are listed below:

- It is comprehensive capacity assessment tool, which is simple and easy to use.
- The tool comprises of seven elements or grids that assess organisational capacity and its components. Each grid features four scales and each scale has been described individually denoting different levels of organizational performance. McKinsey has developed the grid and the individual descriptions of each grid based on its experience of work with a range of organizations as well as with the help from many non profit organisation experts and practitioners.
- The scoring of the organisation is done using the McKinsey Capacity Assessment Grid based on which ranking of each variable is done on a scale of 1 to 4.
- The tool can be used to assess the capacities on an organisation to:

- Identify areas in which the organisation has strong capacities and those that need improvement;
- Assess the changes in organization's capacity over time;
- Identify and assess different views within an organization regarding its capacity.

➲ ***Applicability***

The tool can be applied by non-profit organisation managers, staff, board members and external capacity builders and funders. Though developed for non-profit organisations, the methodology can be easily adapted for use in other kinds of organisations. A few of the variables are specific to NGOs, such as assessment of the functioning of the organisation's board, but these could easily be adapted.

➲ ***Resources/ Inputs Required***

The application of the tool does not require any additional resources or IT infrastructure and can be carried out mostly using the organisation's own resources, however the execution may require the services of a consultant.

➲ ***Analysis***

The tool is simple, comprehensive and easy to use but McKinsey has itself cautioned that the grid is not a scientific tool and should not be used in that sense. It has also clarified that it is difficult to quantify all dimensions of capacity, and the descriptive text based on which scores are decided in the grid are not meant to be exact. They have clarified that the scores provide a general indication of an organization's capacity level, in order to identify potential areas for improvement. While using the tool there is a need to factor in the stage of the development of the organisation. For example, a score of "2" on organizational processes may be sufficient for a new organization, and this area may not merit immediate attention.

➲ ***Reference:***

The grid can be accessed at http://www.emcf.org/pdf/mckinsey_capacitytool.pdf
http://www.emcf.org/evaluation/mckinsey_assessment_tool.htm

2.6.2 Capacity Assessment Tool CARE

➲ ***Brief Description***

This is a tool, which has been developed and used by CARE for assessing the capacity of its NGO partners. The key features and uses of the tool are as follows:

- The tool comprises of a brief questionnaire which is administered to the NGO.

- The questionnaire of five sections covering the aspect of the governance structure within the organisation, its management practices, financial systems and its transparency, its technical / service delivery systems, organisation mission and sustainability.
- It is uses a short, simple checklist and rating format. Each section of the tool has simple questions and each question has been assigned a weightage of one.
- The NGO partner is assessed in five capacity areas. The capacity areas and the weights assigned to them are: governance (5 point), management practices (12 points), finance (5 point), technical / service delivery (7 point), organisation mission and sustainability (4 point).

➲ *Applicability*

The tool has been used by CARE to assess the capacity of its partner NGOs in Somalia, but the tool with simple modifications can be applicable in India context as well. It can also be used as a rapid assessment tool for assessing the capacities of NGOs in short time.

➲ *Resources/ Inputs Required*

The application of the tool does not require any additional resources or IT infrastructure and can be carried out mostly using the organisation's own resources, however administering of questionnaire may require the services of a consultant.

➲ *Analysis*

The tool is simple and easy to use and does not require any technical expertise to execute it however it can only give an overview of organisation's capacity and not reflect its overall health and provide pointers/ identify gaps for further capacity building.

➲ *References*

The checklist can be accessed at www.**care**i.org.uk/download.php?id=39 and www.**care**international.org.uk/download.php?id=42

2.6.3 Organisational Capacity Assessment Tool

➲ *General Description*

This tool has been developed by Marguerite Casey Foundation to help the non profit organisations in assessing their capacities. This tool has been developed by modifying the original McKinsey Capacity Assessment Grid so that it can be

applicable to non profit organisations working primarily in community organization and advocacy.The key features and uses of the tool are as follows:

- This is a self assessment tool that helps non profit organisations identify their capacities, strengths and challenges and develop a capacity building plan.
- It is a diagnostic and learning tool for the organisation using it over time. The tool has been designed to help the key members of an organization to:
  - To develop an understanding of the strengths and weaknesses of the organization's leadership – **Assess leadership capacity**
  - To measure the organization's ability to monitor, assess and respond to internal and external changes - **Assess adaptive capacity**
  - To measure the ability of the organization to utilize resources effectively - **Assess management capacity**
  - To develop a better understanding on the manner in which the organization is able to implement key organizational and programmatic functions - **Assess operational capacity**
- The tool is administered to the representatives of the non profit organisation undertaking assessment and are asked to rate their organization on a variety of capacity elements.
- The assessment contains eight separate worksheets – one worksheet for each dimension of the organisation capacity and additional worksheets for these instructions, general information about the organisation and the person undertaking the assessment. User rate the organisation on a variety of capacity elements. These capacity elements are clustered into four broad dimensions, i.e. Leadership Capacity, Adaptive Capacity, Management Capacity and Operational Capacity. The process calls for multi-level participation in the assessment exercise, including the CEO and Board president of the organisation, staff, board members and constituents. After completing the assessment, the process recommends that participants gather to discuss their ratings and reach consensus on one set of ratings that best represents the organisation. This team approach for assessing organisational capacity both improves validity and reduces the individual biases.

Marguerite Casey Foundation engaged in tailoring the original McKinsey Capacity Assessment Grid on which this Assessment Tool is based because we wanted to make it useful and appropriate for our grantees, who work primarily in community organizing and advocacy. This included creating new questions on community organizing and constituent involvement, as well as strengthening questions on evaluation, marketing, communication, and fundraising. We also added a more robust cultural competency component to several of the capacity elements.

Marguerite Casey Foundation has used the Tool to create baseline data to help us understand the aggregate capacity strengths and weaknesses of the organizations with which we work. We will also use the information provided by the Assessment to help us craft our collective capacity building plan, and to better understand how we can support a group of “movement building” organizations. The data provided by the Assessment allows us to better understand how our dollars might help strengthen grantee organizations as a group, and increase their collective capacity to help families create change.

We believe the Capacity Assessment Tool will be particularly useful to those grant makers who are engaged in collective approaches to capacity building, as well as non profit practitioners who are interested in identifying capacity strengths and weaknesses in their organization. In our pilot of this assessment tool we found that organizations which were able to engage the Executive Director and their Board Chair or other key board members in the process found the tool and process much more useful and productive.

This is an organizational, self-assessment tool designed to help non-profit organisations identify capacity strengths & challenges and establish capacity building goals. This is primarily a diagnostic and learning tool. The tool enables users, including grant makers, to gain a deep understanding of the current capacities as well as track their growth in capacity over a period of time.

The tool is a modification of the McKinsey Capacity Assessment Grid (see #1), but more tailored to organizations that working in community organizing and advocacy. It is used for establishing baseline information, for crafting capacity building pans, and by grant makers/donors that are interested in identifying capacity assets and gaps in organizations they fund.

➲ *Applicability*

This tool can be used for non profit organisations working primarily in community organization and advocacy for identifying their capacities, strengths & challenges and establish capacity building goals for them.

➲ *Resources/ Inputs Required*

The application of the tool does not require any additional resources or IT infrastructure and can be carried out mostly using the organisation’s own resources, however administering of tool may require the services of a consultant with expertise in this field.

➲ *Analysis*

The tool is simple and easy to use and does not require much technical expertise to execute. The advantage of using the tool by donors could be that they can deepen their understanding of the current capacity of their grantees and also track their growth in capacity over time.

➲ *References*

The tool can be downloaded from
http://www.caseygrants.org/pages/resources/resources_downloadassessment.asp

2.7 CAPACITY ASSESSMENT FRAMEWORK

➲ *Brief Description*

This a comprehensive set of tools that have been developed by UNDP for capacity assessment. It includes a Capacity Assessment Practice Note, User's Guide and Supporting Tool and UNDP's "default" Capacity Assessment Framework. The key features of the tool are as follows:

- It helps in serving as a starting point for capacity assessment for UNDP and other development practitioners.
- It provides a comprehensive view of the issues that needs to be addressed in capacity assessment, yet it is flexible enough for adaptation to the needs of any given capacity assessment situation.
- UNDP has conceived Capacity Assessment as the first in a four step capacity development process: Assess Capacity and Needs, Formulate capacity development strategies, Implement capacity development strategies and Monitor and Evaluate capacity development strategies.
- The Practice Note provides a detailed overview of the what, why and how of capacity assessment. The Users Guide provides a step by step process for undertaking an assessment from mobilising an assessment team, designing the assessment process, conducting the assessment, presenting the results and eliciting lessons learned during the process.
- The capacity assessment framework is based on the three related levels of capacity: Enabling Environment, Organisational and Individual –each of which can be an entry point for assessment. It provides a process to examine different types of capacity, including technical and functional capacities within a specific sector or thematic area, as well as cross cutting capacities, and core capacities at all the three levels to provide an extensive picture of the existing capacities. These capacities are enumerated in numerical terms to provide a summary of a country or organisation's current capacities and a series of possible capacity development strategies that can be adapted to different situations and contexts.

The assessment framework is highly interactive and very thorough. Successful use of the materials will require that users follow the instructions and steps involved. The assessment process should result in a comprehensive capacity developed work plan that specifies future capacities to be developed, strategies and interventions to be used, specific targets and indicators and cost estimates.

➲ *Applicability*

This tool can be used for assessing the country or organisation's current capacities and a series of possible capacity development strategies that can be adapted to different situations and contexts.

➲ *Resources/ Inputs Required*

The application of the tool does not require any additional resources or IT infrastructure and can be carried out mostly using the organisation's own resources, however administering of tool may require the services of a consultant with expertise in this field.

➲ *Analysis*

The tool is simple and easy to use but the use of these materials requires time and adaptation to the specific organizational context and some significant advance work and planning.

➲ *References*

Capacity Assessment practice note -
http://www.capacity.undp.org/indexAction.cfm?module=Library&action=GetFile&DocumentAttachmentID=1422

Capacity Assessment supporting tool -
http://www.capacity.undp.org/indexAction.cfm?module=Library&action=GetFile&DocumentAttachmentID=1934

2.8 CONCLUDING REMARKS

Many divergent views on vulnerability assessment emanate from different research groups from across the world. This indicates towards the fact that this field is not yet completely understood. Initially although vulnerability was described in terms of basic elements, however recent trends emerging in this context include:

- The development of models which explain vulnerability and its dynamics in terms of root causes leading to it.

- The development of indicators or indexes which may allow for vulnerability to be traced throughout the years or to compare countries, cities, or societies in this respect.

To develop a clear and inclusive understanding of the term vulnerability assessment, there is a need for decomposing it to incorporate dimensions or topics and levels and thereby developing methods in each dimension to assess the degree of vulnerability of the same, making use of appropriate units.

Vulnerability Assessment should aim at quantification of the vulnerabilities of different aspects, so as to enable subsequent evaluations to determine whether it is being reduced or not. The precision of methods is dependent on data availability as well as the parameters or proxies applied to assess them. The identification of benchmarks via such methodologies serves to set targets towards its control.

Contrary to the assessment of vulnerability per se, the identification and characterisation of the contributing factors towards generating and enhancing vulnerability are also of high importance. Through targeting root causes or factors, the process of vulnerability generation can be controlled by a society.

A number of challenges lie ahead in the field of vulnerability assessment.

- Developing theories that explain vulnerability and its root causes, along with incorporating methods that predict outcomes, whereby these outcomes could be verified after the manifestation of an event that triggers disasters exposing such vulnerabilities
- Reaching a consensus on particular method, such that it can then be applied systematically throughout the world, or at least throughout developing nations which continually face disasters.

Being a complex subject, vulnerability assessment requires additional efforts in terms of research and testing of methods before a consensus is reached on the use of a particular methodology.

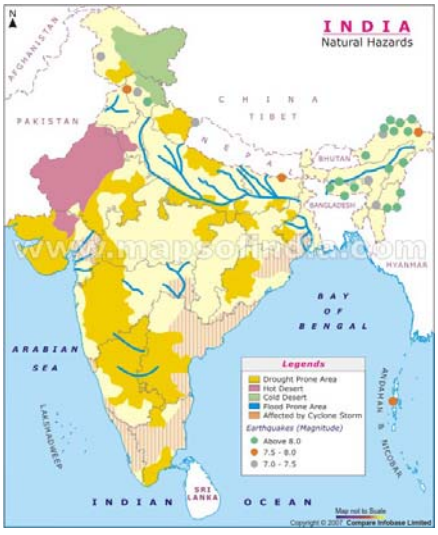
Methodologies for Multi Hazard Risk Assessment

3.1 HAZARD PROFILE: INDIA

A Hazard is a dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage. The hazards of concern to disaster risk reduction are hazards of natural origin and related environmental and technological hazards and risks. Such hazards arise from a variety of geological, meteorological, hydrological, oceanic, biological, and technological sources, sometimes acting in combination. In technical settings, hazards are described quantitatively by the likely frequency of occurrence of different intensities for different areas, as determined from historical data or scientific analysis. Hazards can be categorized into two types. They are:

- Natural Hazards (hazards with meteorological, geological or even biological origin)
- Unnatural Hazards (hazards with human-caused or technological origin) (as defined by the National Disaster Management Authority, India)

It is also important to know that natural phenomena are extreme climatological, hydrological, or geological, but these processes by themselves do not pose a risk to property or persons. It is only when these natural phenomena impact lives of people and pose a threat to property do they qualify as disasters.



The Natural hazard Map of India

Source: http://www.mapsofindia.com/maps/india/natural-hazard.htm

3.1.1 Hazard hotspots in India: A quick review

India has a highly diverse topography. Its vastness and its diverse topography make it highly prone to different disasters in different areas. According to a World Bank study on the hazard profile of India--199 districts*(The smallest administrative unit in the country.) out of a total of 602 districts have been identified as High Risk Disaster Areas. In the North there are the Himalayas that are in a zone of high seismic activity. Moreover, these regions are also prone to avalanches, landslides and mudslides. The forests in the Himalayas and the forests in Central India are vulnerable to forest fires that occur in the hot dry summer months. The western states of, Gujarat and Maharashtra, the Northern states of Delhi, Uttaranchal, Himachal Pradesh and the Andaman isles are particularly vulnerable to Earthquakes. (54% of land area) 15% of the land is prone to flooding. In 1998, 38% of the land was flooded. The Northern Plains are washed by gigantic rivers, Ganges and Brahamaputra and their tributaries that witness annual flooding. Similarly, the rivers of Central India are prone to flooding. Apart from flooding of rivers in monsoons, some areas are prone to flash floods. 91 districts are under Drought prone areas. The eastern coastal belt is vulnerable to periodic cyclones followed by coastal flooding. Storms and cloudbursts also occur with regularity in the states of Andhra Pradesh, Orissa, West Bengal and Tamil Nadu. (8% of the total area) (According to World Bank paper on Hazard profile in India)

Key Vulnerabilities in India

- Coastal states particularly in the eastern coast and Gujarat are vulnerable to cyclone.
- 4 crore hector land mass are vulnerable to floods.
- 68 percent of the net sown area is vulnerable to drought.
- 55 percent of the total land mass is prone to seismic zone III to IV and are vulnerable to earthquake.
- Sub-Himalayan/ Western Ghats are prone to landslides.

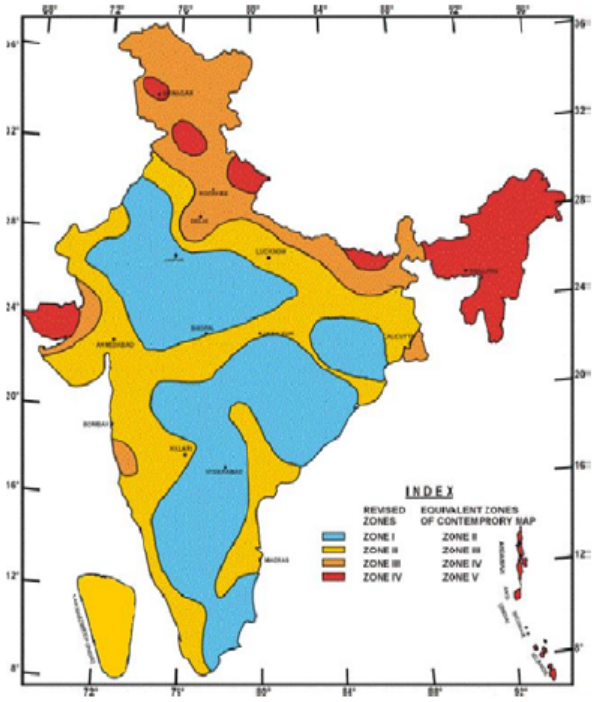
Source: *Disaster Management – The Development Perspective: An extract of the Chapter in the Tenth Five Year Plan Document (2002-2007)*

Some of the key hazards affecting India are:

➲ Earthquakes hazards and disasters

Earthquakes hazards and disasters is a series of underground shock waves and movements on the earth's surface caused by natural processes writhing the earth's crust. According to the latest available seismic zoning map of India the country is

primarily classified into four Seismic Zones. Zone V is the area that is most vulnerable to earthquakes, where historically some of the country's most powerful shock has occurred. Geographically this zone in India includes the following areas : Andaman & Nicobar Islands, all of North-Eastern India, parts of north-western Bihar, eastern sections of Uttaranchal, the Kangra Valley in Himachal Pradesh, near the Srinagar area in Jammu & Kashmir and the Rann of Kutchh in Gujarat. Much of India lies in Zone III, where a maximum intensity of VII can be expected. While metros like New Delhi falls under Zone IV, Mumbai and Chennai lie under Zone III.



Seismic Zones of India

Source*:* Hazards, disasters and your community: A primer for Parliamentarians published by GoI Ministry of Home Affairs National Disaster Management division.

➲ *Tsunami hazards*

Tsunami is a Japanese word meaning “harbor wave”. These waves, which often affect distant shores, originate from undersea or coastal seismic activity, landslides, and volcanic eruptions. Whatever the cause, sea water is displaced with a violent motion and swells up, ultimately surging over land with great destructive power. Low lying coastal area are primarily vulnerable to the direct impact of the tsunami waves as well as the impact of debris & boulders brought by it. Settlements in adjacent area are vulnerable to floods.

➲ *Landslides hazard*

Landslides are slippery masses of rock, earth or debris which move by force of their own weight down mountain slopes or river banks. The Himalayas including Northeastern Mountains ranges are most vulnerable to landslides and are the worst affected. A section of Western Ghats and the Vindhyas also falls under the landslide hazard zones. Peninsular India namely Western Ghats and Nilgiris are also affected by landslides due to torrential rains coupled with loss of vegetation cover.

➲ *Cyclone hazards*

Cyclone is a violent storm, often of vast extent, characterized by high winds rotating about a calm center of low atmospheric pressure. This center moves onward, often with a velocity of 50km an hour. Cyclones affect both the Bay of Bengal and the Arabian sea. Most of the monsoon (June - September) storms develop in the central and in the North Bay and move west-north-westwards affecting Andhra-Orissa-West Bengal coasts. Post monsoon (October-December) storms form mostly in the south and the central Bay, affecting Tamil Nadu-Andhra Orissa-West Bengal-Bangladesh coasts. North Orissa, West Bengal coasts, Andhra Pradesh coast between Ongole and Machilipatnam and Tamil Nadu coast, south of Nagapatnam are some of the most vulnerable areas located in the east coast. In comparison to the east coast, the west coast is less vulnerable to storms both in terms of its frequency and scale. However the following areas like the coastal belt around the Gulf of Kutch adjoining south Gujarat coast and the Maharashtra coast are some of the most vulnerable stops in the western coast.

➲ *Flood Hazards*

Flood is a temporary inundation of large regions as the result of an increase in reservoir, or of rivers flooding their banks because of heavy rains, high winds, cyclones, storm surge along coast, tsunami, melting snow or dam bursts. The flood hazard map is based on the Flood Atlas of India brought out by the Central Water Commission, state wise marking both the areas which are liable to flooding as well as those which have been protected. The maps given in the Vulnerability Atlas of India show the district boundaries and the location of the district towns along with the rivers district wise identification of vulnerable areas will be easy. As per the estimates by the Central Water Commission, approximately 2.808 million hectors of land falls within the flood affected zones.

➲ *Drought hazard*

Drought is an insidious natural hazard that results from a departure of precipitation from expected or normal that, when a season or longer period of time extended over,

is insufficient to meet the demands of human, plant and animal activities. The most vulnerable areas as far as drought is concerned are western and eastern parts of Rajasthan. The other vulnerable states are Madhya Pradesh, Rajasthan, Chattisgarh, Himachal Pradesh, Maharashtra and Tehri Garhwal districts in Uttaranchal.

After having looked at the definitions of the major hazards affecting India as per the Government definition and the main mitigation measures to be followed in the event of a natural hazard, the next section presents the summary formats which catalog various methodologies, tools and approaches to hazard and multi hazard assessments.

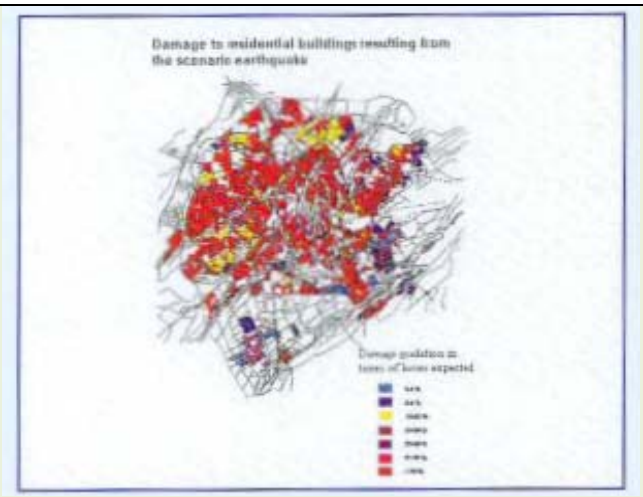
References:

- Hazards, disasters and your community: A primer for Parliamentarians published by GoI Ministry of Home Affairs National Disaster Management division.
- Disaster Management – The Development Perspective: An extract of the Chapter in the Tenth Five Year Plan Document (2002-2007)
- info.worldbank.org/.../Country%20Hazard%20Profiles/Country%20Hazard%20Profiles/India_Kumar.pdf
- UNISDR Terminology on Disaster Risk Reduction, 2009, published by UNISDR, Geneva, Switzerland, May 2009

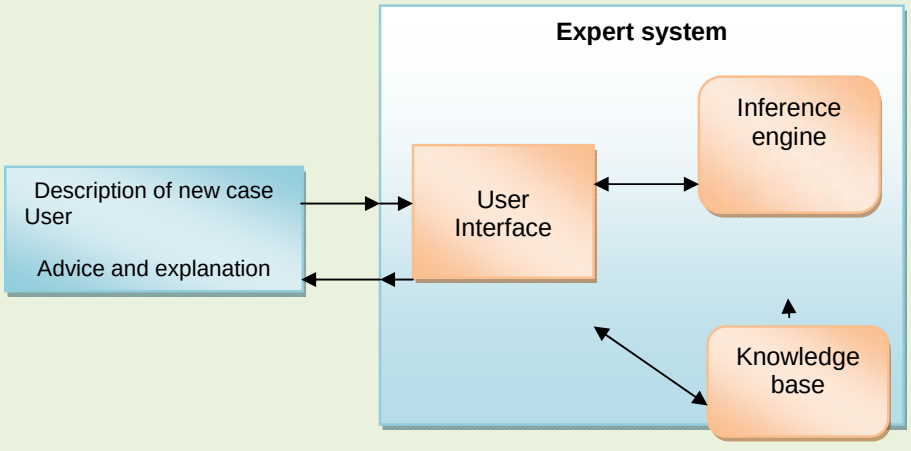
3.2 METHODOLOGIES FOR MULTI HAZARD RISK ASSESSMENT

The following section details out the common and existing methodologies used to conduct hazard risk assessments especially in the Indian context. Generic methods such as hazard mapping, GIS based assessment and Remote Sensing tools have been discussed. In addition tools that have been used for single or multi hazard risk assessment, hazard index and indices based monitoring and hazard zonation through GIS platform have been analysed.

Name of the method/ tool: **Radius: A simplified tool for earthquake risk assessment in urban areas (**Risk Assessment Tool for Diagnosis of Urban areas against Seismic disasters)	
Brief Description	The objective and purpose of this tool is to help the users in analyzing the seismic hazard and physical vulnerability of their cities to earthquakes. The tool allows the user to evaluate the seismic intensity and loss to infrastructure and life. Through its use the potential extent of damage and the potential vulnerable areas in a city can be identified. RADIUS is a web based tool using MS-Excel which allows risk mapping. The area of a city and probable loss to infrastructure and life is displayed as a mesh of rectangular cells that allows the user to get a graphical view of the data.

	 Visual display highlighting damage to residential building ***Source:*** *http://www.unisdr.org/preventionweb/files/2752_RADIUSRiskAssessment.*pdf This tool is good for preliminary investigation for seismic hazards and physical vulnerability but needs to be followed by further validation and more in depth studies. Steps of risk assessment process using RADIUS • It runs through MS Excel and the first step is to load the program in the CD-ROM drive and double click 'RADIUS. htm' • The quantitative input data mentioned below has to be inserted within the excel sheet. • The program then validates the input data and performs the risk analysis • The outputs are in the form of visual results and easily understandable
Application/ Utility	This is an urban area Earthquake risk assessment tool and useful for determining physical vulnerability of cities.
Geographical Scope	Urban municipalities
Inputs/ Resources/data	Inputs into the computer program: (Quantitative, one time input) • Shape of target regions by meshes • Total population and its distribution • Total building, building types (material types, usage, age, structural types and local building codes**)** and their distribution • Ground condition (topography, soil type, rock type, moisture absorption) • Total number of lifeline facilities (location, structure and attribute of railroads, highways, bridges and water, sewage, electric power and gas networks) • Choice of scenario earthquake and its parameters: Reoccurrence of past damaging earthquake or active fault earthquake is commonly assumed. The epicenter, magnitude, occurrence time (day or night) should also be determined
IT Infrastructure/soft ware required	MS-Office, Excel 97 A CD-ROM describing the RADIUS project and guidelines has been prepared and is available free of cost. The software can be collected by contacting the resource agency mentioned below.
Cost for resource input	Cost for collecting the data: Most of the information is available with the city administration and can be obtained for free. Scanning charges of resource maps

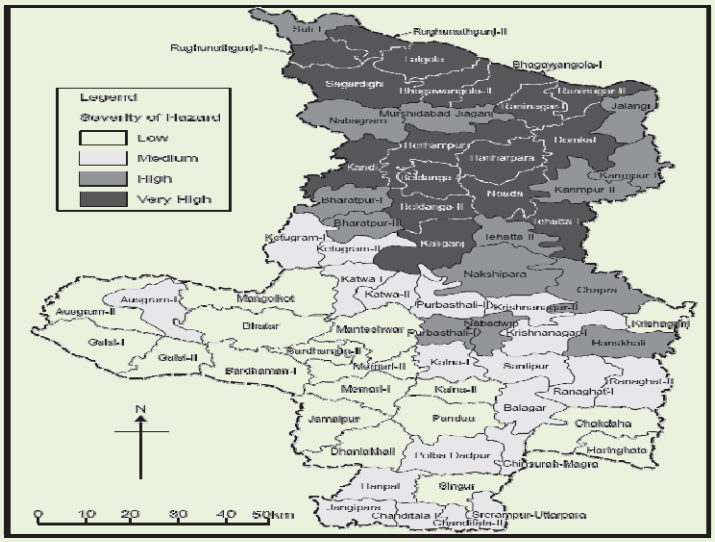
	are upto Rs 50/page. The tool can be used free of cost. The software can be collected by contacting the resource agency mentioned below.
Output/outcomes	Output from the analysis: • Seismic (ground shaking) intensity • Possible extent of building damage • Possible extent of lifeline damage • Casualties such as number of deaths and injuries • Summary tables and thematic maps showing the results
Analysis	The main advantage of this tool is that it is comparatively user-friendly and the software can be collected free of cost from RMSI. It is good for a rapid risk assessment for the urban municipalities. The main challenge lies with the availability of the specific data required for running the software. The time required for this assessment will be around 1-2 months, and cost will be minimal depending on availability of data with the user. It is run through a basic MS-Excel program which is widely available and intensive training is not required. The software provides detailed step by step instructions and guidelines. The resource agency responsible for developing the tool can also be contacted for technical support. More detailed analysis and GIS software may be useful for earthquakes in more fragile areas.
Resource Agency/ persons	Fumio Kaneko and Jichun Sun OYO Group Email:kaneko-fumio@oyonet.oyo.co.jp and sunjc@oyo.com.sg RMSI, India A8, Sector 16 NOIDA, Delhi 201301 PH: 0120 2511102 Email: india@rmsi.com
Reference details	http://www.gisdevelopment.net/application/natural_hazards/overview/nho0017.htm http://www.unisdr.org/preventionweb/files/2752_RADIUSRiskAssessment.pdf

Name of the method/ tool**:** Landslide Hazard Automated Zonation (LHAZ) system **: case study of Tehri Garhwal district, Uttarakhand**	
Brief Description	The landslide hazard automated zonation system is a hazard analysis method and has been developed to determine the intensity and extent of landslide hazard in a particular region. This system uses thematic maps of landslide contributing factors such as soil, lithology (The science which treats of rocks, as regards their mineral constitution and classification, and their mode of occurrence in nature.), topography and geology etc. Using an inference scheme it categorizes a region as different zones of landslide hazard into low, medium and high hazard. The system also generates a map of the landslide hazard zone. This method has been used to carry out landslide hazard zonation in the Tehri Garhwal district in Uttarakhand. The system uses knowledge base available in IS code 14496: 1998 and digitized thematic maps of the various factors leading to a landslide and consists of four modules based on their functionalities. The LHAZ system has been developed using thematic map based information and consists of four modules based on their functionalities. These are the input module, understanding module, expert module and the output module or decision module. The expert module contains the knowledge base and the inference engine of this system through which the landslide zonation is performed. Given below are the functions of these four modules: • Input model: The input model accepts the thematic maps in digitized form • Understanding module: this module interprets the input thematic maps and extracts information to be used for the next functional module i.e. the expert module. • Expert module: The expert module is used for getting decision using the knowledge base with the inference strategy. The knowledge base consists of expert information necessary to decide the intensity of the landslide hazard and the inference engine helps to an estimation of landslide hazard intensity. The expert module consists of the knowledge base and inference engine of the proposed system. Working of the Expert Module  • Output module: this provides a meaningful description of the intensity of landslide hazard prevalent in the region

	It is recommended to contact the resource agency before using the methodology. **Broad steps for undertaking LHAZ** The LHAZ primarily consists of three steps. In the first step data in the form of input thematic maps in digital form have to be put and the maps should be compatible with the understanding module. This can be done by providing the scanned images of input thematic maps and getting it converted into identical code for regions having similar thematic information. In the second step the program interprets input layers of information by means of matching algorithm. This is the understanding or interpretation module where the task of deciphering the meaning of this digital data is done, where the membership of each pixel scanned from the map is based on its proportionate intensity. The third step consists of decision making by the system in order to categorize region to different zones of landslide hazard. The system currently understands soil, lithology, rock type, relief and slope; land use and land cover characteristics from thematic maps.
Application/ Utility	The LHAZ is useful in carrying out landslide hazard risk assessment by categorizing the region into different zones of landslide hazard.
Geographical Scope	This system can be used in the State and District levels for assessing landslides zonation assessment. This assessment is appropriate for use at the district level.
Inputs/ Resources/data	The following input data will be required for undertaking the LHAZ. It is important to mention that a lot of data relating to the nature and composition of soil, land use pattern, land cover and also data on rainfall will be required to undertake the analysis. It is expected that most of the data can be collected from the district planning department. Data requirement: digitized and scanned thematic maps needs to be used. • Nature of data: For this area the features that were taken up for the landslide hazard study were soil type, rock type, relief and slope, land use land cover, rainfall and groundwater condition. The knowledge base works with these parameters where the region specific matching of attributes is done according to the prevailing conditions such as the soil being one of “clayey”, “sandy”, ”mixed” or “fluvial”; rock formations being “phyllite”, “quartzite”, “limestone”, “granite”, “shale” or “slate”. • Data Input: As a first step five thematic maps for soil, rock, relief and slope, land use and land cover (LULC) and rainfall of the Tehri Garhwal district at the scale of 1:1000,000 (were provided as input into the system. Source: These were obtained from the district planning series-index. • The system then produces a landslide hazard zonation map that classifies the landslide hazard into high, moderate and low hazard according to the selected area
IT Infrastructure/ software required	GIS software and hardware and trained manpower will be required for carrying out the program. The system has been developed at IIT, Roorkee and the technical support and training can be obtained for undertaking similar exercise. (see reference details)
Output/ outcomes	The exercise will provide Landslide hazard zonation maps according to high, moderate and low hazards.
Analysis	This method assumes a certain degree of technical expertise on landslide assessments and familiarity with the concepts and terms used. State and district governments can undertake this generation of a landslide hazard zonation map using

	the LHAZ as a fast alternative to detailed and advanced models that are available. The data requirements for this assessment are district level thematic maps which have to be digitized and scanned to put into the program. This is not expected to be expensive or resource intensive. In many cases digitized maps have already been prepared and available with National Remote Sensing Agency (NRSA) and Survey of India. This entire exercise should take 3-6 months depending on the availability of the maps. The program uses the Arc GIS software and trained manpower will be required to use the program. The user can undertake this with some technical support available at IIT, Roorkee. This is appropriate at the district level.
Cost for resource input	Scanned and digitized district level maps for various parameters at the scale of 1:1000,000. The conservative estimate for this activity is at a cost of Rs 1-2 lakhs through a GIS consultant. The maps are available with Survey of India at a scale of 1; 50,000 and cost approx. Rs 300 per sheet.
Resource Agency/ persons	**J.K.Ghosh** Assistant Professor, Dept. of Civil Engg., IIT Roorkee, India gjkumfce@iitr.ernet.in
Reference details	http://docs.google.com/viewer?a=v&q=cache:YCj2AKnQOCoJ:www.gndec.ac.in/~hsrai/civil/resources/conf/GOA/IACMAG08/pdfs/G07.pdf+Automated+system+for+zonation+of+landslide+:+case+study+of+Tehri+Garhwal+district,+Uttarakhand&hl=en&gl=in&pid=bl&srcid=ADGEESjHnyUGFTJIfo0DK7cpos-VcSVJwKnacDGBbaGth4uFrXliS3dcVg2b3OUOp34On7THAMIer1F40XXsVA6KcnyyBs_RKulfkwDLai4aWGsSTMW7jU1K3zffCnTWVEm7NIGH7Sb&sig=AHIEtbR6QBuJ5nOvTb1vHnA6OY4moP7bMw

Name of the method/ tool**: GIS based flood hazard mapping : case study from Gangetic West Bengal**	
Brief Description	This objective of the GIS based flood mapping method is to demonstrate that a moderate GIS resolution regional study would suffice to identify hazard prone and vulnerable zones. The benefit of using this method is that it is efficient and cost-effective for preparing flood hazard maps in data poor countries, particularly those under a monsoon regime where floods pose a recurrent danger such as India. This method is explained through the study which was done in the Gangetic West Bengal area. The unit of analysis in this case is an administrative unit -the development block and revenue villages for which census data on past floods, population and infrastructure are available. The data on past floods is available with the Irrigation and Waterways department (IWD). The district irrigation department also has archived reports and flood maps at a scale of 1:250000 which can be used for comparing and verifying data. The following steps need to be followed to come out with the final result. **1) Flood frequency mapping exercise**: Flood frequency is the most important factor determining flood hazard. The data is available with the IWD's annual flood reports in most states in India. This data is then used to produce a map depicting the frequency of flood occurrences in state. The block administration record usually reports entire parts of an area as inundated whereas only a part might have been actually affected. For this reason this flood frequency map has to be verified against the flood maps available with the district irrigation department. The regional flood frequency map obtained from the IWD does not depict the actual flood prone localities within each block, but usefully serves to identify those that should be prioritized for carrying out subsequent high cost and time consuming sub regional village-level studies. **2) Variables used for hazard mapping**: The next step is creating the hazard map for which hydrological data is integrated with socio economic indicators such as -- population density, road density and access to safe drinking water. The justification for choosing these three indicators is: population density is chosen as an indicator of the economic assets under potential flood threat, road density is an indicator of rapid evacuation measure during flood, and drinking water is an indicator of epidemic which occur post flood. This map is based on inundation maps prepared by the IWD, West Bengal.



2 3. The regional-scale map of flood hazard by development blocks in the Gangetic West Bengal study based on inundation maps prepared by IWD, West Bengal).

This choropleth map shows the flood hazard map for Gangetic West Bengal study

3) Weighting scheme for the composite hazard index:

The weighting scheme may be completed in 3 steps: (As depicted in tables below)

In order to depict the heterogeneity of different environmental and socioeconomic factors contributing to flood hazard, all the variables mentioned above (flood prone, population density, evacuation and epidemic) can be standardized and named.

Secondly, a knowledge-based weighting scheme may be applied to each of the four variables: indicators that represent a high level of dispersion across development blocks can be given more weight. In the case of West Bengal, the variable 'flood-prone' was attached to high importance because where the risk of inundation is very low the other variables cannot indicate or contribute to flood hazard. A scheme of progressive weighting was adopted based on the premise that flood hazard for a particular block increases in a nonlinear manner with the number of flood occurrences over the 10-year period. In other words, the hazard curve becomes progressively steeper at the higher values of 'flood prone'.

Table: Data used in deriving flood hazard variables and maps at regional scales.

Study scale	Suitable scale of representation	Hazard indicators	Hazard factor	Variable name	Source
Regional (development block level)	1 : 500 000	Number of flood occurrences 1991–2000	Risk of flooding	Flood-prone	IWD annual flood reports.
		Population density (persons km^{-2})	Economic assets under flood threat	Pop-den	Census of India, 2001
		Road density (km km^{-2})	Ease of evacuation and sending relief	Evacuation	District Statistical Handbook (1998)
		Access to safe drinking water (% of villages having no safe source)	Outbreak of a waterborne disease in the post-flood situation	Epidemic	District Statistical Handbook (1998)

	Table 2. Differential weighting (k) of 'flood-proneness'. Flood occurrence frequency (flood-prone) — Value of K 1–2 — 0.25 3 — 1.5 4 — 2.5 5 — 4.0 6 — 5.5 The final composite index of flood hazard was calculated as follows: $\text{Flood hazard index} = \text{st\_flood-prone} \times k + [\text{st\_pop-den} \times 1.4 + \text{st\_even} \times (-1.2) + \text{st\_epdm} \times 1]$ Where k is the weighing factor for the st_flood -prone In this case, the guiding principle for selecting these weights was to ensure the dominance of the 'flood-prone' in the composite index; different combinations of the weighting factors were applied to the data and the results studied before arriving at these. The resultant composite index can be modified moderately depending on local conditions. After the final flood hazard index is arrived at; it can be depicted with the help of a choropleth map (Figure above). (A **choropleth map** is a thematic map in which areas are shaded or patterned in proportion to the measurement of the statistical variable being displayed on the map, such as population density or per-capita income. The choropleth map provides an easy way to visualize how a measurement varies across a geographic area or it shows the level of variability within a region.)
Application/ Utility	Flood hazard mapping at the level of a block or village
Geographical Scope	Block level and village level
Inputs/ Resources/data	Data input: quantitative, maps, 10 year data Flood frequency mapping • Ten years flood reports from Irrigation and Water department (IWD) Data required for Hazard Mapping • Population density, road density and access to safe drinking water. Source: These data are available from the IWD annual flood reports, Census of India 2001 and District Statistical handbook 1998 for most states. Weighting scheme for the composite hazard index • Statistical analysis
IT Infrastructure/ software required	Arc GIS software and computer hardware, Statistical package, 2 consultants need to be hired if in house expertise not available: GIS expert and statistical expert
Cost for resource input	Cost for flood history maps and inundation maps and records: Normally the district and block administration have these data and can be bought at predetermined cost depending on the scale of map. However, these days RTI application can be filed under which the administration is obliged to give the data/map either scanned or photocopied and the cost for this can range from Rs 50- Rs 5000 depending on the

	scale of the map required. Other data inputs such as population density, access to water are available or can be downloaded from the district gazette and Census of India. The statistical expert and GIS expert will charge upto Rs 50,000 for the data analysis and preparing GIS maps depending on the scale. These costs are only indicative.
Output/ outcomes	Flood frequency map, composite hazard index and regional flood hazard classification map (choropleth map)
Analysis	This is a relatively technical method for flood mapping and assumes domain knowledge and familiarity with flood analysis by the user. The flood hazard mapping method can be used at the block and village level as a cheap alternative to expensive high resolution terrain data or remote sensing. The data required for this method are not very expensive to gather and are easily available. The disadvantage is that while It can be easily used as a first step for regional and sub regional flood hazard map creation to identify high vulnerable zones, for policy and flood response analysis, it requires follow up through cost and time intensive detailed village level analyses. Using a GIS interface is advantageous here because it not only generates a visualization of flooding but also allows for practical estimation of the probable hazard due to flooding. The other requirement for this method such as GIS software and experts and statistical expert are also easily available and not very expensive. Local universities and institutes can be used.
Resource Agency/ persons	Joy Sanyal and X.X. Lu Department of Geography, National University of Singapore, Singapore Correspondence: X.X. Lu (email: geoluxx@nus.edu.sg)

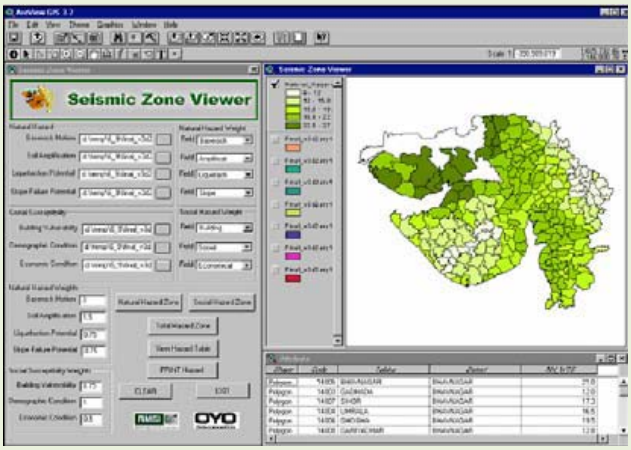
Name of the Methodology: Indicators for drought monitoring and composite drought index	
Brief Description	The traditional method of drought monitoring consists of obtaining information on the key indicators of drought from various Government departments. These indicators are rainfall, reservoir/lake water levels, surface water/groundwater levels, soil moisture and sowing/crop conditions from the revenue administration and other departments. This method is used by various state governments in India as specified by the Ministry of Agriculture and Cooperation, Government of India. The collation of data on these indicators provides a reliable representation of the severity and extent of drought in a state. This method depends upon the collection of various kinds of data corresponding to the indicators mentioned below. The data requirements are mentioned below: Rainfall: The actual rainfall is compared with the long term average which has been standardized on a daily, weekly and monthly basis. This comparison helps in providing information on the deficit or excess of rainfall in a particular sub division for a certain period. According to the IMD drought sets in when the deficiency of rainfall at a meteorological sub division level is 25% or more of the long term average in that sub division for a given period. Storage water levels in reservoirs: Reservoir storage level is a useful indicator of water shortage. Surface water and Groundwater level: Declining groundwater levels are important indicators of drought and a decline of above 4 meters is a stress situation.

	Sowing and crop conditions: An important indicator of drought is the total area sown. A delayed sowing shows rainfall deficiency and indicates the onset of drought. In addition to these indicators, a more scientific approach to drought management uses a number of indices to measure the intensity, duration, and spatial extent of drought. These scientific indices are useful for monitoring drought at the State and National levels. The indices are: Aridity Anomaly Index (AAI): This has been developed by IMD based on rainfall, potential evapotranspiration and actual evapotranspiration, taking into account soil moisture conditions and using the water budgeting method. The aridity anomalies are then classified into mild, moderate and severe arid. These anomalies are used for near real time monitoring and assessment of agricultural droughts across the country at weekly/fortnightly intervals. Standardised Precipitation Index (SPI): SPI is a drought index based on precipitation. The SPI assigns a single numerical value to the precipitation, which can be compared across regions and time scales with markedly different climates. Palmer Drought Severity Index (PDSI): PDSI indicates standardized moisture conditions and allows comparisons to be made between locations and months. PDSI varies roughly between -6.0 to +6.0. More wet conditions are show positive values while more dry conditions show negative values. PDSI values are normally calculated on a monthly basis Crop Moisture Index (CMI): The CMI complements the PDSI. It measures the degree to which crop moisture requirements are met, is more responsive to short term changes in moisture conditions and is not intended to measure long term drought. CMI is normally calculated with a weekly time step and is based on the mean temperature, total precipitation for each week and the CMI value from the previous week. Surface water supply index (SWSI): SWSI integrates reservoir storage, streamflow, and two precipitation types (snow and rain) at high elevations into a single index number. SWSI is relatively easy to calculate and it gives a representative measure of water availability across a river basin or selected region. Normalised Difference Vegetation Index (NDVI): NDVI is based on the concept that vegetation vigor is an indication of water availability or lack thereof. The lowering of vegetation index indicates moisture stress in vegetation, resulting from prolonged rainfall deficiency. Normalised Difference Wetness Index (NDWI): NDWI is expected to give the vegetation or crop turgidity or health. Higher value of NDWI signifies more surface wetness. Moisture Adequacy Index (MAI): The MAI is obtained from the weekly water balance. Drought impact is related to moisture availability at certain crop growth stages. Categories of MAI (severity) at different growth stages are integrated into a single index value to identify drought impact on a particular crop. The Central Arid Zone Research Institute (CAZRI), Jodhpur monitors agricultural drought in the arid regions by using MAI.

	No one indicator or index is adequate for monitoring drought at the state level, a combination of these have to be used for drought declaration. Mostly the combination of rainfall deficiency, the extent of area sown, NDVI, and MAI are used as standard monitoring tools by meteorologists and agricultural scientists for declaring droughts. Application of these indexes: Rainfall: is considered as the most important indicator of drought. A departure in rainfall from its long term. A departure in rainfall from its long term averages is used as a declaration of drought. Area under sowing: Sowing is an important indicator of the spread and extent of drought. The area under sowing provides reliable information on the availability of water for agricultural operations. Drought conditions could be said to exist if the total sowing area of *kharif* (summer crop) crops is less than 50% of the total cultivable area by the end of July/August, depending upon the schedule of sowing in different states. In the case of *Rabi(*winter) crops, the declaration of drought could be linked to the area of sowing being less than 50% of the total cultivable area by the end of November/December along with the other indicators. NDVI: The values obtained for a given NDVI always ranges from -1 to +1. A negative number or a number close to zero means no vegetation and a number close to +1 represents luxurious vegetation. For declaring drought, States need to obtain NDVI values through the NADAM's. The states can declare drought only when the deviation value from the normal is 0.4 or less. NDVI values however need to be applied in conjunction with other indicators. MAI: As mentioned before MAI values are calculated as the ratio (expressed in percentage) of Actual Evapo transpiration to potential Evapo transpiration following a soil water balancing approach during the cropping season. MAI values are critical to ascertaining agricultural drought.
Application / Utility	Drought Hazard Assessment method used to monitor and declare drought in the state
Geographical Scope	The indices and drought index can be calculated at the state level
Inputs / Resources	As mentioned above various kinds of data are required in order to calculate the index and monitor drought through indices. These are quantitative data, the scale ranges from tehsil/taluka/block to district and time series data is required. Rainfall: The rainfall data is collected by IMD and state governments and within the state Government the data is collected at the *tehsil/taluka* level. Storage water levels in reservoirs: State governments collect data on the levels of stored water in important reservoirs through their irrigation departments. Surface water and Groundwater level: The Central Ground Water Board (CGWB) is responsible for monitoring India's groundwater. State Governments also have similar groundwater boards and their periodical reports provide information upon declining groundwater levels.

	Sowing and crop conditions: The State Government agriculture department provides information on sowing on a weekly basis. Area under sowing: The agriculture departments in the State Governments provide data on cropping wise operations; it is generally available for all *talukas/tehsils*/blocks. NDVI: The National Agricultural Drought Assessment and Monitoring System (NADAM's)Instituted by the National Remote Sensing Centre (NRSC), issues a bi-weekly drought bulletin and monthly reports on detailed crop and seasonal condition during *kharif* season These reports present the NDVI and NDWI from the data obtained from the National Oceanic and Atmospheric Administration -Advanced Very High Resolution Radiometer (NOAA-AVHRR) and Indian Remote Sensing (IRS) satellite Wide Field Sensor (WiFS) data. These reports provide quantitative information on sowings, surface water spread and district/tehsil/taluka level/block level crop condition assessment along with spatial variation in terms of maps. For declaring drought, States need to obtain NDVI values through the NADAM's. 11 states—Andhra Pradesh, Bihar, Gujarat, Haryana, Karnataka, Maharashtra, Madhya Pradesh, Orissa, Rajasthan, Tamil Nadu and Uttar Pradesh are covered through these reports. The other states can receive these reports through approaching NRSC. MAI: MAI values are critical to ascertaining agricultural drought. The state agriculture department needs to calculate the MAI values on the basis of data available to it. Further data inputs required to calculate the different index are: ▪ **Meteorological Data** (Daily, weekly, and monthly rainfall, snow fall / fog); Source: IMD, National Centre for Medium Range Weather Forecasting, State Governments ▪ **Hydrological Data** (Water storage in reservoirs / ponds / lakes, river flow, groundwater level, yield and draft from aquifers, water loss through evaporation, leakage, seepage); Source: Central Water Commission, Central Ground Water Board, State Governments (irrigation departments, groundwater agencies, water resources departments/projects) ▪ **Agricultural Data** (Soil moisture, area under sowing and type of crop, crop water requirement, status of growth, crop yield, alternative cropping possibilities, Land holdings); Source: National Crop Forecasting Centre, Directorate of Economics and Statistics, Indian Council of Agricultural Research, Agricultural Census data, State Government agricultural department and agriculture universities ▪ **Satellite Data:** (Vegetation monitoring, rainfall, surface wetness and temperature monitoring); Source: NRSC ▪ **Socio-economic Data** (Availability and prices of food grains, availability of fodder, migration of population, distress sale of assets, vulnerable areas / population): Source: Planning Commission, Department of Food and Public Distribution, Department of Consumer Affairs, Department of Rural Development, Ministry of Women and Child Development, Department of Animal Husbandry, Dairying and Fisheries, Revenue Department of states
IT Infrastructure / software required	Statistical software package will be required for calculating the index and interpreting various data. The State Governments will have their own scientists and statistical experts to run and interpret the data. In

	case training is required agricultural universities at the state level can be contacted or commissioned.
Cost for resource input	Most of the analysis and reports are available free of cost from the various agencies mentioned and the State Government department and can also be obtained under the RTI Act. Software cost and personnel cost for running and analyzing the data will be required. Since the State Governments usually carry out drought monitoring and assessment, they have their own infrastructure and networks that are involved in drought monitoring. Experts such as Agricultural Scientists and Statisticians are required for this analysis and can be hired from universities and institutes.
Output / Outcomes	Composite Drought Index and Drought declaration, including Rainfall Deficiency, Area under sowing, Normalized Difference Vegetation Index (NDVI), Moisture Adequacy Index (MAI)
Analysis	The use of this method assumes a certain degree of domain specialization and understanding of the technical concepts for drought assessment by the user. This method can be used by State Governments/district and block administration due to the scale of the assessment and the multiple kinds of data required. Although the indices based monitoring is relatively fast and data sources easier to find, the composite index based monitoring is more accurate. The disadvantage of this method is the length of time required for data collection and data inputs required. Various experts are needed in order to calculate and analyse and interpret the data to arrive at the index. Support agencies and institutes are available (mentioned in detail above) such as the agriculture universities, ICAR, NRSC for providing data input and analysis. Given the diversity and the time series of data required, It will be difficult for individual and users outside of the Government to implement this method
Resource Agency / Persons	India Meteorological Department, Agricultural Meteorology Division, drought Research Unit National Centre for Medium range Weather Forecasting (NCMRWF) Central research Institute for Dryland Agriculture (CRIDA) Central Arid Zone Research Institute (CAZRI) Ministry of Earth Sciences
Reference details	Manual for Drought Management, Department of Agriculture and Cooperation, Ministry of Agriculture, GoI *agricoop.nic.in/DroughtMgmt/DroughtManual.pdf*

Name of the method/ tool: **Seismic Microzonation Through Geospatial Analysis: example of a seismic microzonation study carried out for certain areas in Delhi.**	
Brief Description	Seismic hazard and microzonation of cities is used to characterize the potential seismic areas that need to be taken into account when designing new structures or retrofitting the existing ones. Seismic hazard is the study of expected earthquake ground motions at any point on the earth. Microzonation is the process of sub division of region in to number of zones based on the earthquake effects in the local scale. Seismic microzonation is the process of estimating response of soil layers under earthquake excitation and thus the variation of ground motion characteristic on the ground surface. GIS is used as a tool to represent the all possible earthquake hazard parameters in the form of geographical maps, which is most useful for government agencies, non-governmental organizations, business communities and public for planning infrastructures developments, emergency preparedness and management. The microzonation can be used as a tool for GIS landuse planning, hazard management, structural engineering, and insurance purposes. The objective of this method is to identify areas for undertaking seismic microzonation with the help of recent advancements in geo spatial technology by the Economic and Social Research Institute (ESRI)*. ESRI's technology was used to create an application using Avenue programming with Arc View software at the background by RMSI known as – "Seismic Zone Viewer" to create seismic hazard zone maps of an area. Since seismic microzonation for large areas is very expensive, it is important to identify areas most prone to natural hazards. The geological/geotechnical and social parameters used in this method are: 1. Base Rock Motion 2. Soil Amplification 3. Liquefaction Potential 4. Slope Failure Potential 5. Building Vulnerability 6. Demographic Condition 7. Soio- economical Condition (See Annex for description of these factors)  The GIS application works through an overlay operation and creates separate social and natural hazard maps, along with creating an integrated map of the input parameters and finally divides the area into multiple Seismic zones. Users have the option to increase or decrease the weight age for any of the input parameters. RMSI developed an application named – "Seismic Zone Viewer" to create seismic hazard zone maps of an area. The application allows a user to modify the weightages as well as gives a facility to select or deselect any of the input layers to modify the hazard model for microzonation. The objective of this application was to create a user-friendly application to generate seismic hazard zone of any area. Steps to be followed: In order to use this software application the following datasets

have to be put depending on the administrative level for which microzonation has to be done. The application then does an overlay analysis and calculations for each input layers along with their respective weights. The data sets are:

a) Rank of Base Rock Motion
b) Rank of Soil Amplification
c) Rank of Liquefaction Potential
d) Rank of Slope Failure Potential
e) Rank of Building Vulnerability
f) Rank of Demographic Condition
g) Rank of Economical Condition

All the input data should have similar boundary conditions. Each of the above mentioned input should contain the rank for each of these layers at the administrative boundary.

Map Database: Maps have to be generated using satellite images and other input sources. The maps then have to be digitized and imported into shape files (ArcView file format) so that a GIS database can be generated.

The maps to be generated using the GIS application are:

Base Map: The base map includes administrative, geological, lineament and fault maps

Base Rock Motion map: This map is prepared on the basis of the base rock depth and geology

Soil Amplification map: This is generated by integrating geomorphology and soil characteristics

Slope Failure Map: This is prepared on the basis of slope of the study area

Liquefaction Potential Map**:** This is prepared on the basis of geology and ground water table of the study area

Building Vulnerability Map**:** This map is generated based on the building heights and the construction materials used in the buildings (kachha and Pucca Houses)

Demographic Map: This map is generated using spatial demographic data

Economic data: This is based on the economic and commercial condition of the administrative unit

The application created by RMSI is used for GIS Mapping and analysis and for the creation of the final microzonation map.

The application can also perform spatial analysis on selected input layers. Weightages need to be defined for each of the individual GIS layers mentioned under the maps above depending on their importance in the overall calculation of hazard. Based on a study carried out by RMSI, it has been found that in normal Indian conditions the weightages for each of the data layers are:

Factor	Item	Weight
Natural Hazard	1 Baserock Motion	3
	2 Soil Amplification	1.5
	3 Liquefaction Potential	0.75
	4 Slope Failure Potential	0.75
Social Factor	5 Building Vulnerability	0.75
	6 Demographic Condition	1
	7 Economical Condition	0.5

Based on the input parameters the application then generates three output maps:

	natural hazard zone map, social hazard zone map and earthquake microzonation map.
Application/ Utility	Seismic microzonation: hazard assessment application
Geographical Scope	Has the potential for being used in the urban municipalities.
Inputs/ Resources/data	Quantitative data and statistical data, one time ▪ Base rock motion ▪ Soil Amplification ▪ Liquefaction Potential ▪ Slope Failure Potential ▪ Building Vulnerability ▪ Demographic, economic and social Parameters- Socioeconomic character The following maps is also required using the GIS application: Base Map: The base map includes administrative, geological, lineament and fault maps Base Rock Motion map: This map is prepared on the basis of the base rock depth and geology Soil Amplification map: This is generated by integrating geomorphology and soil characteristics Slope Failure Map: This is prepared on the basis of slope of the study area Liquefaction Potential Map**:** This is prepared on the basis of geology and ground water table of the study area Building Vulnerability Map**:** This map is generated based on the building heights and the construction materials used in the buildings (kachha and Pucca Houses) Demographic Map: This map is generated using spatial demographic data Economic data: This is based on the economic and commercial condition of the administrative unit The application created by RMSI is used for GIS Mapping and analysis and for the creation of the final microzonation map.
Output/ outcomes	The output of the viewer is a map representing seismic hazard zone of the area based on the earthquake hazards and vulnerability factors of that area. • **Natural Hazard Zone Map:** This map was generated using Base Rock Motion, Soil Amplification, Liquefaction and Slope Failure maps. • **Social Hazard Zone Map:** This map was generated using Building Vulnerability, Economic and Demographic maps. • **Earthquake Microzonation Map:** The Natural Hazard and Social Hazard maps were further integrated to create the Earthquake Microzonation Map of Delhi.
Analysis	The advantage with this tool is visualization of each hazard layer as an individual, as well as in the combination of input layers. In this application a user can modify weightage of any map layer and can visualize the impact of that in an overall scenario. User has a facility to create the seismic zonation map using different combinations (only natural or only social parameters or a combination of both). User can modify any one of these layers or add new map layers as per their requirement. The application will be available with RMSI and their team can also be contacted for technical support or for conducting the hazard risk assessment. It will be a very cost intensive method and needs large budgets for carrying out the seismic microzonation.

	The disadvantage of this application is that it requires a large pool of data and for proper results detailed field based geophysical data and household surveys would be required. It also needs expertise in seismic hazards and GIS operation. Economic zone maps also should be generated from high resolution satellite image based on land use/land cover (LULC). Availability of data from the city administration, housing board, census and NRSA in itself is not very difficult but plotting the information over the base map and generating high resolution images for factors like slope failure are very expensive in nature.
IT Infrastructure/ software required	ArcView 3.2, Avenue was used as a programming language for the application
Cost for resource input	This software has been developed by RMSI on ESRI platform; they have to be contacted to carry out this process as the software is not available to outside agencies. It is estimated that using this method will be quite expensive. RMSI has different rates for per sq. km unit for different cities. Given the complex nature and diversity of data and Digital Maps required it is difficult to give an estimate of cost. The main cost for undertaking the activity would be in procurement of the following items Digital maps: For a city level, most maps will be available with NRSA and can be obtained at a nominal cost, the base map is available for Rs 100-200/map, land use pattern maps are available with the state Government departments free of cost Resource maps: At the city level resource maps can be bought at a conservative estimate of Rs 5,000-10,000/map, scanning charges for A4 size is approximately Rs 20-50 and is available from the city administration. GIS software/hardware: Simple GIS software is available at a conservative estimate of Rs 1 Lakh, in order to put the maps into a GIS development format and carry out the analysis, organizations such as ESRI and RMSI have to be contacted. Hiring of technical consultant: They may charge upto Rs 8000 per day assuming a national client. The entire GIS analysis from data collection to developing formats and analysis may cost Rs 10 lakhs or more.
Resource Agency/ persons	RMSI has been engaged in developing this software and can be utilized for conducting such studies. Their contact detail has been mentioned before. The Department of Science Technology and National Disaster Management Center is already engaged in undertaking such microzonation studies.
Reference details	http://www.rmsi.com/PDF/SeismicMicrozonation_Through_GeospatialAnalysis.pdf

*__ESRI__ is a software development and services company providing Geographic Information System (GIS) software and geodatabase management applications. The headquarters of ESRI is in Redlands, California. ESRI uses the name ArcGIS to refer to its suite of GIS software products, which operate on desktop, server, and mobile platforms. ArcGIS also includes developer products and web services.

Note: As part of the national level microzonation programme, Department of Science and Technology, Govt. of India has initiated microzonation of 63 cities in India (Bansal and Vandana, 2007). Some of them are finished and some of them are ongoing. As an initial experiment, seismic hazard analysis and microzonation was taken up for Jabalpur city in Madhya Pradesh. Further, for many other cities such as Sikkim, Mumbai, Delhi, North East India, Gauwhati, Ahmedabad, Bhuj, Dehradun and Chennai an attempt has been made to carryout microzonation considering geomorphological features and detailed geotechnical studies. Among the above Jabalpur, Sikkim, Gauwhati and Bangalore microzonation works have been completed. However, for Sikkim and Gauwhati, microzonation reports are already available and the report on microzonation of Bangalore is in the final stages which will be released within few months.

3.3 TOOLS AND PLATFORMS THAT CAN FACILITATE MULTI HAZARD RISK ASSESSMENT STUDIES

Name of the Method: **Multiple Hazard Mapping**	
Brief Description	Hazard Mapping is useful in establishing the location and extent to which a particular hazard is likely to pose a threat to lives, infrastructure and the economy of a region. While the probability of hazard occurrence will vary across regions, mapping is used to combine data on natural hazards with socioeconomic data for an area, in order to facilitate analysis. This helps in facilitating communication among participants in the hazard management process and between policy makers, planners and decision-makers. Two important techniques are in practice: ▪ Multiple hazard mapping, and ▪ Critical facilities mapping **Multiple hazard mapping**: Useful information on single natural hazards in a region may be available on maps with differing scales, coverage, and detail, but while conducting risk analysis these unrelated maps are difficult to use or in deciding on suitable mitigation measures. Information from these multiple maps can be combined in a single map to give a composite picture of the magnitude, frequency, and area of effect of all the natural hazards.
Application/ Utility	This is a multiple hazard assessment technique. It is an important criterion to plan for DRR options.
Geographical Scope	This technique can be used across multiple scales i.e. state, community, district levels. It is important to coincide hazard mapping with base maps for a region, as available with the Survey of India.
Inputs/ Resources/data	Usually, data over large areas for extensive time periods are collected by different processes e. g. Community knowledge, Surveys on historic events, Scientific investigation and research are gathered by different process. The processes are: • Existing resource surveys: Is a process of survey, used for identifying the available resources (natural, minerals, forests etc) over an area It is done for different purposes • Geologic survey: A geological survey is the systematic investigation of the subsurface of a given piece of ground for the purpose of creating a geological map or model. • Personal Reconnaissance: Reconnaissance is a mission to obtain information by visual observation or other detection methods about the meteorological, hydrographic, or geographic characteristics of a particular area. Depending on the purpose it can be done by a person or a technical team by physical observation or aerial survey • Flood Survey: In simple term, survey used to understand the situation of the flood affected area/areas • Photogrammetric mapping: Photogrammetric mapping is a methodology by which precision flown aerial photographs with accurate camera and ground control data are combined with digital data capture to produce planimetric, and topographic maps. • Orthophoto: An orthophoto is an aerial photograph planimetrically corrected. Orthophotographs have the positive attributes of a photograph such as detail and timely coverage, and the positive attributes of a map including uniform scale and true geometry. This enables orthophotographs to be used in their primary role as a backdrop on which map features can be overlaid. Orthophotos represent the primary use of remote sensing imagery • Aerial photograph: Aerial photography is the taking of photographs of the

	ground from an elevated position. The term usually refers to images in which the camera is not supported by a ground-based structure • Remote sensing: Remote sensing and Geographical Information system (GIS) provides vital tools which can be applied in the analysis at the district and as well, as the city level. Remote sensing becomes useful because it provides synoptic view and multi- temporal Land uses / Land cover data that are often required for mapping
IT Infrastructure/ software required	For putting hazards information on the base map (already available) different tools are used more common tools are GIS Softwares (Arc Info/ Map Info etc). Regarding manpower it requires a team with domain knowledge and conversant with software usages. Both these resources can be obtained from RMSI.
Cost for resource input	Cost will depend upon the size of the mapping area, for illustration purpose we have given costs for mapping an administrative block. The costs are only indicative and based on the process understanding for this tool. For practical use, one has to consult competent authorities for the actual costing. Resource surveys: The cost of resource survey depends on the type and nature of the survey. On a very conservative estimate it may range between Rs 1-5 lakhs Geological Survey: It is costly. A detailed exploratory geological survey over a block may cost near about a crore or even more. Personal reconnaissance: For visual observation, cost will vary. Involving a semi technical consultant can cost approximately Rs 15,000-Rs 50,000 and the cost for involving an organization or team can vary between Rs 50,000 to Rs 5 lakhs. For an Aerial survey the cost is likely to be more than Rs 10 lakhs (including air craft charges) Flood Survey: Cost will be similar as above Photogrammetric mapping, Orthophoto and Aerial photograph: To get Aerial photo graphs require permissions from Directorate General Civil Aviation [DGCA] India other necessary permissions. After getting these permissions the cost will include air borne platform and photo graph costs. Photographs may cost in the range of Rs 0.25-1 Lakh depending on the size of the block. But the cost of air borne platform will be additional and that depends on the type of aircraft. It is estimated to be very cost intensive. Survey of India, support aerial photography and another agency known as Swallow System in Gujarat support aerial photography(info@swallowsystems.com) Remote sensing: It may cost in the range of Rs 50000 to 5 lakhs depending on the size of the block. These are only rough estimates. Topo Sheets are available from Survey of India for Rs 100 per sheet. Digitized maps for few villages to a block will cost between Rs 1-5 lakhs. The non digitized maps will be available from Survey of India. **Details of topographic map available with Survey of India** • This is more detailed map and is widely used for planning and development purpose by the administrators and town planners. Scale 1:25,000 (coverage 7'30"x7'30", appx. Area 175 Sq Km). • District Planning Maps (Scale 1:250,000) (coverage 1°x1°, Appx. Area 11140 Sq Km) extremely useful map series for general planning

	In addition, Survey of India produces project maps specially prepared to serve the needs of project authorities. The scale and contour interval depends upon the nature of the terrain (country) and the purpose of the survey. Source: **(http://www.surveyofindia.gov.in/maps.html)**
Output/ outcomes	Multiple Hazard Map of required scale
Analysis	The main advantage of using this technique is in the way the output is presented. The visual representation through the map is easy to understand by all users. The main disadvantage is that the maps do not present any extra information but just present different hazards in one map. There are various ways of collecting data to be used in the map and the users can choose whichever way is suitable for them. Organisations such as NRSA, Survey of India, Government departments will already have time series data for different hazards, digital maps and socio economic data depending upon the geographical unit. The data can be obtained at pre designated prices from these organizations. It will be useful to engage institutes specializing in specific hazard studies such as IIT, Delhi or Roorke for the mapping process. The technique is useful for planners and policy makers and to promote convergence among different agencies working on disaster relief management.
Resource Agency/ persons	▪ Maps of India; www.mapsofindia.com ▪ Survey of India; http://www.surveyofindia.gov.in ▪ Building Materials Promotion Council(BMTPC);http://www.bmtpc.org/ ▪ NRSA ▪ Survey of India ▪ IIT-Delhi, Roorkee
Reference details	▪ Multiple Hazard Mapping; http://www.oas.org/dsd/publications/unit/oea66e/ch06.htm ▪ www.mapsofindia.com ▪ http://www.surveyofindia.gov.in ▪ http://www.bmtpc.org/

Name of the Method: Critical Facility[17] Mapping	
Brief Description	A Critical Facilities Map (CFM) is used in DRR scenario to convey to the specialists, planners and policy makers the location, capacity, and service area of critical facilities. Multiple numbers of such facilities can be presented at the same time. The CFM can be combined with a multiple hazard map to highlight the areas that require more information, those that require different hazard reduction techniques, and those that need immediate attention when a hazard occurs. The CFM may be used to discover facilities that require upgrading or expansion and to gauge the requirement of further development of existing facilities. In addition, any need for more (or better) hazard assessment becomes apparent
Application/ Utility	Hazard Mapping of critical facilities in any given geographical area for undertaking appropriate DRR measures
Geographical Scope	This technique can be used across multiple scales i.e. state, community, district levels. It is important to coincide hazard mapping with planning requirements of a region.
Inputs/ Resources/data	Critical facility data can be obtained from different agencies involved with infrastructure, resource surveys, community facilities, economic development, resource exploration, land use planning, emergency preparedness, geotechnical studies, disaster response. (explained in multiple hazard mapping section) In addition, data from other sources such as Census India, District Census Handbook etc all add value to the output. Further, remote sensing data over a particular location may also be useful (in place of data scarcity). It may be better to validate remote sensing data with ground survey.
IT Infrastructure/ software required	For putting Critical Facility information on the base map (already prepared by Survey of India), different tools are used such as GIS Softwares (Arc Info/ Map Info etc). Regarding manpower it requires a team with domain knowledge and conversant with GIS software usages. Depending on the scale of mapping the cost will vary. For a few villages upto a block Rs 1-5 lakhs may be required for preparing GIS Maps. Both these resources can be obtained from RMSI. (mentioned above)
Cost for resource input	Input data cost: Mapping cost: will vary depending on the scale, approximately Rs 1-5 lakhs will be required for block level GIS Maps
Output/ outcomes	Critical Facility Map of required scale
Analysis	The main advantages of making a CFM and combining it with a Multi Hazard Map (MHM) are inputs into hazard management. The map helps in pointing out critical facility that exists in hazard prone zones for decision makers to take appropriate actions. The CFM and MHM help in pointing out areas that need different assessments, emergency preparedness, immediate recovery, or specific vulnerability reduction techniques can be identified. Within a moderate budget a combined map may be developed at block level in hazard/multi hazard prone areas. This should cost approximately Rs 10-20 lakhs. Academic institutes such as IIT and organizations such as RMSI can be contacted for carrying out this exercise. The disadvantage of this technique is that the maps do not show the condition of the critical facilities and that has to be followed up by ground research.

[17] The term "critical facilities" means all man-made structures or other improvements whose function, size, service area, or uniqueness gives them the potential to cause serious bodily harm, extensive property damage, or disruption of vital socioeconomic activities if they are destroyed or damaged or if their services are repeatedly interrupted. (Source: http://www.oas.org/DSD/publications/Unit/oea54e/ch13.htm)

Resource Agency/ persons	▪ Maps of India; www.mapsofindia.com ▪ Survey of India; http://www.surveyofindia.gov.in ▪ Building Materials Promotion Council(BMTPC);http://www.bmtpc.org/ ▪ RMSI ▪ IIT-Delhi and Roorkee
Reference details	▪ Multiple Hazard Mapping; http://www.oas.org/dsd/publications/unit/oea66e/ch06.htm ▪ www.mapsofindia.com ▪ http://www.surveyofindia.gov.in ▪ http://www.bmtpc.org/

Name of the Technique: **GIS[18] tools for hazard mapping**	
Brief Description	GIS can be used for hazards management at different levels of development planning. A GIS platform presents a systematic means of combining various bits of information about a unit of geographic space. Huge volumes of data are compiled on various parameters and are presented through maps which reveal spatial relationships between different attributes. E.g. hazardous events, natural resources, and socioeconomic phenomena, and can thus help planners assess the impact of natural events on existing and proposed development activities. At the national level, it can provide a general overview of the study area, giving planners a reference to the overall hazard situation. At the regional level, it can be used in hazard assessments for resource analysis and project identification. And at the local level, it can be used to formulate investment projects and specific mitigation strategies. The following paragraphs show the use of GIS across different levels: ***Applications at the National Level*** GIS is typically used to classify geographical area based on the occurrence of natural hazards and determine the extent of risk posed by the hazard at the National level. At this level, location is a good indicator for the estimation of the overall hazard situation. Some of the categories which the GIS tool helps to mark out are: Areas that are relatively hazard free and suitable for development projects and areas where further hazard evaluations are required. In hazard-prone areas, GIS can be used to overlay hazard information with socioeconomic and physical infrastructure data such as population density, location of urban areas, ports, airports, roads, electricity network-for a preliminary quantitative assessment of people and property at risk. This information can be used to identify necessary structural and non structural measures, which can be used to reduce vulnerability and development planning. GIS also helps in identifying existing critical facilities, infrastructure, and population in high-risk areas which is useful for vulnerability assessment for effective DRR. ***Applications at the Regional Level*** GIS can be used for a more detailed study of the hazard profile and constraints and the development potential in selected areas. Information collected at the national level through GIS is substantiated at regional levels with more detailed mapped and tabular data. Typically, national-level information is complemented at the regional level with more comprehensive mapped and tabular data. These data can be in the form of: multi hazard assessments, including use of remote sensing information (i.e., aerial photographs and satellite imagery), preparing maps showing floodplain boundaries, landslide areas, seismic zones and tsunami-susceptible areas, and soils, topography, land use, water resources, lifeline network, and density of population and structures. This information can be used to correlate natural hazards to physical infrastructure

[18] GIS consists of hardware and software tools that use specific methods to perform operations on a database. A GIS offers a great number of tools for analyzing the information in a spatial database. When users wish to make a query or review a theme related to a spatial phenomenon, they can use a GIS to derive new information by creating a model that performs the analytical procedures. This process, which is known as spatial analysis, is useful for evaluating suitability and capacity, estimating and predicting, and interpreting and understanding. There are many kinds of spatial analysis in a GIS, including contiguity analysis, proximity analysis, demarcation operations, surface analysis, network analysis. These different forms of analysis include combined relational and spatial operations, as well as logical operations. (Source: *en.wikipedia.org/wiki/Geographic_**information**_system)*

	and lives in an area and carry out in depth analysis. Similar to the national level, the vulnerability of existing infrastructure, economy and human settlements can be determined, to aid disaster management planning. Areas where GIS can be used at the regional level are: • Guidance on land use and intensity. • Preparation of hazard mitigation projects to reduce risk on currently occupied land. • Identification of investment projects and preparation of project profiles showing where hazard mitigation measures (flood protections, earthquake resistant structures, etc.) must be taken into account in the design. ***Applications at the Local Level*** GIS can be used at the local level to determine the feasibility of formulating projects and to locate vulnerable critical lifeline networks for emergency preparedness and disaster mitigation activities. The presence of hazards should affect the site selection, engineering design, and economic feasibility of investment projects. Critical Lifeline networks are the most important elements of an area which should be made least vulnerable to hazard or be given top priority for rehabilitation or reconstruction following a disaster. The main lifeline networks in any area are: ▪ Ports and airports; ▪ Hospitals, health centers, medical posts ▪ Police stations, fire stations ▪ Schools, universities, auditoriums, convention centers ▪ Energy infrastructure and supply system, including pipelines and transmission lines
Application/ Utility	GIS tools can be used for multi hazard assessment and management
Geographical Scope	The GIS tool can be used to assess and prioritize hazards at the National, State and district levels
Inputs/ Resources/data	GIS software is compatible with satellite and remote sensing data. Based on requirements data input may vary and it may require various data bases. Usually, the information to be assembled in a GIS format for hazards management will be determined by the geographical scope of application (national, regional, or local) and by the analysis which is required: natural hazard assessments, vulnerability assessments, disaster preparedness and response, or post-disaster relief and reconstruction activities. In general, there are three different categories of information: ▪ Natural hazards information: In order to gather information related to natural hazards the data inputs should typically comprise: the location, severity, frequency, and probability of occurrence of a hazardous event. Location is the easiest for planners to find; the rest can often be obtained from sectoral agencies, natural hazard research and monitoring centers, and, increasingly, integrated development planning studies. Data on natural phenomenon can also be obtained from The Indian Meteorological Department (IMD), weather forecasting stations set up across states, National Centre for Medium-Range Weather Forecasting (NCMRWF) ▪ Information on natural ecosystems such as slopes and slope stability, river flow capacity, vegetation cover also has to be obtained. These help in estimating

	the effect natural hazards can have on environmental services provided by the natural ecosystems and also determines the factors or conditions that create, modify, accelerate, and/or retard the occurrence of a natural event. These can be gathered from the Irrigation department, agriculture department and forest department at various levels. ▪ Information on population and infrastructure, which is the basis for quantifying the impact natural events, can have on existing and planned development activities. Large-scale data describing lifeline infrastructure, socio economic data and human settlements, for example, are critical elements for preparing vulnerability assessments and for initiating disaster preparedness and response activities. These are available from the district census handbook and www.indiastat.com upon yearly membership of upto Rs 40,000.
IT Infrastructure/ software required	GIS Softwares (Arc Info/ Map Info/ Erdas Image etc) In order to use the GIS software there must be sector experts and software usage knowledge. Experts from local universities or disaster management institutes can be used for GIS Analysis. Resource Agencies such as ESRI, RMSI can be contacted for GIS analysis.
Cost for resource input	Cost including software and others will range between Rs 10-15 lakhs Recurring expenses will include manpower, infrastructure, data bases, maintenance etc.
Output/ outcomes	Requirement based ▪ Hazard/ Multi Hazard Map of required scale ▪ Critical Facility Map of required scale ▪ Land use pattern
Analysis	There are big advantages of using GIS based natural hazard assessments. The main one being higher quality results than those that can be obtained manually. Though there is an investment involved in terms of the GIS software and hardware and associated manpower, many resource agencies are available (ESRI, RMSI) who can be utilized for this exercise. Also very expensive equipment and technicians can be avoided by proper selection of a system and its application. Its disadvantage is that it is not a mapping tool and its application will depend on the available data. Users and planners need to evaluate their need for a GIS based analysis based on their hazard assessment requirement. It is very useful to use GIS when multiple layers of data have to be superimposed in order to carry out hazard risk assessment and large areas are involved. This method is data intensive, relatively expensive and needs skilled manpower.
Resource Agency/ persons	Economic and Social Research Institute (ESRI) NIIT GIS Limited B-1/H-9, MCIA, Mathura Road New Delhi - 110044, India Phone: +91 (11) 4057-0700, 701 Fax: +91 (11) 4057-0516 RMSI (mentioned before)
Reference details	▪ Global Information System, en.wikipedia.org/wiki/Geographic_information_system ▪ www.mapsofindia.com ▪ http://www.surveyofindia.gov.in ▪ www.esri.com ▪ www.erdas.com ▪ Geographic Information Systems In Natural Hazard Management http://www.oas.org/DSD/publications/Unit/oea66e/ch05.htm

Name of the Tool/: **Remote Sensing[19]: Aerial Photography**	
Brief Description	Different types of satellite are used for the earth's observation and they vary on the area they see and the frequency of observation. Two complementary types are particularly relevant to disaster management. Polar-orbiting satellites fly in a relatively low orbit (often at around 1000km above the ground), providing relatively high spatial resolution. But they collect data over the same point once every few days. Geostationary satellites are positioned at a much higher altitude (about 36,000km). They orbit the Earth at the same speed as the Earth rotates on its axis, in effect remaining stationary above the ground and viewing the whole earth disk below. Their spatial data is much coarser, but is collected at the same point every 15 minutes. Each satellite carries one or more sensors on board that take measurements in different wavelengths. Many are useful for disaster monitoring — thermal sensors spot active fires, infrared sensors can pick up floods, and microwave sensors (that penetrate clouds and smoke) can be used to measure earth deformations before and during earthquakes or volcanic eruptions as given below. The Ariel Photography is useful for hazard identification and warning and disaster mitigation, preparedness, response and recovery
Application/ Utility	This method is useful for multi hazard identification at different levels
Geographical Scope	The satellite imageries can be used for every geographical scale ranging from community to global regions.
Inputs/ Resources/data	It generates various data from the images that it is able to capture. No input is required.
IT Infrastructure/ software required	It requires high resolution, sophisticated sensors operating in visible, Infrared and microwave region at various wavelength/frequency with data transmitting facility at the satellite level and at surface a data receiving, analyzing and storing facility is required (known as Earth's Station). In the process it requires sophisticated hardware, softwares and other tools. To analyze satellite data it requires highly trained manpower with specific domain knowledge. Special arrangement (at national level) is required in terms of Hardware, Software and manpower for developing a team.
Cost for resource	It will be cost effective to procure satellite imagery data from different agencies involved in the area such as National Remote Sensing Centre (NRSC). The cost

[19] Remote sensing by satellite (RS) refers to the viewing of the earth's surface using sensing devices fixed onto satellites in orbit. Such data have already proved useful in predicting hazards. It refers to the process of recording information from sensors mounted either on aircraft or on satellites. The technique is applicable to natural hazards management because nearly all geologic, hydrologic, and atmospheric phenomena are recurring events or processes that leave evidence of their previous occurrence. Revealing the location of previous occurrences and/or distinguishing the conditions under which they are likely to occur make it possible to identify areas of potential exposure to natural hazards so that measures to reduce the social and economic impact of potential disasters can be introduced into the planning process.

Aerial remote sensing is useful to natural hazard management for focusing on priority areas, verifying small-scale data interpretations, and providing information about features that are too small for detection by satellite imagery. Among the available airborne systems, the most useful for natural hazard assessments and integrated development planning are:

- Aerial Photography and
- Satellite Imagery with different sensors

(Source: *en.wikipedia.org/wiki/Global_Positioning_System)*

input	will vary a lot depending on the scale of analysis. For satellite imagery at a block level the cost will be Rs 5-10 lakhs.
Output/ outcomes	Satellite Images of different hazards in real-time situation is available. In addition different sets of data on weather, atmosphere and climate, geology, hydrology is available.
Analysis	The main advantage of using Remote Sensing data/imagery is that they are the best resources available to date for identification of hazards. However only specialized Government agencies have the permission and resources to use remote sensing. It is a very expensive method to use.
Resource Agency/ persons	▪ Indian Space Research Organization (ISRO), www.isro.org ▪ National Remote Sensing Centre (NRSC), Hyderbad; www.nrsc.gov.in/ ▪ India Meteorological Department(IMD); http://www.imd.gov.in/ http://www.imdpune.gov.in/ ▪ Space Aplication Centre (SAC) Ahmedabad http://www.sac.gov.in/
Reference details	▪ Remote Sensing In Natural Hazard Assessments, www.oas.org/DSD/publications/Unit/oea66e/ch04.htm ▪ Remote Sensing for Natural Disaster Facts and figures; http://www.scidev.net/en/features/remote-sensing-for-natural-disasters-facts-and-figures.html ▪ www.isro.org ▪ www.nrsc.gov.in/ ▪ http://www.imd.gov.in/ http://www.imdpune.gov.in/ ▪ http://www.sac.gov.in/

3.4 CONCLUDING REMARKS

This section looked at a range of methods, tools and techniques which are primarily in practice for conducting hazard risk assessment in the Indian context. Methods and techniques that are used to analyse both multi hazard and single hazard events have been discussed.

The existing methods, tools and techniques for conducting hazard risk assessment in India have been discussed. In particular the commonly used methods are:

- **Hazard mapping** which is the process of establishing geographically where and to what extent particular phenomenon is likely to pose a threat to people, property, infrastructure and economic activities. Within this multiple hazard mapping and critical infrastructure mapping have been discussed whereby multiple hazards and the risk that it poses to people, infrastructure and the economy is demonstrated. This tool can be used across different geographical level and is not very expensive. The basic input for this tool is maps of various variables and data relevant to the hazard being mapped. Critical infrastructure mapping looks at the risk to an areas critical lifeline support from natural hazards, and the output is useful for planners for effective DRR program.
- The use of **GIS tools** for hazard assessment is extremely useful for accurate depictions and is increasingly being used by Government agencies and other

users. The GIS can be used for hazards management at different levels of development planning. At the national level, it can provide a general familiarity with the study area, giving planners a reference to the overall hazard situation. At the regional level, it can be used in hazard assessments for resource analysis and project identification. And at the local level, it can be used to formulate investment projects and specific mitigation strategies. While this is a slightly expensive technique to use and requires skilled personnel to carry out the GIS analysis, there are many institutes that are engaged in developing software's and carrying out GIS analysis. Individual consultants can be contacted for making GIS Maps and analysis. In order to run the GIS program a software (Arc GIS) is required and that is easily available.

Specific hazards such as floods and earthquakes have been mapped and analysed using GIS platforms. These methods need domain knowledge and specialization and are often cost intensive, the input data are usually thematic maps of various parameters which are available with various Government departments and institutes. These have to be scanned and digitized and then analysed using GIS softwares. A GIS based system for landslide hazard zonation shown through a case study in Uttarakhand has been discussed; while the data requirements and level of technical skill required to use this method is high, with the support of resource agencies such as IIT it is possible to use this method. State and district governments can undertake this generation of a landslide hazard zonation map using the LHAZ as a fast alternative to detailed and advanced models that are available.

- The other **specialized web based tool** such as RADIUS is used by urban municipalities to carry out the cities earthquake risk assessment. The main advantage of this tool is that it is comparatively user-friendly and the software can be collected free of cost from RMSI. It is good for a rapid risk assessment for the urban municipalities. The main challenge lies with the availability of the specific data required for running the software.

- Hazard Mapping techniques are most commonly used in India to carry out hazard analysis. Another method for hazard assessment is the **composite risk index and indices for monitoring hazards** which has been discussed in the case of drought management in India. This method is used by the Ministry of Agriculture to monitor and declare drought in the country. This does not use expensive technology or software and is dependent on time series data collected by different Government departments and specialized institutes for multiple variables. The disadvantage of this method is the length of time and data inputs

required and that various experts are needed in order to calculate and interpret the data to arrive at the index.

- Lastly, the **use of Remote Sensing and satellite imagery** for hazard assessment has been discussed. Remote Sensing is useful for disaster monitoring — thermal sensors spot active fires, infrared sensors can pick up floods, and microwave sensors (that penetrate clouds and smoke) can be used to measure earth deformations before and during earthquakes or volcanic eruptions. They are very useful for carrying out Hazard Identification and Warning; Disaster Mitigation, Preparedness, Response and Recovery. It requires high resolution, sophisticated sensors operating in visible, Infrared and microwave region at various wavelength/frequency with data transmitting facility at the satellite level and at surface a data receiving, analyzing and storing facility is required (known as Earth's Station). In the process it requires sophisticated hardware, softwares and other tools. To analyze satellite data it requires highly trained manpower with specific domain knowledge. Special arrangement (at national level) is required in terms of Hardware, Software and manpower for developing a team. As a result it is not possible to use this method frequently because of its cost and highly skilled personnel requirements. In such a case satellite images can be used, though the cost will vary depending upon the scale of analysis.

Methodologies for Risk Analysis

4.1 INTRODUCTION

There exist two elements essential for assessment of risk: the probability of occurrence for a given threat – **hazard**; and the degree of susceptibility of the element exposed to that source – **vulnerability**. The disaster or the natural hazard is dependent on the characteristics, probability and intensity of the hazard, as well as the susceptibility of the exposed elements based on physical, social, economic and environmental conditions.

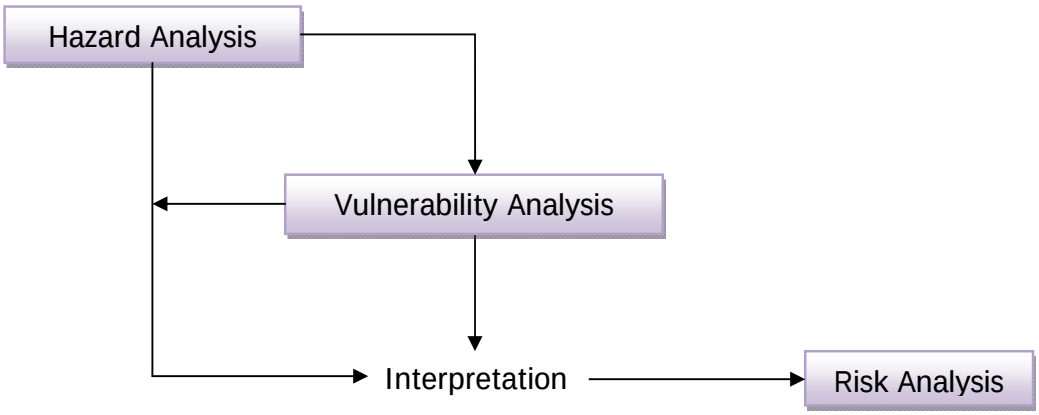


Figure 4.1: ***Risk Analysis***

Vulnerability has been included as a key element in the risk equation as a result of the growing interest in linking the positive capacities of people to cope, withstand and recover from the impact of hazards. It is reflective of a sense of the potential for managerial and operational capabilities to reduce the extent of hazards and the degree of vulnerability. This awareness is reflected by the incorporation of capacity in the risk equation:

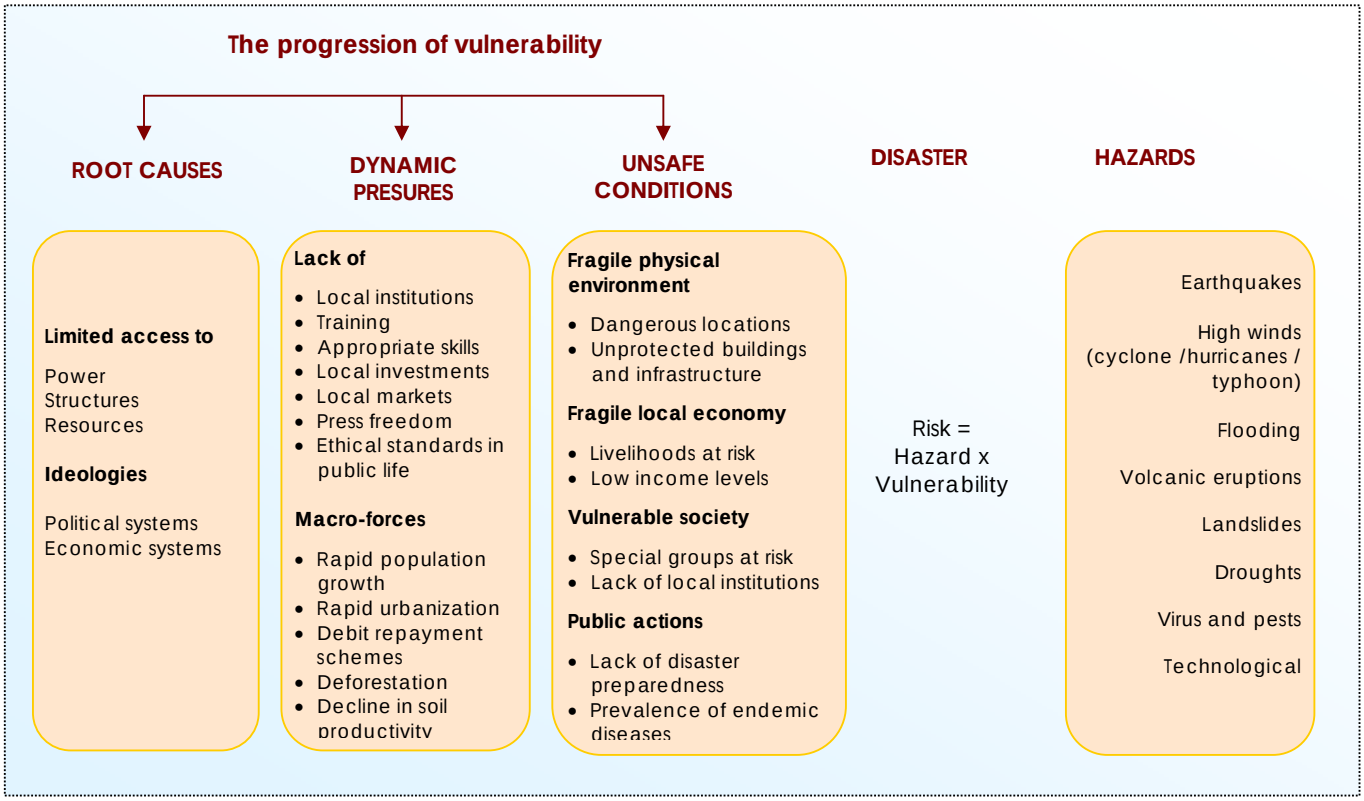
$$\text{Risk} = \text{Hazard (H)} \times \text{Vulnerability (V)} / \text{Capacity (C)}$$

or

$$\text{Risk} = \text{function of (H and V / C)}$$

The basis of the vulnerability analysis in relation to different natural hazards is mainly derived from the *Pressure and Release Model* and the *Access Model*. The models have been presented in the figure below. These models link the vulnerability

conditions with dynamic processes at different scales, as well as different access to resource profiles.



Source: Blaikie et al., 1994

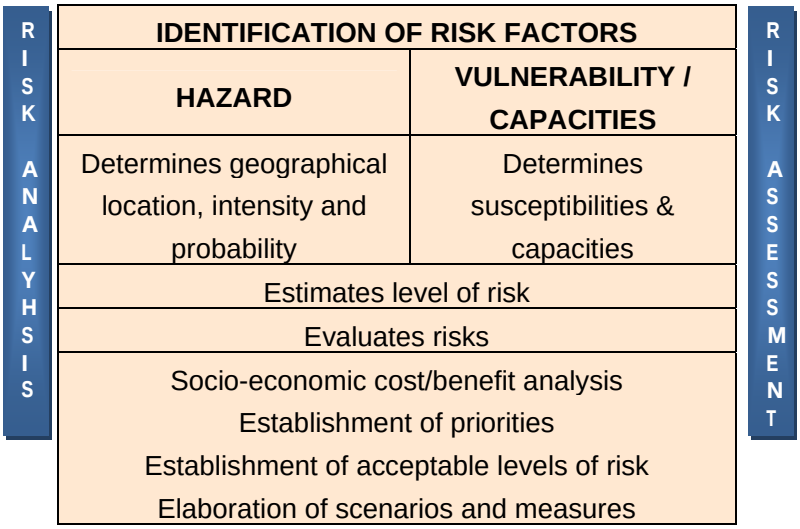
4.1.1 Risk Assessment

Risk assessments include quantitative and qualitative information as well as an understanding of risk, its physical, social, economic, and environmental factors and consequences. It serves as the first step for any other disaster reduction measure.

The systematic use of available information to determine the likelihood of certain events occurring and the magnitude of their possible consequences is included within the concept of risk assessment. It includes the following activities, within the overall process:

- Identifying the nature, location, intensity and probability of a threat
- Determining the existence and degree of vulnerabilities and exposure to the threat
- Identifying the capacities and resources available
- Determining acceptable levels of risk

The analytical phases involved in risk assessment include some of the basic tasks for risk management. The following diagram shows the basic stages undertaken in a risk assessment process.



The identification of hazards usually constitutes the departing point for the risk assessment process.

Hazards as well as vulnerability / capacity assessments utilize formal procedures that include collection of primary data, monitoring, data processing, mapping, and social surveys techniques. In the case of hazard assessment, there is involvement of high technological developments for monitoring and storing data of geological and atmospheric processes usually, whereby the assessment activities are mostly restricted to a scientific community. On the other hand, more conventional methodologies and techniques are used for vulnerability and capacity assessments, by which the community at risk also plays an active role, such as in community-based mapping.

Beyond the above mentioned particularities, hazard and vulnerability / capacity assessment follow a set of formal procedures that are generally captured under the concept of **risk analysis**. Effectively, risk analysis constitutes a core stage of the entire risk assessment process by means of providing a relatively objective and technical information from which to estimate levels of risk.

The information produced by technical risk analysis allows for the establishment of impartial government policy, resources needed for disaster preparedness, and insurance schemes. But, a different range of value judgments are usually taken into account from the estimated levels of risk to the determination of acceptable levels of

risk. Socio-economic cost / benefit analysis usually lead to the establishment of priorities that in turn help to draw levels of acceptable risk. These levels are largely dependent on government, community priorities, interests and capacities. At this stage, the more subjective trade-offs of quantitative and qualitative approaches to risk assessment need to be sorted out.

The disaster **risk reduction** is governed by the distinction between **risk assessment** and **risk perception**. Risk perception may be included in the assessment process in some cases, as in vulnerability / capacity assessment exercise, by incorporation of people's own ideas and perceptions on the risks they are exposed to. The breach between the information produced by technical risk assessments and the understanding of risk by people is widened by the wider and increasing use of computer assisted techniques and methodologies – such as those involved in Geographic Information Systems (GIS).

Therefore, at the various individual, community and institutional scales, the acceptable levels of risk vary according to the relative contribution of views on objective risk versus perceived risk.

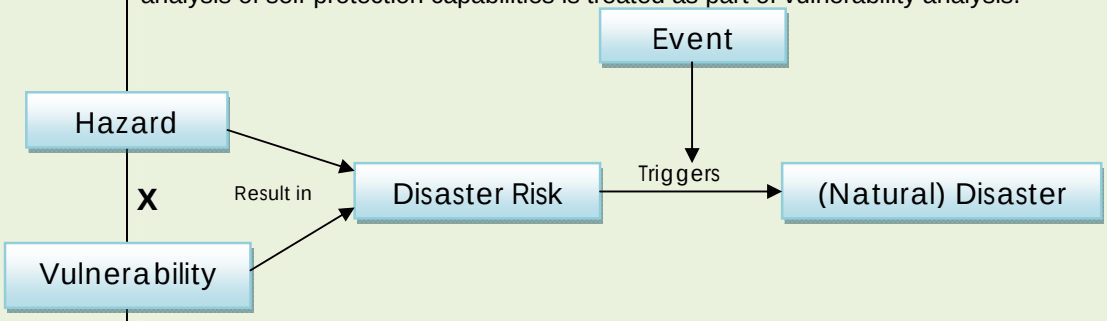
4.2 METHODOLOGY FOR RISK ASSESSMENT

Name of the method/ tool : **Community-Based Risk Screening Tool - Adaptation & Livelihoods (CRiSTAL)**	
Brief Description	The Community-based Risk Screening Tool – Adaptation and Livelihoods (CRiSTAL) is a decision support tool that is based on the Environmental Impact Assessment (EIA) methodology and the Sustainable Livelihoods Framework (SLF). Community-level projects influence climate vulnerability and adaptive capacity. For example, projects encouraging dependence on a particular technology or crop species may be negatively affected by climate change increase the local vulnerability. Conversely, projects that promote resilient crop species, diversified livelihood activities, and risk reduction activities (such as seed banks, storage facilities, early warning systems) increase the local adaptive capacity. Without a specific method for assessing the impacts of a project on some of the local determinants of vulnerability and adaptive capacity, project planners and managers find it difficult to design activities that foster adaptation to climate change. CRiSTAL aims to provide a logical, user-friendly process to help the users better understand the links between climate-related risks, people's livelihoods, and project activities. CRiSTAL was developed in response to the outcomes of Phase 1 of the Livelihoods and Climate Change project, which examined how ecosystem management and restoration (EM&R) or sustainable livelihoods (SL) projects reduced community vulnerability to climate stress. Projects that secured the local natural resource base, reduced exposure to climate hazards and diversified livelihood activities had, in many cases, increased community resilience to a range of threats, including climate change. In effect, these projects contributed to climate change adaptation. By focusing on community-level projects, CRiSTAL promotes the

	development of adaptation strategies based on local conditions, strengths and needs. The Goal of CRiSTAL is to promote the integration of risk reduction and climate change adaptation into community level projects. CRiSTAL is designed to provide a basis for improving community- and project-based decision-making so that adaptation opportunities can be maximized, and mal-adaptation minimized. It is expected to be relevant in project design as well as project evaluation. The tool is organised into two modules, each containing a set of framing questions. The first module called, Synthesizing information on climate and livelihoods, is designed to help users collect and organise information on the climate and livelihood context of the project area, preferably through stakeholder consultations and other participatory methods. The information gathered and organised in Module 1 provides a basis for the analysis undertaken in Module 2. **Module 1: Synthesizing information on climate and livelihoods** **Goal:** To help collection of data and organize information on the climate and livelihood context in the project area **Methodology:** Project planners and managers gather information through stakeholder consultations, participatory workshops, site visits, document review, Internet research, and interviews. The second module, called Planning and Managing Projects for Climate Adaptation, is to be completed by project planners and managers with input from relevant stakeholders. It uses the information from Module 1 to help project planners and managers understand how project activities affect livelihood resources that are either vulnerable to climate risk or important to coping strategies. In doing so, users can try to (re)design project activities so they maximize opportunities for enhancing adaptive capacity. **Module 2: Planning and Managing Projects for Climate Adaptation** **Goal:** To help analyse the links between planned or ongoing projects and the climate-livelihood context. **Methodology:** Project planners and managers carry out analysis individually or through small project staff meetings. Users also rely on additional stakeholder inputs to assist with the analysis, such as community leaders, researchers, partner organizations. At a minimum, users are encouraged to share proposed project adjustments with stakeholders for feedback.
Application/ Utility	CRiSTAL is a decision support tool developed jointly by the International Institute for Sustainable Development (IISD), the International Union for Conservation of Nature (IUCN), the Stockholm Environment Institute in Boston (SEI-US) and the Swiss Foundation for Development and International Cooperation (Intercooperation). Specifically, CRiSTAL is intended to help project planners and managers to: ▪ Systematically understand the links between local livelihoods and climate

	▪ Assess a project's impact on livelihood resources important to adaptation ▪ Devise adjustments that improve a project's impact on livelihood resources important to adaptation
Geographical Scope	The tool is intended for community-level project designers and managers. The tool can be used for local community level assessment.
Inputs/ Resources/ Data	For the two modules of the method, data requirements are as follows: **Module 1: Synthesizing information on climate and livelihoods** Data required on two major areas: What is the climate context of the project? Data required includes relevant (regional, national, eco-zone) information on climate change, as well as information on local climate hazards, impacts etc. What is the Livelihood context of the project? Data input required would be like available livelihood resources (natural, physical, financial, social, human resources) and project information. **Module 2: Planning and Managing Projects for Climate Adaptation** Data required are on two major areas: What are the impacts of project activities on livelihood resources that are: – vulnerable to climate risk – important to coping strategies How can project activities be adjusted to reduce vulnerability and enhance adaptive capacity in the project community?
IT Infrastructure/ software required	Computer required and a basic understanding of Microsoft Excel. Microsoft Excel™ is required to run CRiSTAL. One can download the CRiSTAL tool and the User's Manual by going to: http://www.cristaltool.org/content/download.aspx .The manual is presently available in English, Spanish and French languages. The application of methodology would also require the use of data entry software like CS Pro and use of statistical packages like SPSS and STATA. The information gathered using PRA technique will require content analysis using N Vivo/ Atlas Ti software.
Cost for resource input	The tentative cost of inputs required for using the methodology are: ▪ Questionnaire : Rs 250-600 per sample/ household + Consultancy fee of the data collection firm ▪ PRA/Focused Group Discussions (FGD) : Rs.1,00,000 per PRA / FGD exercise per village ▪ Analysis using N Vivo/ Atlas Ti software: Up to Rs. 50,000 ▪ SPSS & STATA software : Ranging from Rs 2,00,000 (single user) to Rs. 5,00,000 (multi user) ▪ CS Pro: Downloadable free of cost from the internet but may need customization as per needs of data entry. The consultant may charge Rs. 10,000 to 50,000 for making such changes. ▪ Environmental Data: Available free for the use by government agencies from IMD and IITM ▪ Census data : Available in the census CD (less than Rs 1000 per CD) ▪ Demographical Data : Available from Indiastat (Subscription more than Rs 50,000) ▪ Other Secondary data : Various government department websites available free of cost ▪ The above costs vary with respect to the scale of application and data

	requirement
Output/ outcomes	CRiSTAL is intended to help users systematically to understand the links between local livelihoods and climate; assess a project's impact on livelihood resources important to adaptation; and to devise adjustments that improve a project's impact on livelihood resources important to adaptation. An effective use of this tool is expected to enhance local adaptive capacity through a better understanding of: ▪ Current climate hazards and climate change affecting a project area and local livelihoods ▪ People's coping mechanism, looking specifically at the resources needed to cope with climate stress ▪ Project activities affecting livelihood resources that are vulnerable to climate risk and/or important to local coping strategies ▪ Project activities that can be adjusted to enhance adaptive capacity
Analysis	The advantage of this methodology is that it relies on participatory and consultative processes like stakeholder consultations, participatory workshops, site visits, document review, Internet research, and interviews, which makes the results obtained from it more grounded to field conditions and around the needs/ requirements of the targeted stakeholders. However, the effectiveness of the method would depend upon availability of trained staff to execute it at the ground level.
Resource Agency/ Reference details	To learn more about CRiSTAL and associated training opportunities, please contact: Anne Hammill (ahammill@iisd.org) or Béatrice Riché (briche@iisd.org), International Institute for Sustainable Development (IISD). User's Manual can be downloaded from: http://www.cristaltool.org/content/download.aspx The field testing reports of CRiSTAL are available from the IISD website at: http://www.iisd.org/security/es/resilience/climate_phase2.asp CRiSTAL training workshops are being conducted in different regions around the world. Training workshops were conducted in Mozambique and Ghana in 2007 and a workshop was conducted in French in Niger in 2008. CRiSTAL is currently being used in projects in Africa and there are plans to expand activities to North America, Asia, Oceania and Latin America. For details on future training please visit: http://www.cristaltool.org

Name of the method/ tool: **Risk analysis for disaster risk management - GTZ Germany**	
Brief Description	**Risk analysis** (RA) is used here to refer to a method of determining the quantitative or qualitative degree of risk. The term "risk analysis" consists of the underlying concept of **"participative risk analysis"** (P-RA), whereby the affected target population are involved in the various stages of risk analysis, and adopt the DRM as their own. **Risk analysis (RA)** combines hazard analysis and vulnerability analysis, together with analysis of protective capabilities (as described in figure). In this methodology, the analysis of self-protection capabilities is treated as part of vulnerability analysis.  *Disaster as the product of Hazard and Vulnerability*
Application/ Utility	The risk analysis methodology is used to enhance the importance and priority of disaster prevention and preparedness and make it more effective, as a way of reducing damage and losses from extreme natural disasters (droughts, floods, landslides, earthquake), thereby reducing the need for emergency aid.
Geographical Scope	The methodology can be applied at all levels, from the national to local level, within all countries prone to natural hazards and disasters
Inputs/ Resources/ Data	Various inputs required for application of this methodology include: GIS maps, time series seasonal data (metereological, geological, hydrological), demographic data, socio-economic, natural/environmental data, geographical (location, extent), temporal (frequency, duration) and dimensional (scale, intensity) Within the analysis, the following methods are also used: integrated modeling, PRA/RRA, participative risk analysis
IT Infrastructure/ software required	The application of the methodology requires the use of GIS software such as ArcGIS, ERDAS; use of data entry software like CS Pro and use of statistical packages like SPSS and STATA. The information gathered using PRA technique will require content analysis using N Vivo/ Atlas Ti software.
Cost for resource input	The tentative cost of inputs required for using the methodology are: 1. Questionnaire : Rs 250-600 per sample/ household + Consultancy fee of the data collection firm 2. PRA/ Focused Group Discussions (FGD) : Rs.1,00,000 per PRA / FGD exercise per village 3. Analysis using N Vivo/ Atlas Ti software: Up to Rs. 50,000 4. SPSS & STATA software : Ranging from Rs 2,00,000 (single user) to Rs. 5,00,000 (multi user) 5. CS Pro: Downloadable free of cost from the internet but may need customization as per needs of data entry. The consultant may charge Rs. 10,000 to 50,000 for making such changes. 6. Analysis using GIS softwares will cost in range of Rs 2,00,000 to Rs 5,00,000 7. Census data : Available in the census CD (less than Rs 1000 per CD)

	8. Demographical Data : Available from Indiastat (Subscription more than Rs 50,000) 9. Other Secondary data : Various government department websites available free of cost The above costs vary with respect to the scale of application and data requirement
Output/ outcomes	Hazard maps, Risk zone maps, scenarios, forecasts, risk assessment tables, risk assessment matrix, awareness raising, use of concrete measures (Prevention, preparation, Early warning systems, Environmental management, Land use planning, spatial planning; Cooperation, alliances, Financing instruments, Poverty reduction) and capacity building
Analysis	The advantage and for that matter the disadvantage of this methodology is that its effective application is dependent on the following considerations: 1. For an effective DRM, **political commitment** as well as the existence of defined institutional responsibilities for disaster reduction and disaster response is essential. The democratic consultation processes and cooperation between and with institutions is heavily dependent on the political dynamics of the region. 2. Availability of resources and capability for their mobilization for the implementation and analysis of the **results of the RA.** These results are to be taken into account e.g. in spatial and land use planning. 3. Project sustainability is dependent on the **Cultural acceptability** of the innovations (e.g. methods and techniques). For this sustainability, important factors include promotion of self-organisation by the affected population and consideration of traditional and local knowledge. 4. The use of emergency aid instruments (aid shipments, food aid) often hinder **"ownership" and personal initiative** among those affected. Therefore, a dual strategy is needed to be pursued to deal with this problem during emergency aid, combining aid contributions with promotion of "ownership" and personal initiative. 5. Existence of **different interests** gives rise to **different perceptions** of hazards. A consensus within all the participants, measures such as transparent information management, disclosure and discussion of the various interests and clarification of the various roles are important and useful. 6. Risk analysis is applicable at **various levels and in different contexts**. The first step in this regard is to investigate or clarify: a) whether the aim is to reduce disaster risk at local, regional or national level b) whether the product is intended for a community (implementation), technical agency (research, analysis), financial institution (cost-benefit analyses, profitability) or insurance company (tariffs). 7. An apparent tendency is to give emphasis on **inputs for data collection** and analysis, sparing little time and resources for evaluation of data and formulation of solidly-based planning statements, particularly in agreement with actors and subsequent implementation. 8. Clear definition and agreement on concrete goals for risk analysis and the data required for the same, is essentially required.
Resource Agency/ Reference details	GTZ Eschborn office, reykoh@t-online.de or liukohler@web.de The details of the methodology can be sourced from: www.gtz.de/de/dokumente/en-riskanalysis-chs1-6.pdf

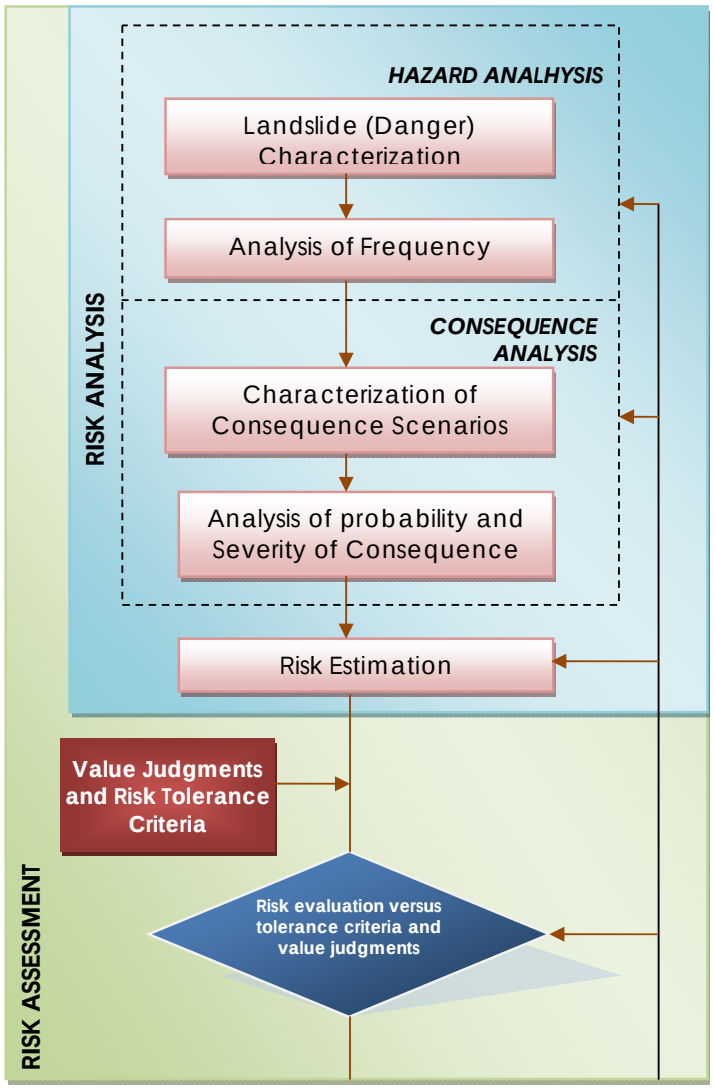
Name of the method/ tool: **ANFAS: A Decision Support System for Flood Risk Assessment** (datA fusioN for Flood Analysis and decision Support)	
Brief Description	ANFAS was developed to provide the decision makers with a method that can be used for assessing the potential impact of river floods. A tool which they could use easily in order to estimate the flood extent and the associated socio-economic impacts for different scenarios. The intended users of the system were defined to be not the highly skilled hydraulic experts or modelers, but rather the technical staff, managers, stakeholders and decision-makers, who have enough background in floodplain management and could interactively use the system and interpret its outputs. The overall objective of the ANFAS is development of a Support Decision System for flood prevention and protection, integrating the most advanced techniques in data processing and management. In the event of a flood, the decision makers need to decide on the most appropriate reactions: evacuation of the population, reinforcement of dikes, etc. The aim of the ANFAS is to develop a tool to help decision makers in taking the decision that will limit the flood damage. ANFAS intends to carry out the following tasks: • Data from the most advanced acquisition technology, particularly remote • sensing imagery - optical, radar, interferometry radar – are used and incorporated into a conventional Geographical Information System database • Developing advanced data processing tools for scene modelling and flood simulation. In order to take into account information extracted from real images for the calculation of parameters for the simulation model, computer vision and scientific computing are used together. • ANFAS has a strong end-users involvement through the definition of the objectives, the conception of the System, the evaluation of the simulation results. It ensures that the System provides answers "terrain needs" and is well adapted in practical use. • There is involvement of industrial partners for the realisation of the final System. It is of major importance for the design of the System. One of the main characteristics of the System is to be modular, i.e. to be composed of blocks easily interchangeable.
Application/ Utility	ANFAS is dedicated to the technical services of the decision makers for the preventive planning of floods. It places a tool for building, simulating, and comparing flood scenario at their disposal, through an Internet interface. The applicability of ANFAS System is: • Performing flood simulation • Water flow propagation is simulated in a given situation, using which the user can interact with the scene that models the real site in order to add/remove dikes or other human constructions • Assessing flood damage through either using the simulation results or using the remote sensed images of a real flood event • Analysis of geological property changes due to repetitive floods for a given site at a prospective level.
Geographical Scope	The system finds applicability in the low lying and flood prone regions.

Inputs/ Resources/data	The method makes use of hydraulic modeling, impact assessment and GIS assessment. ***Hydraulic monitoring and impact assessment:*** • Topography, land use data (location of population, elements at risk), ground elevation/terrain data of the selected site through ground based survey, LIDAR (Light Detection And Ranging), stereo-optical images and interferometry processing • Land use and land cover mapping through radar (RADARSAT and ERS) and optical (SPOT) images are used singly or in combination ***2-D Flood simulation*** • Time series data on velocity of water in river channel and flood plain and depth • Dyke height ***GIS*** • All model results converted to GIS formats ***Impact Assessment of damages from flood*** • Identification of elements at risk: houses, roads, agricultural production etc and assessment of their value • Vulnerability assessment of these elements • Estimation of social, financial, economic damages
IT Infrastructure/ software required	The application of this methodology would require GIS software packages such as ESRI's ArcView v. 3., ERDAS
Cost for resource input	The tentative cost of inputs required for using the methodology are: 1. GIS input maps with layering could cost between Rs 50,000 to Rs 5,00,000. However, this cost might increase in case higher degree of layering is required 2. GIS softwares: Ranges between Rs 2,00,000 to 3,00,000 3. Environmental Data: Available free for the use by government agencies from IMD and IITM 4. Census data: Available in the census CD (less than Rs 1,000 per CD) 5. Demographical Data: Available from IndiaStat (Subscription more than Rs 50,000) 6. Other Secondary data: Various government department websites available free of cost 7. Cost of model (depends on the scale) 8. The above costs may vary with respect to the scale of application and data requirement.
Output/ outcomes	Web visualizations: display maps on the web that show the flood extent and the "alert time", i.e. the time it takes for the flood wave to reach any particular area. Second type of visualization: ▪ Display the duration of the flood for any area in the floodplain

	▪ Produce a variety of thematic maps for the water depth as a function of time ▪ Display animations that show how the flood wave propagates ▪ Display flood hydrographs (water depth as a function of time) for each cross section and area in the flood plain ▪ Display a graph with the evolution of the longitudinal water line in the river as a function of time and others The output of the System is as follows: ▪ Visualisation: consisting of the bi-dimensional maps of the extent of the flood. Time sequence maps retracing the propagation of the simulated flood are provided in case simulation is performed ▪ Direct impact assessment ▪ Evaluation of the total affected area, including regional and statistical analyses over the affected area; simple socio-economic assessment directly caused by flood
Analysis	This system can be used for the risk assessment in only the low lying and flood prone areas, and does not cater to the needs of risk assessment with respect to the other natural hazards.
Resource Agency/ Reference details	ANFAS: A Decision Support System for Flood Risk Assessment (datA fusioN for Flood Analysis and decision Support), 2000- 2003, http://www.ercim.org/anfas http://www.ercim.eu/ANFAS/ Poulicos Prastacos1, William Castaings2, Nathalie Courtois3, Ladislav Hluchy4, Patrick Houdry5, Viet Tran4 1 FORTH, P.O. Box 1527 - 711 10 Herakleion - Greece, poulicos@iacm.forth.gr 2 INRIA - Domaine Universitaire - BP 53 - 38041 Grenoble Cedex 9 - France, william.castaings@imag.fr 3 BRGM, 1039 rue de Pinville - 34000 Montpellier - France, n.courtois@brgm.fr 4 II-SAS Dubravska cesta 9, 845 07 Bratislava, Slovakia, hluchy.ui@savba.sk, viet.ui@savba.sk 5 EADS S&DE, 6 Voie l' Occitane - BP 171 - 31676 Toulouse Labège Cedex - France, patrick.houdry@sysde.eads

Name of the method/ tool: **Risk based framework for landslide risk assessment**	
Brief Description	Landslide risk assessment involves a process developing a decision recommendation on the tolerance of existing risks and adequacy of present risk control measures. If these conditions are not satisfied, whether the alternative risk control measures are justifiable or implementable. The risk analysis and risk evaluation phases are included within the risk assessment. Through landslide risk evaluation, determination of the expected degree of loss due to a landslide (specific risk) and the expected number of lives lost, people injured, damage to property and disruption of economic activity (total risk) are required to be carried out. Therefore, initiating the process with the identification and description of the threat to move towards an evaluation of the claimed exposure, leading to a characterization of the risk, is professed. The four fundamental underlying assumptions that form the basis of hazard analysis are: 1. Landslides will always occur in the same geological, geomorphological, hydrogeological and climatic conditions as in the past 2. the main conditions that cause landslides are controlled by identifiable physical factors 3. the degree of hazard can be evaluated 4. all types of slope failures can be identified and classified Landslide risk assessments are generally carried out using the risk based framework. It begins with an analysis of hazard and consequences, following which the process of establishing a measure of risk (risk estimation) is carried out. Risk evaluation forms the last level of assessment, whereby the prevention measures are determined according to the levels of risk. **<u>Risk analysis</u>** The cross-correlation of hazard analysis and consequence analysis are included within the risk analysis. Initially, the probability of occurrence of a catastrophic event is established, e.g., the probability of live losses, or the probability of a landslide causing N or more casualties. Use of several qualitative or quantitative approaches is carried out according to the scale of the study, the data available, the experience of the specialist, and the scope and purpose of the hazard and risk assessment. The approaches and methods for regional studies are mostly based on remote-sensing including satellite imagery and aerial photographs. The use of local knowledge and databases concerning relevant parameters and elements at risk is carried out for more detailed studies. For urban areas, qualitative or semi-quantitative approach may be adopted. A fully quantitative approach can be attempted but faces limitations due to lack of extensive and accurate data and also due to spatial and temporal variability of factors and parameters and due to other significant uncertainties. The direct quantification of the vulnerability component of the risk is often not carried out. The cross correlation of the landuse map and a personal evaluation of the experts is used for determining vulnerability.

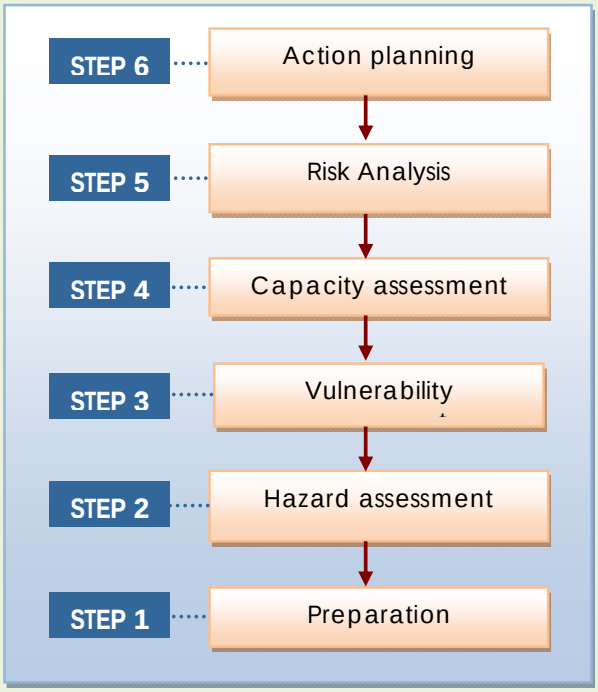
	A diagrammatic representation of the steps to be followed while applying this method has been presented below.
Application/ Utility	25 EU states have made use of the methodology for landslide risk assessment.
Geographical Scope	The methodology is applicable on a national level to the local level, for assessment of risk with respect to landslide hazard.
Inputs/ Resources/data	The various data inputs required for carrying out the risk assessment with respect to landslides include: topography, lithology, soil map, climate data, seismic data, landslide inventory, occurrence /density of existing landslides, land use, land cover map, elements at risk, socio economic data The different kinds of maps required for landslide risk assessment include: historical maps, hazard zonation maps, element at risk map, risk zonation map, Geomorphological map, inventory map. The maps used in this case vary from 1/5000 to 1/50000 scale.
IT Infrastructure/ software required	The application of this methodology would require GIS software packages such as ESRI's ArcView v. 3., ERDAS
Cost for resource input	The tentative cost of inputs required for using the methodology are: 1. GIS softwares: Ranges between Rs 2,00,000 to 3,00,000 2. Environmental Data: Available free for the use by government agencies from IMD and IITM 3. Census data: Available in the census CD (less than Rs 1,000 per CD) 4. Demographical Data: Available from IndiaStat (Subscription more than Rs 50,000) 5. Other Secondary data: Various government department websites available free of cost 6. Cost of model (depends on the scale) 7. The above costs may vary with respect to the scale of application and data requirement.
Output/ outcomes	Risk estimation
Analysis	Some of the pros and cons of using this method for landslide risk assessment include: **Advantages:** • Allows for a rapid assessment taking into account a large number of factors • No hidden rules • Automation of the procedure • Standardisation of data management **Disadvantages:** • Totally subjective methodology based on the use of implicit rules that hinder the critical analysis of the results • Subjectivity in attributing weighted values to the single classes of each parameter
Resource Agency/ Reference details	EU FP 6 RAMSOIL project http://www.ramsoil.eu/NR/rdonlyres/9179FD01-072A-449C-8EE4-CE1DC33DFF76/56314/PR22landslidesreport.pdf



Name of the Method/ tool: **Uncertainty and Risk Analysis**	
Brief Description	This method is applicable through critical review of available literature and data or through data analysis using software programs. Uncertainty and risk analysis allows for addressing the errors and unknowns associated with data and information, by the user. Definition f the decision criterion forms the key element of uncertainty and risk analysis. Qualitative assessment of uncertainty and risk is carried out using the probability ratings such as slight, moderate, and high. Quantitative uncertainty is assessed using decision analysis tools (e.g., decision trees) or sensitivity analyses such as Monte Carlo analysis. This method is often used in conjunction with other assessment techniques. The steps used in this process include: • **Identification of the risks:** A description of techniques used to get a list of possible risks, and how to determine which risks are appropriate for modelling • **Quantification of the risks:** It looks at issues that arise when trying to accurately quantify risks, such as which distribution is appropriate for what type of process, what is correlation, etc.

	• **Risk analysis:** This is carried out through Monte Carlo simulation within a spreadsheet model, from the impact upon model design to the generation of outputs • **Presentation of the results:** A description of the different ways of presenting the results of uncertainty and risk analysis, both graphically and in translating the results back into easily understood terms • **Beyond presentation:** Interpretation of the outputs from modelling in the context of decision making with respect to planning for facing the particular natural hazard
Application / Utility	Quantitative analyses using decision theory or simulation techniques are most useful for evaluating the data used for benefit-cost or similar quantitative analyses.
Geographical Scope	All locations; all sectors; national or site-specific.
Inputs / Resources / Data	Historical data on past events, impacts of past events, etc
IT Infrastructure / software required	Excel spreadsheet software; @Risk, Crystal Ball software applications.
Cost for resource input	The tentative cost of inputs required for using the methodology are: 1. GIS softwares: Ranges between Rs 2,00,000 to 3,00,000 2. Environmental Data: Available free for the use by government agencies from IMD and IITM 3. Census data: Available in the census CD (less than Rs 1,000 per CD) 4. Demographical Data: Available from IndiaStat (Subscription more than Rs 50,000) 5. Other Secondary data: Various government department websites available free of cost 6. Cost of model (depends on the scale) 7. The above costs may vary with respect to the scale of application and data requirement.
Output / Outcomes	Depending on the method used, a quantitative or qualitative estimate of the uncertainty or risk associated with the particular natural hazard is obtained. A risk register is the output from the risk identification phase, which is essentially a document containing some or all of the following for each risk: • *Generic risk* - the general heading the risk falls under • *Specific risk* - the particular risk being considered • *Qualitative description of risk* - a brief description and an example scenario • *Assessment of the impact of the risk* which is a subjective assumption as to how sensitive the output is to this particular risk, classified into high (H), medium (M) and low (L). It can be useful to set boundaries for these assessments • *Assessment of the probability of the risk* which is a subjective indication as to how likely this risk is to occur, again classified into high, medium, and low
Analysis	A number of critical issues are required to be borne in mind during the quantification process, namely: – the nature of the variables – the dangers of double counting risks

	– the danger of missing important risks out – the inclusion or not of rare events
Resource Agency / Reference details	Joel Smith, Stratus Consulting, P.O. Box 4059, Boulder, CO 80306 USA; Tel: +1.303.381.8000; Fax: +1.303.381.8200; e-mail: jsmith@stratusconsulting.com; website: http://www.stratusconsulting.com/. Brklacich, M. and B. Smit. 1992. Implications of changes in climatic averages and variability on food production opportunities in Ontario, Canada. *Climatic Change* 20:1-21. Katz, R.W. 2002. Techniques for estimating uncertainty in climate change scenarios and impact studies. *Climate Research* 20:167-185.

Participatory Assessment of Disaster Risk (PADR) Method	
Brief Description	PADR is a participatory risk assessment method that has been developed based on the Crunch and Release models. PADR uses five categories of analysis. These five categories relate to different types of assets viz. Economic, Natural, Constructed, Individual and Social. The method based on the premise that an asset is something that can be used for improving well-being. By analysing these categories for risk assessment one can ensure that all aspects of vulnerability and capacity are assessed through appropriate risk reduction measures. The key steps followed under the method have been shown in the flow chart below. The methodology is initiated with preparatory activities, which includes formation & training of teams and facilitation of the community. This is followed by hazard, vulnerability and capacity assessment using participatory approaches. The participatory tools used for **hazard assessment include** hazard map, ranking, seasonal calendar, time line, historical map. V**ulnerability assessment and capacity assessment is generally done using** risk map (hazard map also showing 'elements at risk'), transect walk, seasonal calendar, time line, venn diagram, folk songs, stories, poetry, drama. These are mostly based on PRA approaches. Following these assessments, the risk analysis is done by considering it as a function hazard, vulnerability and capacity. The risk analysis then helps in development of action plan for mitigating the risks. **The six steps of Participatory Assessment of Disaster Risk** 
Application/ Utility	PADR can be used for various stakeholders (local people, facilitation team and key informants) to understand the risks experienced by local people and the causes of their vulnerability, assess local capacities and identify activities needs to be carried out to reduce the risk of disaster. This method has been effectively used for risk analysis of floods in Darbhanga district of Bihar and in the slums of Delhi.
Geographical Scope	This is a participatory tool that can be used for risk analysis at the community level.

Inputs/ Resources/data	The methodology would need input on following aspects to undertake risk assessment: Economic assets: This will include data on household income and expenditure and possessions that can be turned into money Natural assets: This will include data on forests, rivers, grazing areas, wild fruits, trends in quality and availability, such as deforestation or lowering of the water table Constructed assets: This will include data on man-made assets. These include basic infrastructure such as houses, roads, schools, hospitals, electricity cables and wells. They also include tools and equipment that people use to be productive such as a plough Individual assets: This will include data on people's skills, knowledge, ability to work and physical health Social assets: This will include information social structures, kinships, relationships, institutional structures
IT Infrastructure/ software required	The application of methodology would require the use of data entry software like CS Pro and use of statistical packages like SPSS and STATA. The information gathered using PRA technique will require content analysis using N Vivo/ Atlas Ti software
Cost for resource input	The tentative cost of inputs required for using the methodology are: ▪ Questionnaire : Rs 250-600 per sample/ household + Consultancy fee of the data collection firm ▪ PRA/ Focused Group Discussions (FGD) : Rs.1,00,000 per PRA / FGD exercise per village ▪ Analysis using N Vivo/ Atlas Ti software: Up to Rs. 50,000 ▪ SPSS & STATA software : Ranging from Rs 2,00,000 (single user) to Rs. 5,00,000 (multi user) ▪ CS Pro: Downloadable free of cost from the internet but may need customization as per needs of data entry. The consultant may charge Rs. 10,000 to 50,000 for making such changes. ▪ Census data : Available in the census CD (less than Rs 1000 per CD) ▪ Demographical Data : Available from IndiaStat (Subscription more than Rs 50,000) ▪ Other Secondary data : Various government department websites available free of cost ▪ Other Costs : Vary with respect to the scale of application and data requirement
Output/ outcomes	The use of methodology will help in undertaking participatory risk analysis that will lead to the development of an action plan for mitigation of risk of the targeted community
Analysis	The advantage of using the PADR process is that it leads to increase in people's understanding of their vulnerabilities and capacities, so that they can develop positive approaches to improve their situation. Using this approach, disaster risk can be fully assessed by local people and effectively reduced through a range of activities. However there are two important issues that needs to be considered for its use i.e. (i) good facilitation, and (ii) a proper understanding the categories of analysis by the facilitators, which form the basis of the vulnerability and capacity assessments. PADR is not only appropriate for use before a disaster. It can also be used after a disaster in order to improve the quality and sustainability of relief, rehabilitation and

	reconstruction work. By using PADR after a disaster, traditional approaches to relief can be replaced with more effective developmental relief. This involves looking at long-term reduction in vulnerability of local people.
Resource Agency/ Reference details	Further information on the methodology can be obtained from Tearfund, 100 Church Road, Teddington, TW11 8QE, UK. Reference: Paul Venton and Bob Hansford, Reducing risk of disaster in our communities

Deterministic Vs. Probabilistic Earthquake Hazards And Risk Assessment Method	
Brief Description	Deterministic Vs. Probabilistic Earthquake Hazards And Risk Assessment Method makes use of both deterministic and probabilistic approaches. This method is based on the premise that all probabilistic methods are inclusive of all deterministic events with a finite probability of occurrence. Under this rationale this methodology uses the complementary nature of deterministic and probabilistic analyses: deterministic events are checked with a probabilistic analysis to ensure that the event is realistic and reasonably probable, and a probabilistic analysis is checked with deterministic events to see that rational, realistic hypotheses of concern have been included in the analyses. Determinism vs. probabilism is not a bivariate choice but a continuum in which both analyses are conducted, but more emphasis is given to one over the other. Emphasis here means weight in the decision-making process, regarding the choices that are available for risk reduction or loss mitigation. This includes system layout, design or retrofit levels, insurance, disaster planning, and recovery efforts. The most perspective will be gained if both deterministic and probabilistic analyses are conducted. Factors that influence the choice include the decision to be made (i.e. the purpose of the hazard or risk assessment), the seismic environment (whether the location is in a high, moderate, or low seismic risk region), and the scope of the assessment (whether one is assessing a site risk, a multi-site risk, or risk to a region).
Application/ Utility	The application of the methodology depending upon the scope of application are as follows: • The analysis of a specific site generally requires a probabilistic approach, but a deterministic check on the resulting decision. Generally many tectonic faults and unidentified seismic sources contribute to the seismic hazard and risk at a site, and the integration of these through a probabilistic analysis provides the most insight. • Multiple-site analyses often require a probabilistic analysis because of multiple variables and complexities of the system. Often several technical fields are required for the analysis (seismology, earthquake engineering, structural engineering, mechanical engineering, and industrial design), and a set of deterministic assumptions with varying degrees of conservatism can be misleading. A probabilistic model provides a way for all technical fields to quantify their interactions and effects in a common format. • Regional assessments often benefit most from deterministic models, where the probability of occurrence of the scenario in, for example, any one city is small, but is large for the region. This concept of multiple deterministic scenarios will allow rational preparation, even though the details of the forecast earthquake may be wrong. The detailed scenario is also a strong motivational tool to those not familiar or comfortable with detailed mathematical models.
Geographical Scope	This method can be used for analysing a specific building, a group of facilities or communities, or a region at risk depending upon the scope of assessment.

Inputs/ Resources/data	Seismic Data on events, frequency and magnitude of earthquake
IT Infrastructure/ software required	Very advanced statistical packages would be required for this methodology along with support from Indian Meteorological Department (IMD), Indian Institute of Tropical Meteorology (IITM) and IITs for using this method.
Cost for resource input	The tentative cost of inputs required for using the methodology are: 1. IMD data: free for certain government agencies but for others it is obtainable at a price depending upon the volume and period of data sought. 2. Other Costs : Vary with respect to the scale of application and data requirement
Output/ outcomes	The use of methodology will help in undertaking participatory risk analysis that will lead to the development of an action plan for mitigation of risk of the targeted community
Analysis	Deterministic and probabilistic seismic hazard and risk analysis method is a complementary approach. The strength of one over the other depends on the earthquake mitigation decisions to be made, on the seismic environment, and on the scope of the project. In general, more complex decisions and subtler, detailed seismic environments strongly suggest the probabilistic analysis, whereas simpler decisions and well-understood seismicity and tectonics point toward deterministic representations. This is not to say that one analysis should be used to the exclusion of the other. In fact the most insight will come from using both, allowing the probabilistic analysis to guide the choice of deterministic events, and letting the deterministic events guide the refinement of the probabilistic analysis. In this way we will make more informed decisions to reduce seismic risk.
Resource Agency/ Reference Details	The above methodology and text has been adopted from the paper Deterministic Vs. Probabilistic Earthquake Hazards And Risks by Robin K. Mcguire. Further information can be sought from the author at Risk Engineering, Inc., 4155 Darley Avenue, Suite A, Boulder, Colorado, 80305, USA, Email Mcguire@Riskeng.Com

Name of the method/ tool : **Risk and Vulnerability Assessment Tool**	
Brief Description	RVAT is used to build a website based platform with GIS Maps[20] with Hazard, Vulnerability layers. This website based portal would facilitate the decision makers and planners to design risk reduction measures for various hazards. These maps are easy to interpret so any one who is not familiar with GIS could understand and interpret as per requirement. Detailed description of these steps is available in the RVAT Tool kit document. **Data Analysis** • Societal Analysis • Critical Facilities Analysis • Economic Analysis • Environmental Analysis • Hazards Analysis • Risk and Vulnerability Assessment • Hazards Locator **Interactive Maps** • Risk and Vulnerability Assessment Interactive Maps • Parcel Analysis Interactive Maps • Community Rating System Interactive Maps • Hazards Locator Interactive Maps
Application/ Utility	RVAT would assist emergency managers, planners, the public, and others to facilitate efforts on reducing hazard vulnerabilities through awareness and education, hazard mitigation, and comprehensive land-use and development planning RVAT is demonstrating innovative and effective tools and methods for conducting a risk and vulnerability assessment (RVA). GIS Map based website and tools and methods would be develop and readily adaptable to other communities and areas
Geographical Scope	RVAT can be implemented at any place for which Remote sensing Maps are available
Inputs/ Resources/data	• Remote sensing maps for the selected region • GIS Arc Maps for the analysis and creating layers • Census data could be used in the to develop the layers and different interfaces
IT Infrastructure/ software required	GIS Tool Arc GIS Remote sensing software ERDAS 9.1 Internet connectivity and dedicated website Hardware supporting ERDAS 9.1 and Arc GIS GPS instrument
Cost for resource input	Cost of Arc GIS is in range of Rs 200000 to Rs 500000 Cost of ERDAS 9.1 is in the range of Rs 500000 to Rs 800000

[20] *Environmental Systems Research Institute® Arc Internet Map Server (ArcIMS®)*

	Consultancy fee to process one Map will vary from Rs 25000 to Rs 200000 GPS instrument in the range of Rs 20000 to Rs 100000
Output/ outcomes	Final product consists of a GIS Map[21] based application platform for decision makers and planners, this would include detailed and comprehensive GIS Maps[22] defining vulnerable and hazard areas further supporting risk assessment. Output of RVAT exercise give following output: • Community Rating System • Storm Surge Visualization • Parcel Analyzer • Mitigation Opportunities
Analysis	RVAT uses the following assessments to analyse hazards i.e. critical facilities, societal, economic, environmental and mitigation opportunities analysis, floodplain management, parcel analysis hazards locator tool and entitled observations and forecasts link to real-time and near real-time atmospheric, oceanic, and hydrologic information on the Internet. The data requirements for each of these analysis are immense and pose a great challenge to the decision makers taking up the risk assessment of a particular area, with respect to the prevalent natural hazards.
Resource Agency/ Reference details	Coastal Storms Initiative—Florida Pilot Risk and Vulnerability Assessment Tool, National Oceanic and Atmospheric Administration, Coastal Services Center

[21] Environmental Systems Research Institute® Arc Internet Map Server (ArcIMS®)

[22] Environmental Systems Research Institute® Arc Internet Map Server (ArcIMS®)

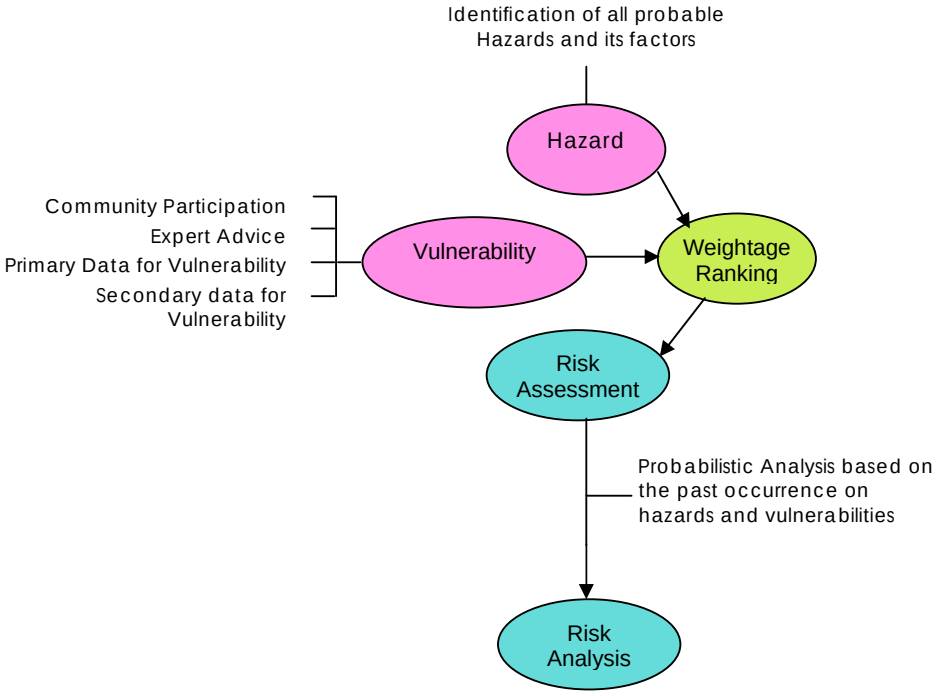
Name of the method/ tool : **Participatory Risk Assessment for Informal Sectors**	
Brief Description	Participatory risk assessment methodology is using most of the participatory bottom-up approach. Participatory risk assessment empowers communities by involving them in every level of defining problems, deciding solutions, implementing activities and evaluating the results of interventions. Methods used in this exercise are Participatory Rural Appraisal (PRA), Rapid Rural Appraisal (RRA) and Participatory Action Research (PAR). Participatory is an open methodology as in this any method or tool would be used for risk assessment based on the community participation. Participatory risk assessment is an approach explains how risks are generated and reduced. Applicability of participatory risk assessment is almost in any context, urban or rural, and specific sectors, specific departments, and integrated process across sectors within one specific settlement or as part of an integrated and holistic planning process used by a community-based organization. Analysis is based on the integrated participatory risk assessment with phases, activities and outcomes: *(To develop understanding on the various steps and approaches on the below given methodology refer: Weathering the Strom: Participatory risk assessment for informal sector)* **Step one is the Participatory Ground Work** *(1 to 2 months per Block)* • Scope the risk context and the feasibility for risk reduction initiatives • Establish enabling local stakeholder and institutional arrangements • Do background research on the settlement's risk and development profile • Make clear administrative and logistics arrangements with key stakeholders '***Scoping the risk context***' refers to a process of general consultation with a wide range of resource people (i.e. disaster risk management, urban planning, fire services and disaster risk university research units) on possible settlements that face increased risks of fire, environmental health problems or flooding **Step two Participatory Risk Assessment** *(3 to 5 weeks per Block)* • Ensure risk assessment process is participatory, inclusive and robust • Do thorough on-site field assessment **Participatory risk assessment** would be based on the following data: Disaster risk profile (Government department data, earlier publish reports, disaster data), Socio-demographic profile and history, Service delivery information and development plans. **Preparatory Field assessment** would be on-site visits and through development of GIS Maps based on time series aerial photography for district and rural area level maps, municipal level maps, Aerial photographs **Hazard identification and ranking:** Through participatory approach every hazard which community is facing would be ranked on the scale of 1 to 5. ▪ *Development of Problem Trees and Solution Trees*: through participatory

	approach ▪ *Development of seasonal calendar mentioning all types of hazards* ▪ *Development of a weekly calendar mentioning all types of hazards* ▪ *Development of Community Risk history table:* Mentioning all types of risks community is facing in the time series range of last 30 years ▪ *Development of community settlement maps:* Mapping of settlement with the help of community ▪ *Identification of high risk areas:* Ranking in range of 1 to 5 ▪ *Development of Venn Diagram:* it gives the visual presentation to different risks due to various hazards ▪ *Conduct a Transect Walk*: Through community participation ▪ *Development of risk Management Table:* this defines in the context of hazards and vulnerability What, Who, and How community is facing each risk **Step three is integrated disaster risk reduction plans** *(3 to 4 weeks per Block)* • Make risk reduction planning participatory, inclusive, with achievable, 'do-able' activities • Integrate local actions with supportive municipal development processes • Increase local responsibility for risk reduction • Establish monitoring & evaluation processes • Risk Reduction Priorities
Application/ Utility	Participatory Risk Assessment is use for community risk assessment, to develop recommendation plans (long term plan, short term plan and Integrated development plan) Implementation This methodology is focusing on professional Group and practitioners such as: Disaster risk management practitioners, Roads and Stormwater, Water Services, Integrated Development Planning, Solid Waste, Environmental Health and Environmental Management, Primary Health Care, Housing, Social Services and Health, Adult education and training, Community-based and nongovernmental **Organizations** Participatory Risk Assessment is based on the following steps: • Clear identification of priority hazards and risks in the settlement • Clear spatial representation of risk conditions that can be upscaled into IDPs and Spatial Development Frameworks (SDFs) • Clear identification and assessment of risk-associated vulnerabilities and capacities
Geographical Scope	Participatory Risk Assessment is used in any context urban or rural across specific sectors, specific departments and specific settlements
Inputs/ Resources/data	• Time Series Aerial Maps • Secondary Data from different government departments, CBOs etc • FGDs and In-depth discussions • Seasonal data through secondary research • Surveys • Spatial mapping using geographical information systems (GIS)
IT Infrastructure/ software required	• Data Analysis will be through statistical packages such as SPSS 15.0 and STAT it will cost between Rs 200000 (Single User) to Rs 500000 (Multi User) • Data entry software CS Pro 4.0 is available for free in internet. But • If GIS will be used in analysis it will cost in range of Rs 200000 to Rs 500000

Cost for resource input	• Cost for in-depth field survey is in the range of Rs 100000 to Rs 500000 per Block • Cost for per sample of in-depth interview Rs 250 to Rs 600 • Data from Indiastat – More than Rs 50,000 • SPSS for data analysis- Rs 100000 • Data from secondary sources from Government websites – Available for Free • PRA exercise per village will cost in range of Rs 50000 to Rs 300000 • Consultant may charge Rs. 20000 to Rs. 50000 for designing CS Pro 4.0 customized interface for data entry • N Vivo or Atlas Ti 3.0 for qualitative analysis, it's cost is upto Rs 50000
Output/ outcomes	Time series aerial GIS maps, Problem and Solution Tree, Seasonal calendar mentioning all types of hazards, Weekly calendar mentioning all types of hazards, Risk history table, Community settlement maps, High risk areas, Venn Diagram, Risk Management Table
Analysis	Some of the important issues for consideration with respect to the method of participatory risk assessment include: • Participatory risk assessment involves the target community in the qualitative risk assessment, which would be further validating through secondary data and GIS maps. • At the initial stage in this methodology through community participation vulnerable groups would be identified and then they identified sever hazards and vulnerable areas would be identify. • At every stage community participation would be required and standard tools • This step is focusing on the following issues: Scoping the risk context and the feasibility for risk reduction initiatives, Establishing enabling local stakeholder and institutional arrangements, doing background research on the settlement's risk and development profile, Making clear administrative and logistics arrangements with key stakeholders. Whereas the output of this exercise gives Clarity and agreement on settlement to be supported, Identification and engagement of key stakeholders from the settlement and local government, Consolidated information on the settlement's development and disaster risk profile (including maps, aerial photos and reports) • This methodology uses the qualitative rating for Hazard, vulnerability and then risk analysis. Ranking would be through community participation.
Resource Agency/ Reference details	**Weathering the Storm: Participatory risk assessment for informal settlements** Disaster Mitigation for Sustainable Livelihoods Programme University of Cape Town, Rondebosch 7701 South Africa, Tel 27 (0)21 650 2987, Fax 27 (0)21 689 1217

Name of the method/ tool : **Risk Factor Analysis: Qualitative Risk Management Tool**	
Brief Description	Risk Factor Analysis (RFA) is a systematic qualitative risk analysis. It uses per-conceptual risk analysis, an intermediate approach. Project risk analysis is implemented through graded approach i.e. the scope and approach of the analysis must be customized to fit the Hazard and Vulnerability. RFA is using the weightage expert ranking on the qualitative scale that is ranking of hazards and vulnerability on the scale of 1 to 5. It is also using the ranking by vulnerable community on the similar scale. The primary steps involved in conducting a risk factor analysis are as follows: • List of various hazards and vulnerable groups, • Identify various risk factors with expert and with community participation • Develop a risk-ranking scale for each risk factor • Rank risk for each hazard and vulnerability for each risk factor • Sum results across risk factors for each hazard and vulnerability • Apply the risk analysis equation for the assessment of risk based on each hazards and vulnerability ranking • Analysis of final score for Risk Assessment and Risk Analysis Below diagram and tables are explaining the framework of the methodology.
Application/ Utility	RFA can be applied for risk assessment and risk analysis. It can also be used for ranking various hazards and vulnerabilities.
Geographical Scope	RFA can be applied in the national, state and district level. Where data on hazards and vulnerabilities are available.
Inputs/ Resources/data	• Data of various hazards, its frequency, intensity, duration and extent • Secondary data on status of socio economic, financial, health, livelihood, natural resource etc • Data of various institutions, CBOs, SHG and social networks • Map of area where methodology would be applied
IT Infrastructure/ software required	• Data Analysis will be through statistical packages such as SPSS 15.0 and STAT it will cost between Rs 200000 (Single User) to Rs 500000 (Multi User) • Data entry software CS Pro 4.0 is available for free in internet. But • If GIS will be used in analysis it will cost in range of Rs 200000 to Rs 500000
Cost for resource input	• Cost for in-depth field survey is in the range of Rs 100000 to Rs 500000 per Block • Cost for per sample of in-depth interview Rs 250 to Rs 600 • Data from Indiastat – More than Rs 50,000 • SPSS for data analysis- Rs 100000 • Data from secondary sources from Government websites – Available for Free • PRA exercise per village will cost in range of Rs 50000 to Rs 300000 • Consultant may charge Rs. 20000 to Rs. 50000 for designing CS Pro 4.0 customized interface for data entry • N Vivo or Atlas Ti 3.0 for qualitative analysis, it's cost is upto Rs 50000
Output/ outcomes	RFA gives risk assessment and risk analysis with ranking of various hazards and vulnerabilities
Analysis	Risk factor analysis is used for the risk assessment and risk analysis based on the concept that risk is the function of vulnerability and hazards. Since the data

	requirements in these methods are huge, therefore, the application of this method is quite expensive, depending upon the scale of application of the method.
Resource Agency/ Reference details	John P. Kindinger,Probabilistic Risk and Hazards Analysis Group, Los Alamos National Laboratory John L.Darby,Probabilistic Risk and Hazards Analysis Group, Los Alamos National Laboratory



Example Risk Factor Evaluation for Hazards

Hazards	A	B	C	Risk Factor for Hazards
Hazard 1	Low (1)	Low (1)	High (5)	7
Hazard 2	Medium (3)	High (5)	Medium (3)	11
Hazard 3	Low (1)	Low (1)	High (5)	7
Activity Total	4	7	13	25

Example Risk Factor Evaluation for Vulnerability

Vulnerability	A	B	C	Risk Factor for Vulnerability
Vulnerability 1	Low (2)	Low (1)	High (4)	7
Vulnerability 2	Medium (3)	High (4)	Medium (3)	10
Vulnerability 3	Low (2)	Low (1)	High (5)	8
Activity Total	7	6	12	25

4.3 CONCLUDING REMARKS

An effective strategy for disaster risk reduction is based on the notions of hazard, vulnerability and capacity, along with an operational basis for a culture of prevention. Some of the critical areas of concern in terms of the disaster risk reduction process include:

➲ *Risk assessments for decision making*

The review and documentation as to how risk assessments contribute to modify the risk and their utilization in the decision making process presents an overall challenge

➲ *Terminology, data and methodology*

The primary input for identification of trends in hazard, vulnerability as well as for feeding of the risk assessments and disaster impact analysis is the availability of data. At many incidences, either the relevant data for risk analysis is unavailable, or its quality and accuracy are not reflective of an accurate picture. The need for working towards a standardization and systemization of all issues related to accuracy/technical soundness, political neutrality, methodologies and processes related to collection, analysis, storage, maintenance and dissemination of data is rendered imperative.

Many different conceptual models attempt to examine the same things with respect to methodologies. However, the actual use of hazard, vulnerability and capacity assessment to reduce risk, in practice, raises an important issue requiring attention.

➲ *Higher visibility and priority to reduce vulnerability and strengthen capacities*

The public authorities are mainly responsible for reducing vulnerability to risk. However, the data regarding disaster impact, especially concerning small and medium scale disasters and of the social and environmental considerations, is considerably lacking. Economic considerations are highly influential in the decision-making process of the political authorities. Lack of the quantitative measurement on a realistic scale renders it difficult for the political decision-makers to acknowledge and factor in these considerations into their legislative mechanisms and into development planning efforts.

Inclusion of capacity as an important factor in the disaster risk formula presents a further opportunity for the enhancement of a conceptual framework to assess this factor.

➲ *Addressing new trends in hazard and vulnerability*

A recognition and in-depth analysis of the changing nature of hazards and vulnerabilities is required in the present scenario. The frequency and intensity of hazardous natural phenomena are influenced by the ecological imbalances such as climate change. In addition, environmental degradation exacerbates the impact of natural hazards. Risk assessments reflective of the dynamic and complex scenarios are required to feed into the disaster risk reduction strategies. The challenge with respect to emergent new trends in hazards and vulnerability exists in the use of conventional ways to identify, monitor, evaluate, cope and recover from risks.

Data Sources, Existing Resources and Various Softwares

5.1 INVENTORY OF DATA SOURCES

Over the years Government of India has supported planned activities to collect, collate and disseminate data of different types for various types of end users. Some of them are freely available and few are priced publication (in the form of survey report, books, CD, etc) Multi nodal agencies are involved in the process. Some of the relevant data are included in the inventory below:

Available Data	Range of Availability	Nodal Agency
Census data on population, demographic pattern, employment, critical facility available, demographic maps, population projection etc	National, State, District, Block and Village level	Census of India Ministry of Home Affairs http://www.censusindia.net/ http://censusindia.gov.in/
Data on vulnerable groups living below poverty line, food security, socio economic, education, housing, migration pattern etc	National, State, District, Block and Village level	Ministry of Panchayati Raj Institution BPL Census 2002 Data Base (http://bpl.nic.in/ds.php?bpl)
Agricultural Statistics	National, State, District, Block and Village level	Department of Agriculture Co-operation, Ministry of Agriculture http://agricoop.nic.in/
Data on livestock's	National, State, District, Block and Village level	Department of Animal Husbandry, Dairying & Fisheries, Ministry of Agriculture http://dahd.nic.in/census.htm
Socioeconomic Survey India(1)	National, State, District, Block and Village level	Ministry of Finance, Govt of India www.finmin.nic.in/
Information(in the form of publications and data) socio economy, education, employment, statistics, programme implementation etc	National and State level (case studies may cover at district and local level)	National Sample Survey Organization, Ministry of Statistics and Programme Implementation http://mospi.gov.in/
Maps, Topo sheet of different types (political, physical, photogrammetry, critical facility etc,)	National to Village level	Survey of India, Ministry of Science and Technology http://www.surveyofindia.gov.in
Hazard Related Data		

Available Data	Range of Availability	Nodal Agency
Meteorological Data of Rainfall Temperature, Humidity, wind speed	Almost at district level	India Meteorological Department(IMD); Ministry of Earth Sciences http://www.imd.gov.in/ http://www.imdpune.gov.in/
Climatological data (Cyclone, Thunderstorms, Tornados)	Throughout the country	IMD
Seismic Data (Earth Quake)	Indian region	IMD and National Geophysical research Institute http://www.ngri.org.in
Geophysical data	Indian region	Geological Survey of India(GSI)
Ocean Data	Indian region	National Institute of Ocean Technology(NIOT) http://www.niot.res.in/
Forests data and related information	National and sate level	Forest Survey India http://fsi.org.in/
Remote Sensing Data	User based	National Remote Sensing Centre(NRSC)
Data on water resources /flood (River water flow) data	Overall Country	Central Water Commission, Ministry of Water Resources
Disasters(natural and manmade) related information, guidelines, acts, policies etc	National level (applicable to State District and local level)	National Disaster Management Authority http://ndma.gov.in/ndma/dmact.htm

(1)Socio-economic data at State, district and block level may be available with respective Department of the State (Usually the Department of Finance). At district information may be available in the district portal maintained by NIC.

As discussed in earlier sections Hazard, Risk and Vulnerability Assessment requires a lot of physical, social, environmental, economic and spatial data for analysis. In India, data at moderate level is available for all regions.

5.2 INSTITUTIONS SUPPORTING HAZARD RELATED ACTIVITIES

There are several organizations in the country working directly or indirectly on natural disasters. These organizations are involved with observations, hazard data collection and analysis, providing operational forecasts, scientific research and

technology development. However few of them are involved HRVA. The following inventory includes some of the prominent organizations in the area.

Organizations	Activities
NDMA www.ndma.gov.in/	NDMA as the apex body is mandated to lay down the policies, plans and guidelines for Disaster Management to ensure timely and effective response to disasters. Towards this, it has the following responsibilities:- ▪ Lay down policies on disaster management ▪ Approve the National Plan ▪ Approve plans prepared by the Ministries or Departments of the Government of India in accordance with the National Plan ▪ Lay down guidelines to be followed by the State Authorities in drawing up the State Plan ▪ Lay down guidelines to be followed by the different Ministries or Departments of the Government of India for the Purpose of integrating the measures for prevention of disaster or the mitigation of its effects in their development plans and projects ▪ Coordinate the enforcement and implementation of the policy and plan for disaster management; ▪ Recommend provision of funds for the purpose of mitigation; ▪ Provide such support to other countries affected by major disasters as may be determined by the Central Government; ▪ Take such other measures for the prevention of disaster, or the mitigation, or preparedness and capacity building for dealing with the threatening disaster situation or disaster as it may consider necessary; ▪ Lay down broad policies and guidelines for the functioning of the National Institute of Disaster Management.
National Institute of Disaster Management (NIDM) http://www.nidm.net/	The National Institute of Disaster Management (NIDM) came into existence since October 16, 2003. It is a premier national organization working for human resource development at in the area of disaster mitigation and management. NIDM is gearing up to be the leading center of excellence in the field of disaster risk mitigation and management in India and the region. MIDM works as a think tank for the government by providing policy advice and facilitating capacity building services including strategic learning, research, training, system development and expertise promotion for effective disaster preparedness and mitigation. It is supporting the national, state and district level administration to tackle natural calamities and will also be coordinating research projects, training programmes and will build a database on natural disasters with case studies.
India Meteorological Department(IMD) http://www.imd.gov.in/ http://www.imdpune.gov.in/	Mandate ▪ To maintain long term authenticated meteorological records ▪ To provide the data series for research and national building activities ▪ To design optimal observational network for collection of reliable meteorological data ▪ To issue seasonal forecasts of southwest monsoon rainfall for economic

Organizations	Activities
	growth of country ▪ To advice farmers about cropping patterns, to face the vagaries of monsoon rainfall ▪ To Install and upkeep of surface meteorological instruments. ▪ To issue day to day forecast of weather condition (actual and expected) over the country. ▪ To lay down norms for the aviation and cyclone warning services for the country to keep at par with the international standard. ▪ To impart training in the field of weather forecasting to Indian, South Asian and
Indian Space Research Organization (ISRO) www.isro.org	The Indian Space Research Organisation (ISRO is the primary body for space research under the control of the Government of India, and one of the leading space research organizations in the world. It was established in its modern form in 1969 as a result of coordinated efforts initiated earlier. Takings into consideration its budget it is probably one of the most efficient space organizations on the globe. Under the guidance of a number of scientists, ISRO has conducted a variety of operations for both Indian and foreign clients. ISRO's satellite launch capability is provided by indigenous launch vehicles and launch sites. In 2008, ISRO successfully launched its first lunar probe, Chandrayaan-1, while future plans include manned space missions, further lunar exploration, and interplanetary probes. ISRO has several field installations as assets, and cooperates with the international community as a part of several bilateral and multilateral agreements
National Remote Sensing Centre (NRSC), Hyderabad www.nrsc.gov.in/	National Remote Sensing Centre (NRSC), is one of the centers of ISRO, striving to realize the Indian Space Vision, as a key player in Earth Observation Programme and Disaster Management Support programme. NRSC is responsible for acquisition, processing, supply of aerial and satellite remote sensing data and continuously exploring the practical uses of remote sensing technology for multilevel (global to local) applications. It provides the necessary trained manpower through capacity building in remote sensing applications. NRSC has wealth of images from Indian and foreign remote sensing satellites in its archives and also has the capability to acquire data pertaining to any part of the globe on demand. NRSC also supports, through ANTRIX, establishment of International Ground Stations and International reseller network to receive, process and market IRS data products globally. NRSC provides end-to-end solutions for utilization of data for natural resource management, geospatial applications and information services. NRSC facilitates several remote sensing & GIS application projects for natural resources and environmental management catering to food security, water security, energy security and sustainable development. NRSC is also providing single window, disaster management support services through the Decision Support Centre.
Space Application Centre (SAC) Ahmedabad http://www.sac.gov.in/	SAC is one of the major centres of the Indian Space Research Organisation (ISRO). It is a unique centre dealing with a wide variety of themes from payload developments to societal applications. SAC is responsible for realizing the applications-oriented programmes of ISRO in the areas of Satellite Communications and Remote Sensing. SAC is also a host institution for the training programmes related to Satellite

Organizations	Activities
	Communication and Meteorology under the Centre for Space Science & Technology Education in Asia and the Pacific (CSSTEAP) affiliated to the United Nations (UN). Design and development of payloads for communications and remote sensing satellites Communication Transponders for INSAT/GSAT series of satellites Sensor systems for Earth Observation and Meteorological satellites
Central Water commission(CWC) Delhi http://www.cwc.nic.in/	Central Water Commission is a premier Technical Organization of India in the field of Water Resources and functioning as an attached office of the Ministry of Water Resources, Government of India. The Commission is entrusted with the general responsibilities of initiating, coordinating and furthering in consultation of the State Governments concerned, schemes for control, conservation and utilization of water resources throughout the country, for purpose of Flood Control, Irrigation, Navigation, Drinking Water Supply and Water Power Development. It also undertakes the investigations, construction and execution of any such schemes as required CWC is charged with the general responsibility of initiating, coordinating and furthering in consultation with the State Governments concerned, schemes for the control, conservation and utilization of water resources in the respective state for the purpose of flood management, irrigation, navigation, drinking water supply and water power generation. The Commission, if so required, can undertake the construction and execution of any such scheme. In exercise of the above responsibilities following are the broad main functions of CWC: To undertake necessary surveys and investigations as and when so required, to prepare designs and schemes for the development of river valleys in respect of power generation, irrigation by gravity flow or lift, flood management, environmental management, rehabilitation and resettlement, soil conservation, anti-water logging measures, reclamation of alkaline and saline soils, drainage and for drinking water supply; ▪ To collect, coordinate the collection of, publish and analyse the data relating to tidal rivers, rainfall, runoff and temperature, silting of reservoirs, behaviour of hydraulic structures, environmental aspects etc. and to act as the Central Bureau of Information in respect of these matters; ▪ To collect, maintain and publish statistical data relating to water resources and its utilization including quality of water throughout India and to act as the Central Bureau of Information relating to water resources; ▪ To standardize instruments, methods of observation and record, materials for construction, design and operation of irrigation projects; ▪ To initiate studies on socio-agro-economic and ecological aspects of irrigation projects for the sustained development of irrigation;
Indian Agricultural Research Institute www.iari.res.in	Premier agricultural research institution in the country. Actively involved with training and research. Works in the areas of crop modeling and development of new seed varieties suitable in hazard affected areas. Support Government in agricultural policy and planning.
Ministry of Environment and Forests (MoEF) moef.nic.in	Nodal agency for the Environmental Protection and Chemical Hazard Management
Ministry of Earth Sciences	Mandated to provide the nation with best possible services in forecasting the monsoons and other weather/climate parameters, ocean state, earthquakes, tsunamis and other phenomena related to earth systems through well

Organizations	Activities
www.dod.nic.in	integrated programmes. The Ministry also deals with science and technology for exploration and exploitation of ocean resources (living and non-living), and play nodal role for Antarctic/Arctic and Southern Ocean research. The Ministry's mandate is to look after Atmospheric Sciences, Ocean Science & Technology and Seismology in an integrated manner.
Indian Institute of Tropical Meteorology(IITM) Pune www.tropmet.res.in	Premier Research Centre with outstanding research talent capable of understanding and exploring effective Atmospheric sciences with: Atmospheric, Oceanic and Climate Science. It has a centre for climate modeling.
Geological Survey of India http://www.portal.gsi.gov.in/portal	Through its existence of more than 155 years, Geological Survey of India has gathered immense expertise regarding various aspects of geoinformation management and has generated voluminous amount of geoscientific data through its relentless field surveys and laboratory studies. GSI disseminates these information in the form of maps, publications and unpublished reports. GSI had always catered to the needs of the Govt. departments /enterprises, academicians and public entrepreneurs in the mineral, industrial, infrastructure, urban and environmental planning sectors. GSI has built a national geoscience database in the form of 1:50,000 / 63,360 geological maps covering almost the entire country. GSI provides technical consultancy, data and services to prospective investors and agencies, both national and multinational on different commodities and aspects.
National geophysical Research Institute (NGRI) Hyderabad http://www.ngri.org.in/	Earthquake Hazard Assessment ▪ Application of synthetic aperture radar interferometry (InSAR) to measure ground deformation for seismic hazard studies in and around India ▪ Study of seismogenic earthquake sources in SCR and Kopili lineament, NE India for seismic hazard assessment ▪ Rigidity and Kinematics of the Indian Plate and its margins by space geodesy techniques using GPS,GLONNAS,GALLILEO satellite systems and VLSI ▪ Study of the Indian plate geo-dynamics through intense seismic and GPS campaign mode monitoring ▪ Lithospheric structure, deformation and tectonics of the Eastern Himalaya and Andaman arc regions Geo-Environmental Studies ▪ Ecology and environmental studies in and around greater Hyderabad Environmental impact assessment and remediation of inorganic and organic pollutants derived from mining and industrial activities ▪ Environmental Geophysics
National Institute of Ocean Technology (NIOT) http://www.niot.res.in/	Mission ▪ To develop world class technologies and their applications for sustainable utilization of ocean resources. ▪ To provide competitive, value added technical services and solutions to organizations working in the oceans. ▪ To develop a knowledgebase and institutional capabilities in India for management of ocean resources and environment.

Organizations	Activities
	Ocean Observation System Considering the importance of ocean observations to the country like India having a long coastline of about 7500 km and a vast oceanic area of 2.02 million sq. km of EEZ available for exploitation, Department of Ocean Development, Government of India has established the National Data Buoy Programme (NDBP) in 1997 at National Institute of Ocean Technology (NIOT) Chennai. A network of twelve data buoys has been established both in Arabian Sea and Bay of Bengal during the implementation period of 1997-2002, which has subsequently been increased to twenty five and poised for further growth. The moored data buoys are floating platforms, which carry sensors to measure Wind Speed & Direction, Atmospheric Pressure, Air Temperature, Humidity, Conductivity, Sea Surface Temperature, Current Speed & Direction and Wave Parameters.
National Institute of Oceanography(NIO), Goa http://www.nio.org	Mandate ▪ To develop knowledge on physical, chemical, biological, geological, geophysical, engineering and pollution aspects of the waters around India ▪ To provide support to various industries, government and non-government organisations through consultancy and contract research ▪ To disseminate knowledge on the waters around India
Forest Survey of India (FSI), http://fsi.org.in/	Forest Survey of India (FSI), is a premier national organization under the union Ministry of Environment and Forests, responsible for assessment and monitoring of the forest resources of the country regularly. In addition, it is also engaged in providing the services of training, research and extension. Established on June 1, 1981, the Forest Survey of India succeeded the "Preinvestment Survey of Forest Resources" (PISFR), a project initiated in 1965 by Government of India with the sponsorship of FAO and UNDP. The main objective of PISFR was to ascertain the availability of raw material for establishment of wood based industries in selected areas of the country. In its report in 1976, the National Commission on Agriculture (NCA) recommended for the creation of a National Forest Survey Organization for a regular, periodic and comprehensive forest resources survey of the country leading to creation of FSI. After a critical review of activities undertaken by FSI, Government of India redefined the mandate of FSI in 1986 in order to make it more relevant to the rapidly changing needs and aspirations of the country. Activities ▪ Forest Cover Assessment ▪ Inventory of Forest areas ▪ Thematic Maps ▪ Inventory of Trees Outside Forests (Rural & Urban) ▪ Inventory data processing ▪ Methodology Design ▪ Training and Extension
Survey of India http://www.surveyofindia.gov.in	The Survey of India acts as adviser to the Government of India on all survey matters, viz Geodesy, Photogrammetry, Mapping & Map Reproduction. However, the main duties and responsibilities of the Survey of India are enumerated below:

Organizations	Activities
	▪ All Geodetic Control (Horizontal and Vertical) and Geodetic and geophysical Surveys. ▪ All Topographical control, Surveys and Mapping within India. Mapping and Production of geographical maps and Aeronautical Charts. ▪ Surveys for Developmental Projects. ▪ Large-scale Cities, Guide Maps & Cadastral Surveys etc. ▪ Survey and Mapping of special purpose maps. ▪ Research and Development in Digital Mapping and creation of Digital Topographical Data Base on 1:250,000, 1:50,000 and 1:25,000 scale, Printing, Geodesy, Photogrammetry, Topographical Surveys and Indigenization. ▪ Demarcation of the External Boundaries of the Republic of India, their depiction on maps published in the country and also advice on the demarcation of inter-state boundaries. ▪ Prediction of tides at 44 ports including 14 foreign ports and publication of Tide Table one year in advance to support navigational activities.
Building Materials & Technology Promotion Council http://www.bmtpc.org/	▪ Developed Vulnerability Maps ▪ Promote development, production, standardization and large-scale application of cost-effective innovative building materials and construction technologies in housing and building sector. ▪ Promote new waste-based building materials in urban and rural regions. ▪ Develop and promote methodologies and technologies for natural disaster mitigation & management ▪ Provide S & T services to professionals, construction agencies and entrepreneurs in selection, and marketing for technology transfer, from lab to land, in the area of building materials and construction.

Some of the related publications (in the country)

GIS based Earthquake Risk-Vulnerability Analysis and Post-quake Relief Planning
Dr Jothimani Ponnusamy, Senior Professor & Head, Centre for Disaster Mitigation & Management (CDMM), Vellore Institute of Technology University, Vellore, Tamilnadu
mapindia.org/2010/proceeding/pdf/Jothimani.pdf

Recent developments toward *earthquake risk* reduction in India, Special Section: Seismology 2000, Anand S. Arya
Department of Earthquake Engineering, University of Roorkee, Roorkee 247 667, India
www.ias.ac.in/currsci/nov102000/1270.pdf www.ias.ac.in/currsci/nov102000/1270.pdf

Development of tailored climate information for flood and drought risk assessment and prediction over India, Andrew W. Robertson and Upmanu Lall (IRI) and Krishna Kumar (IITM), NOAA-MoES Science Colloquium, 12-Sep-2008
dod.nic.in/IRI-IITM.pdf dod.nic.in/IRI-IITM.pdf

ICT for Disaster Risk Reduction, the Indian Experience
Government of India, Ministry of Home Affairs, National Disaster Management Division
www.ndmindia.nic.in/.../ICT%20for%20Disaster%20Risk%20Reduction.pdf

Disaster Management In India, A Status Report
Government of India, Ministry of Home Affairs, National Disaster Management Division
http://ndmindia.nic.in/EQProjects/Disaster%20Management%20in%20India%20-%20A%20Status%20Report%20-%20August%202004.pdf

Drought : The Indian Scenario, Subrata Bose and Neeraj Saxena
http://nidm.gov.in/drought.htm

Strategy Paper on - Prevention/Protection and Mitigation from Risk of Tsunami Disasters.
Ministry of Home Affairs, Government of India
http://ndmindia.nic.in/Tsunami2004/Strategy%20Paper%20on%20Tsunami.pdf

GIS in Flood Hazard Mapping: a case study of Kosi River Basin, India
http://www.gisdevelopment.net/application/natural_hazards/floods/floods001.htm

Winrock International India (with partners IITM, IIT-Delhi, IIM-A, DFID-Defra)
State Level Vulnerability Assessment due to cyclone and flood: A Case Study of Orissa

Winrock International India (NATCOM- India)
Assessment of Vulnerabilities of forest and associated livelihoods in the central region

Conclusions & Recommendation

The objective of the baseline document, as mentioned earlier, is to develop a common understanding on the methodologies available for Hazard Risk and Vulnerability Assessment (HRVA) and its assessment. The document provides a compilation of the various methodologies available in the context of vulnerability and capacities assessment, hazard assessment and risk analysis, along with an inventory of the existing resources available for basic data requirements, existing resources and applications of various softwares.

A description of the key issues, challenges and specific inferences regarding methodologies related to multi hazard risk assessment, vulnerability & capacity assessment and risk analysis have been provided at the end of each chapters dealing with them and have therefore not been mentioned here. This section deals more with conclusions and inferences on the general issues and challenges related to methodological application.

A comprehensive assessment of various kinds of vulnerabilities of hazard-prone areas at national, state, and local levels using information on a variety of natural phenomena, including coastal storms, floods, tsunamis, landslides, drought, earthquakes, etc. requires the use of a combination of these methodologies, particularly in the Indian context. In addition, the issues that arise in synchronization of these methodologies to cater to the specific needs with respect to the prevalent socio-economic scenarios in a developing country such as India require special attention of the development practitioners or the decision makers. Here National Disaster Management Authority (NDMA) can play the role of a nodal agency for coordination and networking between various research/ action research agencies/ organizations specializing in the use of these methodologies and promote its synchronization, application and pilot testing.

The data and information required for the application of the HRVA methodologies is not easily accessible in the public domain. However, different government departments and institutes at various levels possess some form of raw data, but issues such as data integration, compatibility, scales, accuracy, and resolution need to be addressed to make the information useful at the local level for consideration in application of HRVA methodologies, especially in the case of various kinds of natural hazards that affect India. Recently Department of Civil Engineering, Indian Institute of Technology (IIT), Delhi has developed a GIS based web interface called ‘Hydrological Information System’ which uses the IMD data for providing sub basin wise drought and flood vulnerability analysis. All river basins have been covered under this program, which can provide tremendous support to

action research and development oriented organizations to assess and apply the results in the local context. Similar initiative needs to be undertaken by other apex level academic, research and technical institutions in the country. Here agencies like UNDP and relevant Ministries can play a pivotal role in supporting such efforts by these agencies.

To overcome the issue of data availability real-time and long-term monitoring of key indicators, collection of data, electronic archiving, management, and open sharing of data, images and maps on natural hazards is needed. The present baseline document has provided a list of methodologies and approaches to undertake HRVA. To make effective use of these methodologies, it is important for the DRR authorities to develop a hazard risk information data base to support hazard identification and undertake risk analysis. The data base could contain all the necessary data collected through the HRVA methods along with digital demographic maps, critical facilities maps, infrastructure maps, seismic maps, topographical maps, land use and land cover maps, flood plain maps and also digital images of the location. This reduces the start time while using a methodology for conducting HRVA.

Highly variable local conditions and characteristics existing in India demand for tailor-made HRVA methodologies and tools that can be adapted to the local needs and provide better site-specific estimates. Inappropriate estimates of risks lead to higher time and cost implications for the development planners and decision makers, leading to diversion of resources earmarked for use in the disaster management programmes. Here agencies like NDMA, NIDM, Disaster Management Institute (DMI), state level DMAs and other research agencies working in this field should undertake awareness generation, training and capacity building initiatives for NGOs, CBOs and other field level institutions to build grassroots level capacities for development and application of these methodologies as per local needs and requirements.

Apart from the issues in quantitative risk assessments, the qualitative risk assessment is also fraught with methodological challenges, particularly since it is subjective in nature and may lead to inconsistency depending upon the understanding and skill of the person applying it. This is further so because of lack of trained teams that can implement such methodologies at the field level. Collaboration between social scientists, planners, and other professionals needs to be undertaken to educate the public, business leaders, and policy makers regarding tools and approaches that can be used for mitigating the impacts of extreme events.

In conclusion, various relevant Government agencies/organizations dealing with DRR and humanitarian relief are involved in development of new methods and tools to conduct assessments of disaster risk, making vulnerability Atlas and state wise hazard and risk maps. For e.g. Building Materials Technology Promotion Council (BMPTC) has developed

Vulnerability Atlas of India[23]. The Vulnerability Atlas gives State-wise hazards maps and district-wise damage risk tables for all states and union territories. At country level, UNDP, in its Global Report Reducing Disaster Risk- a Challenge for Development[24] identified rural poverty is one of the key factors that attribute risks to hazards. However in order to mainstream HRVA in DRR a lot of effort still has to be made in training, capacity building and awareness at the state, district and community level. Adequate resources need to be allocated for carrying out these assessments and collection of necessary data, information and maps that feeds in to HRVA.

[23] http://www.bmtpc.org/disasterandmitigation.htm

[24] United Nations Development Programme, Bureau for Crisis Prevention and Recovery, www.undp.org/bcpr