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Climate Risk Management [CRM] Framework for India

Addressing Loss and Damage (L&D)

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Towards a disaster free India.....

Maj Gen Manoj Kumar Bindal
VSM
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सत्यमेव जयते

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Foreword

Climate change is a reality and is affecting every walk of our life. Compounded by other facets of environmental changes, viz. land-use changes and natural resource degradation, climate change impacts on natural systems and processes compound to produce extreme events and disasters, causing serious damages and losses to lives, infrastructure and resources. Addressing climate change related risks to development-environment complex, calls for integrated, systemic and planned approach aligned to international strategies and national action plan on climate change. Recognising the importance of loss and damage as core concerns, a framework has been delineated using diverse sets of knowledge, lessons of pilots and interventions at different levels, to address the knowledge gap in this area.

I feel happy in presenting this report entitled 'Climate Risk Management (CRM) Framework for India-Addressing Loss & Damage (L&D)'. It is based on the lessons of case studies and pilot projects for improving the knowledge base towards addressing climate risk at national and local levels. While traditional Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA) strategies typically act within an incremental adjustment learning loop, climate-related risks discussed in the context of potential L&D (Loss and Damage) may not only require new or innovative response measures, but particular attention paid to locally-applicable techniques for the understanding of risks and risk-management interventions, such as Vulnerability Capacity Assessments (VCAs) and community-led focus groups. While addressing the challenges posed by financial, technical and institutional constraints, transformative adjustment towards effective risk management can help in reducing climate change induced damages and losses.

While a number of approaches already exist in the field of short-term climate risk assessment and management, mainly in the field of extreme events, existing approaches do often not sufficiently address long-term, slow-onset changes due to climate change. Decisions systems like EIA do incorporate environmental impact and risk scenarios, which also offer opportunity for integrating anticipatory disaster impact assessment. Ministry of Environment Forests & Climate Change (MOEFCC) being the nodal Ministry of National Action Plan on Climate Change has considered reduction of damage and losses due to climate change impacts as a key concern. In this context, National Institute of Disaster Management (NIDM) in technical cooperation with GIZ adopted the structured process building on a methodological framework to assess and develop various measures at both national as well as state level contextualized to the need of Indian sub-continent.

This endeavour aims at providing practical guidelines and recommendations on climate risk assessment and risk management. I am sure the publication would be useful contribution towards addressing the challenge of systematic knowledge base on the subject of climate risk assessment and management at national, state and local levels.

Manoj Kumar Bindal

Dr Ashish Chaturvedi
Director, Climate Change
GIZ-India

Foreword

It gives me immense pleasure to introduce the publication titled 'Climate Risk Management (CRM) Framework for India-Addressing Loss & Damage' developed under 'Climate Change Adaptation in Rural Areas-India (CCA-RAI)' project. As part of Indo-German Technical Cooperation on Climate Change and funded by German Federal Ministry of Economic Cooperation and Development (BMZ), GIZ India is implementing CCA-RAI project in partnership with the Ministry of Environment, Forest and Climate Change (MoEF&CC), Government of India. The programme intends to integrate climate adaptation measures into the national and state development and strengthen the capacities of key actors for financing, planning, implementing and monitoring of climate change adaptation measures in project partner States of Himachal Pradesh, Punjab, Telangana and Tamil Nadu.

GIZ as part of this project, in partnership with International Institute for Applied System Analysis, (IIASA) and National Institute of Disaster Management (NIDM) has developed a generic Climate Risk Management (CRM) framework that can be utilised to provide guidance to assess climate risk and develop appropriate measures to address climate vulnerabilities as well as residual risks that could contribute towards loss and damage.

Internationally there is an increasing recognition that adaptation and mitigation may not be enough to manage the impacts of climate change and both climate science and the international climate negotiations stress the urgent need to develop and implement effective climate risk assessment and management approaches in order to avert, minimize and address losses and damages. The issues of climatic vulnerabilities and disaster risks thus, required a clear and present need for India to develop a robust CRM framework which can be utilized to help make decisions in tackling both these issues.

In Indian context this publication sets out a structured process building on a methodological framework to assess climate risks and develop various risk management measures at both national as well as state level. I am sure that this framework will support. I trust that the framework presented in this publication will prove to be a useful tool for institutions and stakeholders to assess and determine their response to climate-related risks in India. Further, this will enable them to make informed decisions to plan and implement measures for managing climate risks.

On behalf of GIZ India, I would like to express my gratitude in particular to Mr. Ravi S Prasad, Additional Secretary, Climate Change, MoEF&CC for providing valuable guidance for completing this assignment. I would also like to thank colleagues from GIZ Global Programme, Risk Assessment and Management for Adaptation to Climate Change for the support and technical cooperation.

Dr Ashish Chaturvedi

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ABBREVIATIONS

AOSIS	Alliance of Small Island States
BAU	Business as Usual
BMZ	German Federal Ministry for Economic Cooperation and Development
CCA	Climate Change Adaptation
CL	Collin and Lowe
COP	Conference of Parties
CRM	Climate Risk Management
DDMA	District Disaster Management Authority
DM	Disaster Management
DRR	Disaster Risk Reduction
DST	Department of Science and Technology
GIS	Geographic Information Systems
HDR	Human Development Report
IIASA	International Institute for Applied Systems Analysis
INCCA	Indian Network for Climate Change Assessment
INR	Indian Rupee
IPCC	Intergovernmental Panel on Climate Change
ISRO	Indian Space Research Organisation
L&D	Loss and Damage
MGNREGS	Mahatma Gandhi National Rural Employment Guarantee Scheme
MHA	Ministry of Home Affairs
MoEF	Ministry of Environment and Forests
MoEFCC	Ministry of Environment, Forests and Climate
NAPCC	National Action Plan on Climate Change
NCMC	National Crisis Management Committee
NDMA	National Disaster Management Authority
NDRF	National Disaster Response Force
PL	Pielke and Landsea
PRA	Participatory Rural Appraisal
SAPCC	State Action Plan on Climate Change
SCEN	A Development Scenario
SDG	Sustainable Development Goals
SDMA	State Disaster Management Authority
SFDRR	Sendai Framework for Disaster Risk Reduction
SIDS	Small Island Developing States
SREX	Special Report on Extreme Events
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
VCA	Vulnerability Capacity Assessments
WIM	Warsaw International Mechanism

1. EXECUTIVE SUMMARY

Globally, weather and climate-related risks, which potentially cause loss and damage, have increased dramatically over the past few decades. The most recent climate projections indicate a significant increase in the frequency, duration and intensity of extreme weather events as well as severe slow-onset climate-related changes. These pose a growing risk to sustainable development of communities and countries. Internationally there is an increasing recognition that adaptation and mitigation may not be enough to manage the impacts of climate change and both climate science and the international climate negotiations stress the urgent need to develop and implement effective climate risk assessment and management approaches in order to avert, minimize and address losses and damages. Specifically, a working definition for Loss and Damage (L&D) by the UNFCCC has been as follows: *"Loss and damage refers to negative effects of climate variability and climate change that people have not been able to cope with or adapt to."*

While a number of approaches already exist in the field of short-term risk assessment and management, mainly in the field of extreme events, existing approaches do often not sufficiently address long-term, slow-onset changes due to climate change. Also, risk and vulnerability assessments often do not meet the information needs of policy-makers and local governments in order to manage the risks of climate change and associated losses and damages effectively.

Against this background, the German Federal Ministry for Economic Cooperation and Development (BMZ) commissioned the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH with the implementation of the global programme on 'Risk Assessment and Management for Adaptation to Climate Change'. The programme aims at generating practical guidelines and recommendations on climate risk assessment and effective climate risk management for the international partners of German Development Cooperation worldwide. Better linking climate change adaptation, disaster risk reduction and the emerging work on how to deal with climate-related loss and damage at national and local levels as well as integrating these into comprehensive climate risk management approaches is regarded as a key aspect of this work.

This project, cooperating with the BMZ financed project Climate Change Adaptation in Rural Areas of India (CCA RAI) and partnering with KPMG India and IIASA, develops a generic Climate Risk Management (CRM) framework (building on ongoing GIZ applications, such as in Tanzania) that can be utilized to assess and develop various measures at various levels when dealing with large scale climate vulnerabilities as well as residual risks that could contribute towards national loss and damage.

The report sets out a structured process building on a methodological framework to assess and develop various measures at both national as well as state level and in exemplary fashion and applies this to the context of India as a proof of concept. The aim of the framework and process, in line with one of the goals of the 5 year workplan of the Loss and Damage mechanism to see Loss and Damage being incorporated into global and national policy and practice, is to support national institutions to assess and determine their response to climate-related risks in India.

1.1 A Climate Risk Management Process

The **six step climate risk management (CRM) process** operationalises climate risk management at scale (see Figure 1).

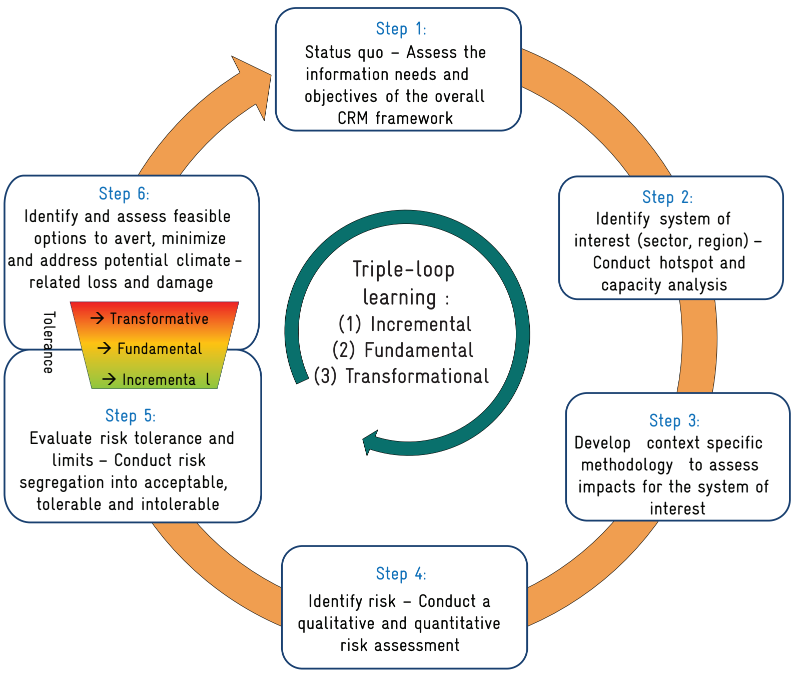
1. Assess and **match information needs with risk management objectives.**
2. Define **System of Interest.**
3. Develop **context-specific methodology**.
4. **Risk identification** to identify low and high-levels of climate-related risk.
5. **Risk evaluation** to identify acceptable, tolerable and intolerable risks.
6. **Assessment** of **risk management options.**

The framework is embedded in a learning framework for identifying appropriate actions and adjusting these dynamically over time with increased knowledge. While traditional Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA) policy typically acts within an incremental adjustment learning loop, climate-related risks discussed in the context of potential L&D may not only require new innovative response measures, but particular attention paid to locally-applicable techniques for understanding risks and risk management interventions, such as Vulnerability Capacity Assessments (VCAs) and community-led focus groups. Incremental actions are and need to be taken, yet in the face of severe financial, technical and institutional constraints, fundamental and transformative adjustment of the overall risk management approach at the national and subnational level needs attention.

1.2 Operationalising the Framework for India

The six steps can be broken down as described in the following discussion and as applied to the Indian case for the two prototype states Tamil Nadu and Himachal Pradesh.

Figure 1: Climate risk management (CRM) process for assessing Loss and Damage



Step 1: Define Status Quo

Step 1 assesses the status quo, screens the information and data requirements and frames the objective of the overall CRM framework application. This step comprises highlighting data needs and potential gaps in data availability as well as quality. The first step defines the overall objective of the CRM framework while showcasing the need for developing interlinkages between climate change and disaster risk management in terms of assessment of risks and associated data as well as institutional analysis.

India application: The first step provides a comprehensive assessment of the Indian status quo on climate change impacts and adaptation as well as disaster risk management at the selected level, e.g. sub-state community, from the country's climate and disaster profiles to a detailed assessment of the institutions involved in the both areas and the potential interlinkages between the two.

Step 2: Identify System of Interest

Step 2 takes the debate from more general level to more specific levels. This step identifies the concrete system of interest by conducting climate-related risk hot spot and capacity analysis. Step 2 is used to clearly define and delineate the boundaries of the system of interest on which the CRM framework will be applied. For example, for the current project based on stakeholder consultations, a decision was made to utilize the administrative boundaries of states as the system of interest for the framework being developed. While Step 1 defines the objective of the framework highlighting the interlinkages between climate change and disaster risks, Step 2 involves detailed climate-related risk and capacity analysis which will result in identification of suitable illustrative systems of interest, also called hot-spots.

India application: States in each climate sensitive region in the country (as listed in Step 1) are subjected to various selection criteria to assess their feasibility as a suitable system of interest for implementation of the CRM framework being developed. The figure below illustrates the process of selection of states as system of interest:

The application led to identifying two hot spot states: Tamil Nadu and Himachal Pradesh, where a broad range of climate-related risks are considered significant and are being dealt with by affected households and communities, prior work had been conducted to assess risks, and capacity to respond to risk at government level has been found to be substantial.

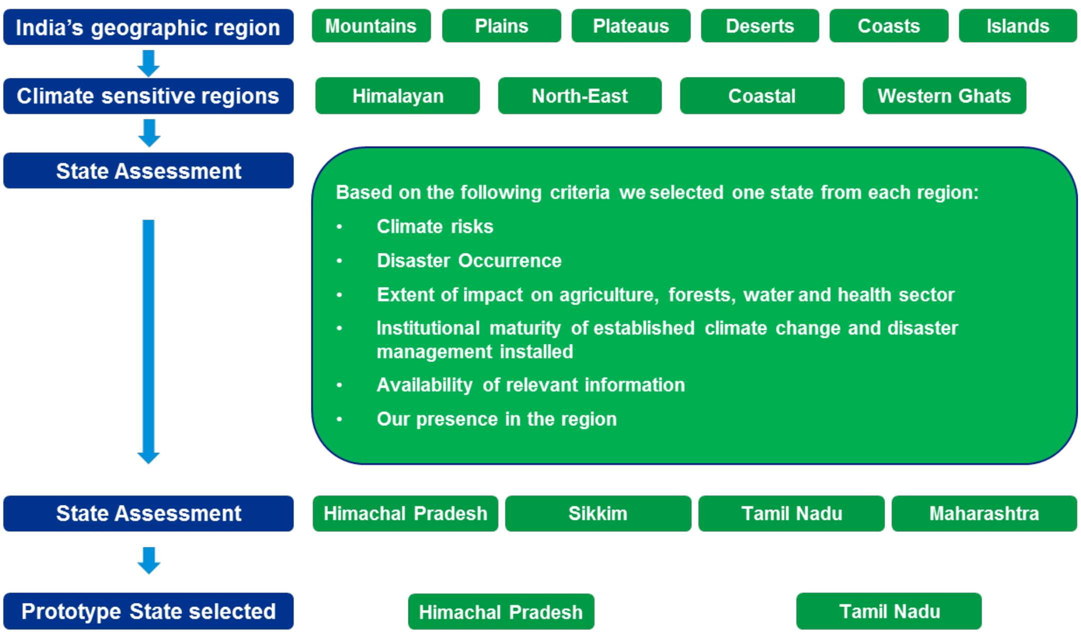


Figure 2: Illustrative selection of hot-spot states (system of interest)

Step 3: Develop Context Specific Methodology

Step 3 develops a context specific multi-method approach customized to the region(s) of interest to assess potential climate-related impacts. Products may comprise general informational studies (building on what is available on hazards and impacts, backward looking climate-risk analysis (broad risk assessment and scenarios using **available** data and information on risk) and forward-looking scenario and risk based model analysis (detailed risk assessment and scenario generation, attribution assessment) may be selected depending on the available data, resources, and expertise as well as expected output to be generated in the specific context. Next to the traditional assessment of market-based impacts, the context of L&D requires shedding light on non-monetary impacts as well as effects on informal economic activities.

Step 4: Identify Risks

Step 4 identifies risk, which is considered as determined by the risk drivers hazard, exposure and vulnerability. The climate risk assessments go through a structured process for calculating risks and the benefits of relevant adaptation measures. Thereby, direct as well as indirect, economic as well as non-economic effects have to be assessed, e.g. by employing impact chain logic. A comprehensive approach needs to align top-down insight from expert-based methods and tools with bottom-up information on households' and communities' risks gathered through participatory processes.

India application: A model-based assessment of current and future flood risk shows that expected damage (as expressed as a share of GDP is already substantial and bound to increase with climate, but also socio-economic (asset increase) change (see figure 3).

Table 1: Types of assessment studies and current application

Product incl. Methods and Tools	Purpose	Resource and Time Commitment	Expertise Required	Application
Informational, impact-focused study (use available information, on hazards and impacts)	Provide a broad overview of past hazards, losses and damages	Small – Person- weeks	Climate science and policy, empirical skills, statistics	Himachal Pradesh
Backward-looking climate risk analysis (broad risk assessment and scenarios using **available** data and information on risk)	Overview of past and future risks building on reported loss and damage	Moderate Person-months	Climate science and policy, risk management, economics, statistics	Tamil Nadu
Forward-looking climate risk analysis including new climate scenarios (detailed risk assessment and scenario generation, attribution assessment, more scientific)	Detailed climate scenario-based risk analysis building on risk modelling determined by hazard, exposure and vulnerability analyses	Substantial Person-months up to person-year	Climate science and policy, risk management, economics, statistics, climate modelling	NA

India application: Our study conducts an informational assessment for the state of Himachal Pradesh and for Tamil Nadu strongly focuses on the backward-looking approach, which builds on a broad risk assessment and available scenarios (as available for Tamil Nadu) utilizing available information to provide an overview of past and future risks on reported loss and damage.

For Tamil Nadu, the dominant risks are cyclonic storms with associated wind and flood damage (sudden-onset event) and salinisation in the wake of sea level risk and coastal inundation (a more slow-onset type of event). For the adelphi and GIZ study in Tamil Nadu statistical modelling was undertaken building on the reported damages

Figure 3: Expected urban damage due to riverine flood risk in India (in % of GDP) in 2030 for different combinations of RCPs and SSPs, compared to 2010..

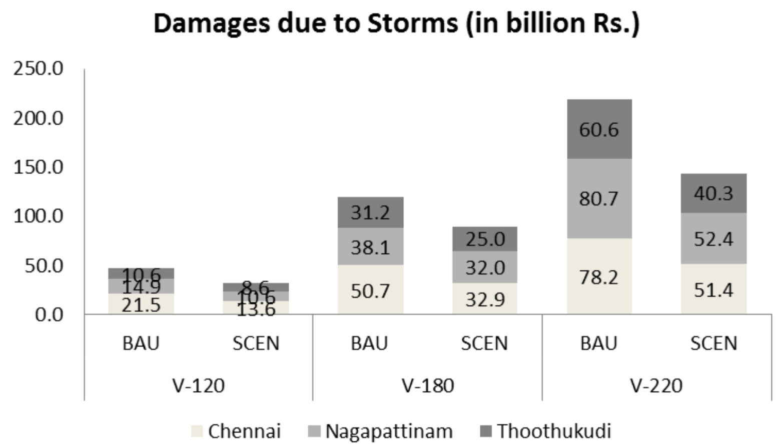


Figure 4: Economic damages from storms in Tamil Nadu for a baseline and a scenario with adaptation. Adelphi and GIZ, 2015. Note: BAU: baseline as usual (no additional adaptation); SCEN: adaptation-storm proofing homes

to understand the potential to avoid and reduce future cyclone-related damage.

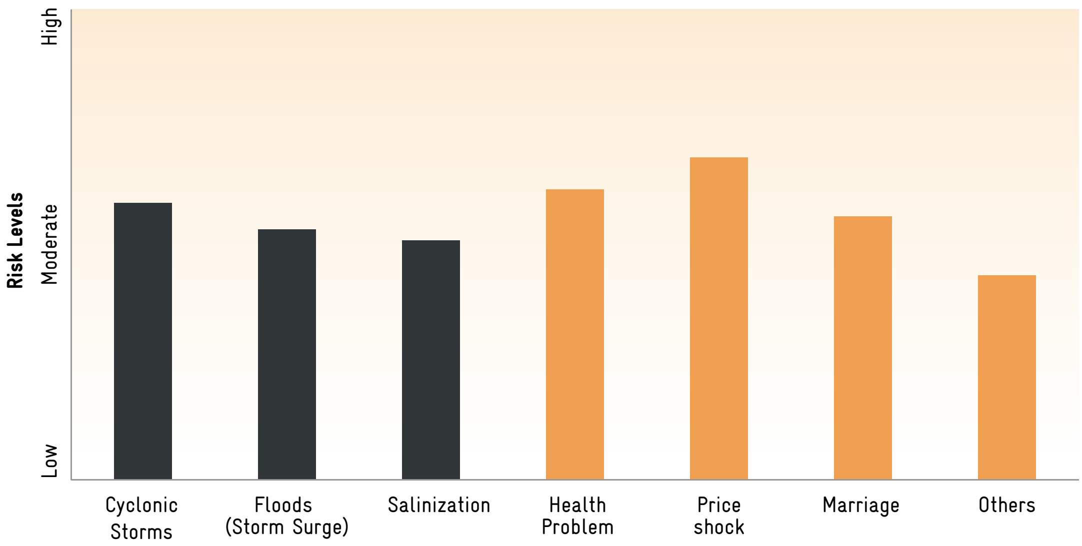
Overall, the risk analysis compiled for the report (building in available data and modelling), shows that risk is on the increase due to climate change, but also socio-economic changes (currently the stronger contribution. Furthermore, part of the risk can be reduced by storm-proofing housing (the SCEN scenario) as compared to a baseline of not doing (BAU scenario). Yet, reduced damages would amount to a maximum 30%, so substantial residual risk would remain overall.

Step 5: Evaluate Risk Tolerance and Limits

Step 5 sets out to understand what risk means to those potentially affected. This involves evaluating risks by establishing risk tolerance thresholds. Two basic approaches are presented: (i) semi-quantitative surveys or focus group-based assessments, which gauge risk tolerance from reported risk perceptions and risk responses ; (ii) risk-based modelling formalising risk-based decision-making building on modelled risk perceptions, e.g. to understand government actors risk tolerance for dealing with climate-related risks.

India application: Building on surveys and participatory engagement with farming and non-farming households and the public sector in Tamil Nadu, the study finds climate-related risks (cyclones, floods, salinisation) as important (overall considered moderate) and of similar concern as other prevalent risks, such as associated with price shocks and health problems.

Figure 5: The risk space in Tamil Nadu as evaluated from household responses (mean)

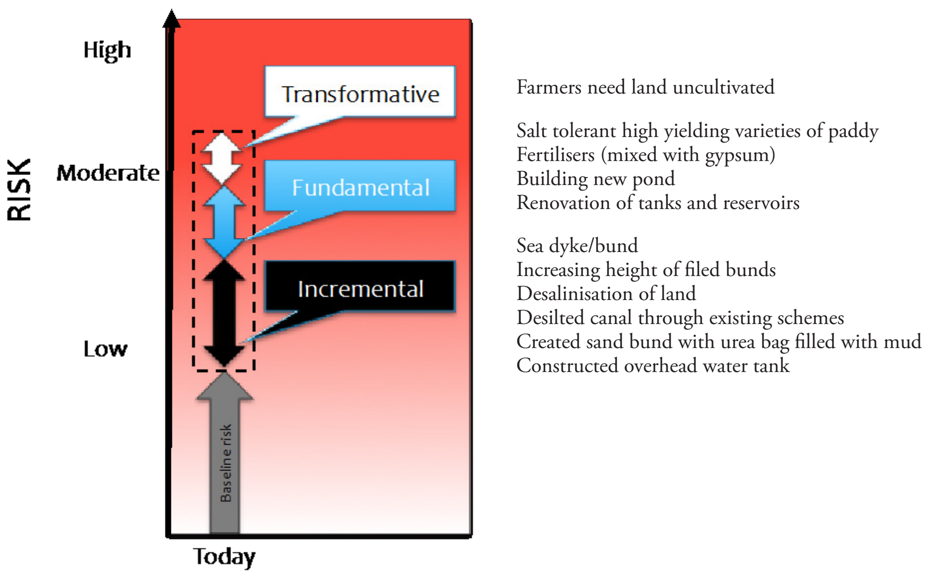


Step 6: Identify Feasible Options

Step 6 assesses potential options to reduce climate risks and identifies risk management options for residual risk, which potentially cause loss and damage. There is a wide spectrum of potential risk reduction, preparedness and risk financing measures that can be taken in order to reduce or finance risk. While risk reduction and prevention are at the centre of attention, it is important to identify options to deal with residual risks that could potentially lead to loss and damage. A key focus of our study dealing with severe risks touching on the limits of adaptation is to apply the risk management classification developed above, which groups risk responses into incremental, fundamental or transformative. This step also incorporates the identification of technologically, ecologically as well as socioeconomically feasible options.

India application: The community-focussed survey conducted in Tamil Nadu led to a list of various risk management actions undertaken and under consideration. For example, for farm-level household responses, the following schematic can be worked out building on our methodological approach. Most interventions can be considered as incremental, some as fundamental, and one as transformative (leaving land uncultivated) (see figure 6).

Figure 6: The risk and options space in Tamil Nadu as identified from household responses (farm level)



1.3 Conclusions and Implications

The exemplary application of the comprehensive CRM framework to India and the states of Tamil Nadu and Himachal Pradesh serves to test the methodological approach and glean its usefulness at state and local levels. The methodology is meant to support public sector institutions (and, when applied to other contexts, other governments nationally and internationally) in order to assess and determine their response to climate-related risks at the national as well as the sub-national level. The application to India largely consisted of a backward-looking climate risk analysis for the state of Tamil Nadu, for which information developed for a prior project was post-processed according to our six step climate risk management process.

Our assessment for Tamil Nadu shows risks are on the rise due to climate and socio-economic factors, and that these risks are significant in terms of affecting households and the public sector.

Furthermore, actions taken are largely of incremental nature, but also fundamental and importantly transformative actions are already being taken by farmers and households exposed to cyclone and flood risks, indicating links to the Loss and Damage debate. Government institutions work well within their remit to provide incremental assistance yet are usually not charged to deal with fundamental and transformative options. Thus, the options space needs more attention and deliberation with those at risk and in charge to further deploy interventions with public support from state, national to international levels. As argued in the literature (see e.g. Mechler and Schinko, 2016), the CRM framework and associated L&D debate is largely about extending support for (negatively or positively) transformative options. Thus, we suggest the different policy regimes at national and international levels would deal with the categories of risk management options as follows:

- **Incremental options:** National and state-level DRR and CCA related policy options.
- **Fundamental options:** National and state-level DRR and CCA related options, international levels to deal with L&D related actions.
- **Transformative options:** Predominantly international levels for L&D related actions.

Identification and evaluation of feasible options (interventions, measures, policies, among others) for addressing potential climate-related loss and damage will result in better implementation of the six-step CRM framework in the system of interest, to be further scaled up to address climate risks and L&D within regional, state and national boundaries.

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2. INTRODUCTION

2.1 Point of Departure and Objectives

Globally, weather and climate-related risks, which potentially cause loss and damage have increased dramatically over the past few decades. The most recent climate projections indicate a significant increase in the frequency, duration and intensity of extreme weather events as well as severe slow-onset climate-related changes. These pose a growing risk to sustainable development of communities and countries.

Internationally there is an increasing recognition that adaptation and mitigation may not be enough to manage the impacts of climate change and both climate science and the international climate negotiations stress the urgent need to develop and implement effective climate risk assessment and management approaches in order to avert, minimize and address losses and damages. While a number of approaches already exist in the field of short-term risk assessment and management, mainly in the field of extreme events, existing approaches do often not sufficiently address long-term, slow-onset changes due to climate change. Also, risk and vulnerability assessments often do not meet the information needs of policy-makers and local governments in order to manage the risks of climate change and associated losses and damages effectively.

Against this background, the German Federal Ministry for Economic Cooperation and Development (BMZ) commissioned the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH with the implementation of the global programme on **'Risk Assessment and Management for Adaptation to Climate Change'**. The programme aims at generating practical guidelines and recommendations on climate risk assessment and effective climate risk management for the international partners of German Development Cooperation worldwide. Better linking climate change adaptation, disaster risk reduction and the emerging work on how to deal with climate-related loss and damage at national and local levels as well as integrating these into comprehensive climate risk management approaches is regarded as a key aspect of this work.

This project, cooperating with the BMZ financed project Climate Change Adaptation in Rural Areas of India (CCA RAI) and partnering with KPMG India and IIASA, develops a generic Climate Risk Management (CRM) framework (building on ongoing GIZ applications, such as in Tanzania) that can be utilized to assess and develop various measures at various levels when dealing with large scale climate vulnerabilities as well as residual risks that could contribute towards national loss and damage.

The report sets out a structured process building on a methodological framework to assess and develop various measures at both national as well as state level and in exemplary fashion and applies this to the context of India as a proof of concept. The aim of the framework and process is to support national institutions to assess and determine their response to climate-related risks in India.

2.2 Definitions and Classifications

A Climate risk management (CRM) framework highlights the various risk management actions to be taken to respond to climate-related risk considering any perceived or real constraints and limits to adaptation. In order to inform the risk management and adaptation discourses, this framework can be utilized at a national level to assess and develop various measures at both national as well as state level when dealing with large scale climate risks as well as residual risks that could contribute to potential loss and damage.

Generally acknowledging political and normative controversies with regard to the international Loss and Damage debate, and taking an objective scientific point of view, the CRM Framework underlines the need to support vulnerable communities in hot-spot countries that are severely impacted by climate change, particularly when dealing with high-level climate-*related risks*. Loss and Damage refers to physical and financial impacts and risks that have not been avoided (and reduced), can be avoided, and are in certain cases unavoidable. To operationalise support for those countries with highest needs, we suggest here a conceptual L&D decision-support CRM framework, comprising of rigorous climate risk analytics and comprehensive climate risk management approaches.

So far there has been no accepted official definition of loss and damage. The working definition of Loss and Damage (L&D) as defined by UNFCCC is as follows[1]:

> **"Loss and damage refers to negative effects of climate variability and climate change that people have not been able to cope with or adapt to."**

These effects include a communities' or regions' inability to adequately respond to climatic changes and the adverse effects and associated costs with the adaptation and coping measures. These effects can be both economic and non-economic in nature

While evaluating L&D as a whole, it refers to the physical and financial impacts and risks that have not been avoided (and reduced), can be avoided, and are unavoidable vis-à-vis climate related risks. These risks have been associated with sudden-onset events (flooding, cyclones etc.) and slow-onset impacts (droughts, sea level rise, glacier melts etc.). The popular consensus while discussing losses is that it is associated with irreversibility, such as the fatalities/ destruction from disasters cannot be reversed, however the damages/ impacts resulting from such disasters can be lessened/ alleviated by various measures

2.3 A History of Loss and Damage

The concept of Loss and Damage has been raised by the Alliance of Small Island States (AOSIS), representing the vulnerable small island development states, on international forums, since the inception of UNFCCC. During the 18th Conference of Parties (COP18), in 2012, in Doha, the COP officially invited all parties to augment establishment of a Loss and Damage mechanism. In line with this call for action at COP 19, in Warsaw, a Warsaw International Mechanism (WIM) for Loss and Damage was established and allocated responsibility to address L&D.

The mechanism's mandate is *'to address loss and damage associated with impacts of climate change, including extreme events and slow onset events, in developing countries that are particularly vulnerable to the adverse effects of climate change'*.[2]

1 Loss & Damage: Evidence from the Front Lines, UNFCCC, 2012, Accessed at: https://unfccc.int/files/press/media_outreach/application/pdf/cop18_mw_loss_and_damage.pdf

2 http://unfccc.int/adaptation/workstreams/loss_and_damage/items/8134.php

The following figure showcases the chronology of L&D at the UNFCCC negotiations[3].

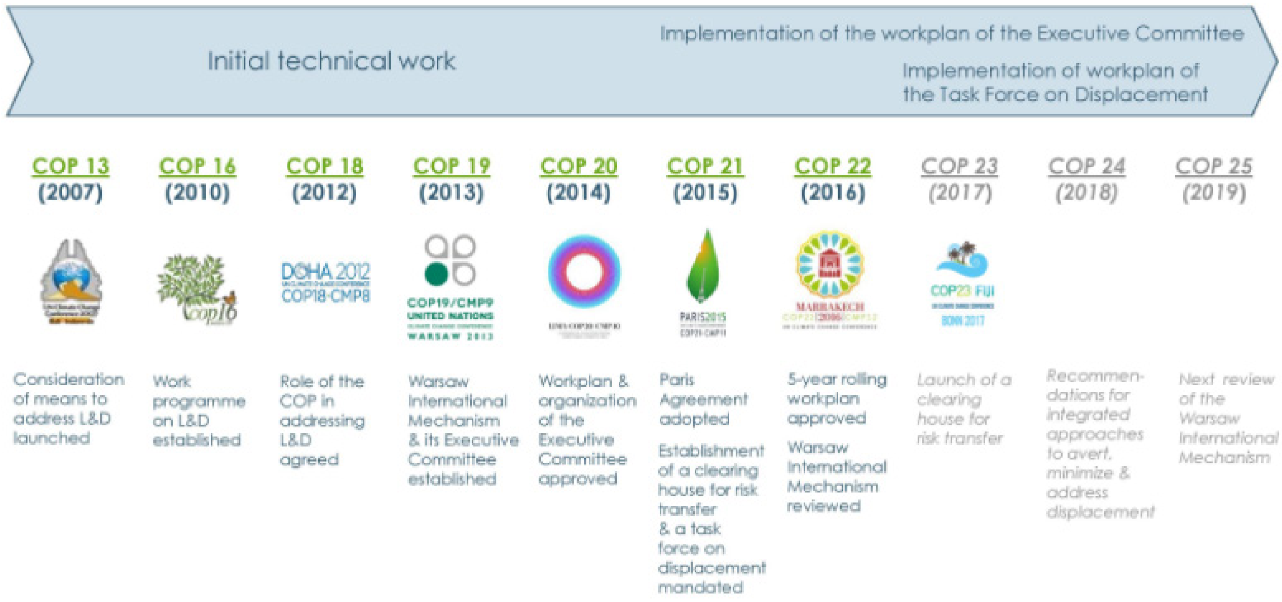


Figure 7: Loss and damage chronology at UNFCCC

3 Milestones, UNFCCC, Accessed at: http://unfccc.int/files/adaptation/cancun_adaptation_framework/loss_and_damage/image/jpeg/milestones.jpg

3. CLIMATE RISK MANAGEMENT FRAMEWORK

This report sets out a CRM framework making use of a customized six-step comprehensive CRM assessment and climate risk analytical approach. A CRM assessment helps to understand the current and future impacts as well as potential actions to avoid and reduce risks. CRM has become the overarching methodological framework for assessing climate change impacts and subsequent adaptation requirements. This has been further reinforced by the Special Report on Extreme Events (SREX) by IPCC and its 5th Assessment Report[4] (IPCC, 2014) which have identified development of a CRM framework for comprehensively reducing, preparing for, and financing climate-related risk, while tackling the underlying risk drivers, including climate-related and socio-economic factors. These risks associated with hazard, vulnerability and exposure have been illustrated in the figure below:

The Intergovernmental Panel on Climate Change (IPCC) has attributed slow-onset events and some sudden-onset extreme climatic events to anthropogenic greenhouse gas emissions based on an event based trend analysis. In order to frame a CRM framework which is strongly focused on climate vulnerability, there is a need to include a risk perspective by emphasising risk as an outcome metric, with an understanding of the risks and impacts linked to 10, 50, 100 year events, estimated using probabilistic distributions. This approach also identifies the difference between frequent and rare events, which are a key feature of climate related risks. Risk assessment can be applied to sudden-onset and slow-onset climate-related processes unfolding over timescales from hours to days to months and years (figure 9).

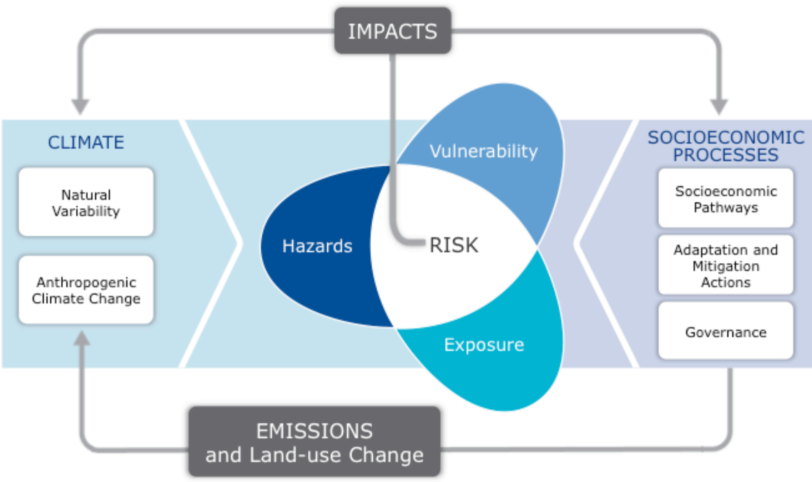
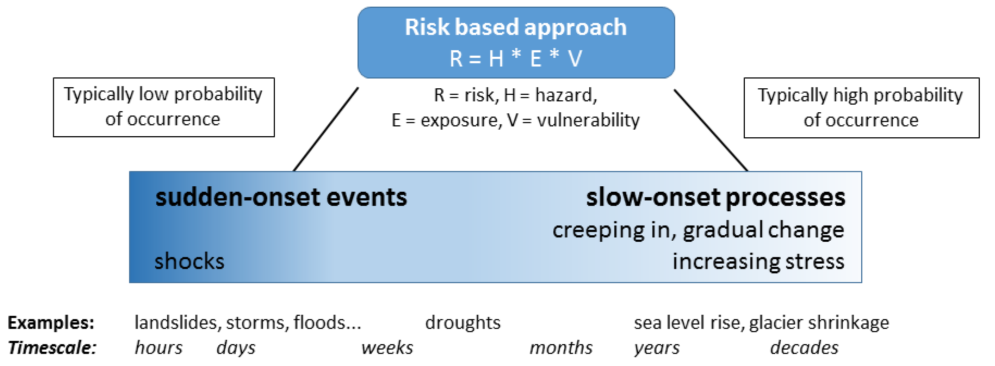


Figure 8: Risk as a function of hazard, exposure and vulnerability. IPCC, 2012 & 2014

4 Fifth Assessment Report (AR5), IPCC, 2014, Accessed at: https://www.ipcc.ch/report/ar5/

Figure 9: The risk concept as applied to sudden-onset and slow-onset processes



Furthermore, in addition to climate risk assessment, a climate risk analytical approach supports operationalisation at decision-making level especially while dealing with the scale of the framework.

While formulating the risk analytical approach, there is a need to identify the following key components:

- Risk identification to identify low and high-levels of climate-related risk
- Risk evaluation to identify acceptable, tolerable and intolerable risks
- Risk tolerance, which will need to be customisation friendly, since it should incorporate recommendations from the stakeholders primarily impacted by climate change
- Embedding in a learning framework for identifying appropriate actions and adjusting these dynamically over time with increased knowledge.

This approach has the following key characteristics:

- A comprehensive CRM approach focus on the shorter-time horizon and up to the period of 2030/40, which is generally considered the relevant time scale for decisions on climate risks and adaptation, and synergistically integrate information relevant to Disaster Risk Reduction (DRR), Climate Change Adaptation (CCA) and L&D policy and actions.
- This approach comprises of the present and future climate-related risks including the three loss categories defined earlier namely avoided, unavoided and unavoidable (beyond 2°C and strong global warming) risks.
- A comprehensive CRM approach/ policy is able to categorize adjustments/ interventions into incremental, fundamental and transformative .
- Considering the increasing impacts of climate change, the CRM framework particularly needs to focus on fundamental and transformative actions which go beyond the traditional DRR and CCA measures, in addition to fostering transformative capacities of communities which are particularly at risk.

The framework is to be dynamic in nature, which allows for updating decisions over time with mounting evidence and insights based on the local conditions. It will constitute traditional DRR and CCA policies, which normally follow an incremental adjustment-learning loop in addition to new innovative response measures to tackle climate-related risks under the ambit of potential L&D. In order to allow for the implementation of this framework, a fundamental and transformative adjustment of the overall risk management approach at the national and subnational level will need to be assessed.

This six-step approach **climate risk management (CRM) process** builds on a number of best-practice criteria as identified in the literature and further to discussed in the report.

- **Risk-based frameworks** (actual and potential risk)
- Consider **portfolios of risk policy options**

- Consider **monetary and non-monetary risks**
- Visualisation of climate risks with **high and low adaptation**
- **Consider slow-& sudden-onset events**
- **Impact chains** to visualise and assess linkages between direct and indirect impacts
- **Risk evaluation: Consider risk tolerance and risk layering**
- Integrate with **climate scenarios**
- Allow for learning as part of **multi-stakeholder collaboration**

A six-step CRM approach developed builds on these best-practice criteria and is illustrated in the following figure:

The framework approach operationalises climate risk management at scale in order to:

1. Assess and **match information needs with risk management objectives**
2. Define **System of Interest**
3. Develop **context-specific methodology**.
4. **Risk identification** to identify low and high-levels of climate-related risk.
5. **Risk evaluation** to identify acceptable, tolerable and intolerable risks.
6. **Assessment** of **risk management options**

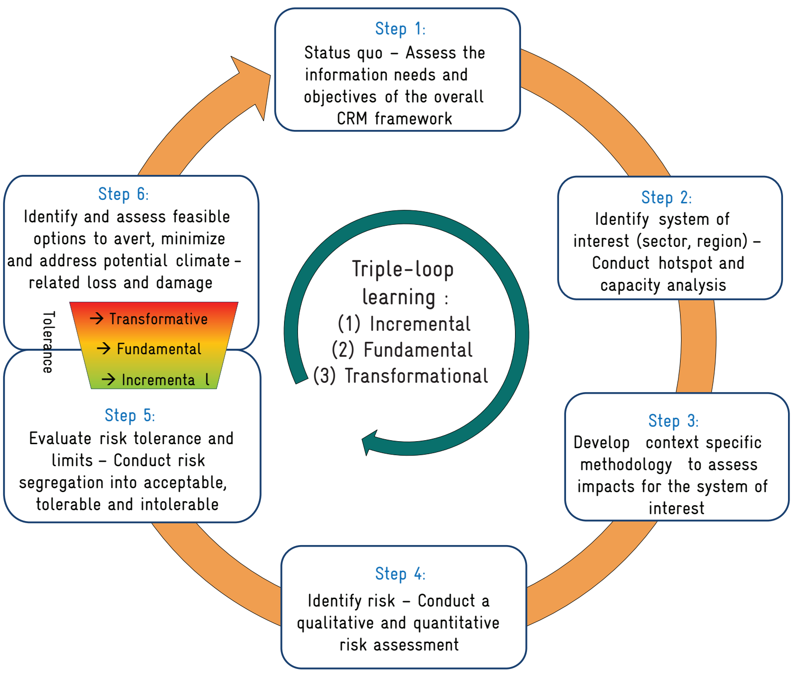


Figure 10:
Six Step CRM Framework

Box 1: Theories of learning for climate risk management

Organizing processes such as the comprehensive CRM framework for India suggested here implies tackling fundamental scientific questions involving uncertainty, as well as applying learning theories for reducing these uncertainties. In the context of climate change, Jones et al. (2014) suggest distinguishing between CRM assessment methodologies and responses based on the notions of complexity and uncertainty. In a similar vein, Lavell et al. (2012) suggest a learning loop framework that integrates different learning theories, such as experiential learning, adaptive management and transformative learning. Each loop, or theory of learning, is targeting a specific CRM situation characterized by differences in the level of uncertainty decision making processes are confronted with.

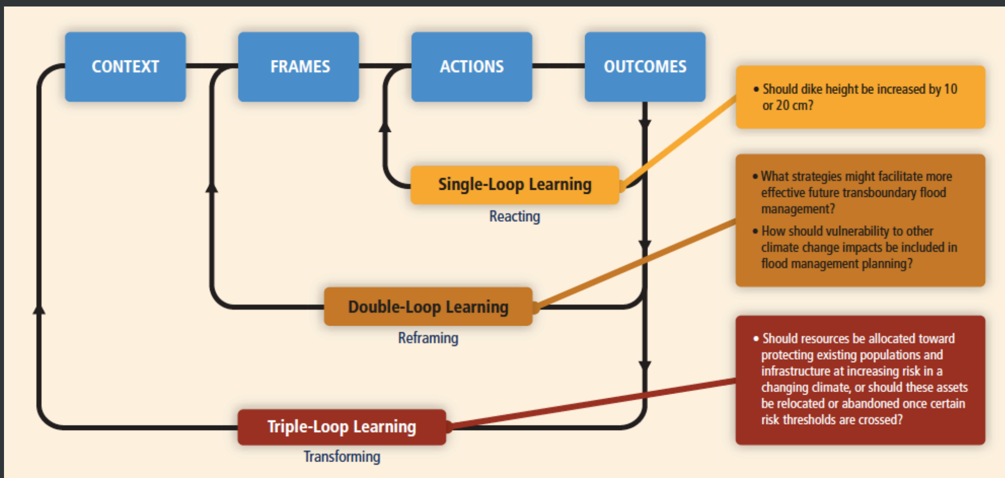


Figure 11: Learning loops: pathways, outcomes, and dynamics of single-, double-, and triple-loop learning and applications to flood management. Lavell et al., 2012

Accordingly, in the short term for simple risks—characterised by relatively low uncertainty in terms of occurrence and outcomes, as well as linear cause-effect relationships–, standard analytical, expert-centric techniques (such as risk modelling) would be suitable for deriving estimates of future risks. Over time, providing there was an increase in knowledge, these estimates could be improved and in turn communicated to key stakeholders. Complicated risks, defined by uncertainty in outcomes and frequency, become prevalent in the medium-term and would need to see strong collaborative and iterative stakeholder interaction, including reframing both learning and management processes as well as mental and analytical models. Finally, in the long-term, complex risks, characterized by deep uncertainty and contested outcomes, require strong deliberative and adaptive exercises to foster shared understanding and ownership. This approach to learning raises deep questions regarding the underlying principles of CRM, which could lead to a fundamental transformation of existing CRM practices, where e.g. planning is aimed at robust strategies rather than optimality.

4. DEFINE STATUS QUO

Step 1's function is to help users of the CRM framework determine and define the purpose of using the framework. Once the objectives of utilizing the framework have been defined, project proponents will need to check the availability of various data points on numerous elements such as climate change in the region, regional institutional infrastructure and capacity, amongst others that will be necessary to support this framework in achieving its defined objectives. Ultimately, the purpose of the assessment, its level of complexity and the approach to communicate the results will depend on the specific audience of the assessment and the objectives defined at the beginning of the assessment.

This step will require screening of available and potential data availability and requirements pertaining to DRR and CCA and other such traditional approaches. The quality of data currently available in the region of interest will be crucial. It is also important to define the purpose in close collaboration with all partners, clients and stakeholders that are relevant within the scope of the assessment. This step also builds on identification of data points required for implementation of the overall framework at a national or sub-national level, which can then be narrowed down to a regional level (see Step 2), by identifying the potential gaps in the data quality and its availability both on a national as well as a regional level.

As mentioned earlier, the purpose of this step is to identify the primary objective of the six step CRM process. In case of the current project, our primary objective is to develop a robust, scalable CRM framework for India which can be utilized at multiple levels across the country (national, sub-national, regional, local, etc.) to determine the various climate change risks likely the impact the country while also providing a broad understanding of the loss and damage likely to be caused due to these risks. For the purpose of this report we have applied Step 1 at the national level.

Given the aforementioned objective, Step 1 will also be utilized to take a stock i.e. understand the status quo regarding the climate change and disaster risks/impacts currently affecting the country. Furthermore, as part of Step 1 we will also study the existing climate and disaster related institutions currently active in the country as well as the actions taken by these institutions to manage climate change and disaster risks in India.

Thus, the CRM framework will support the identification, monitoring and reduction of climate related risks and associated loss and damage. Some of the key elements that will need to be considered in Step 1 to achieve this objective will include:

- Information on the climate vulnerability profile at the level of assessment
- Information on the disaster risk profile at the level of assessment
- Information on socio-economic profile at the level of assessment

- Information on existing and potential adaptation options at the level of assessment
- Information on vulnerable people, regions or sectors at the level of assessment
- Information on funds allocated to vulnerable people, regions or sectors at the level of assessment
- Maturity of DRR and CCA policies and institutions and existence of any inter-linkages between them
- Information on the technical skill sets and capabilities of existing resources, and whether there is a need to establish new institutions exclusively for the CRM framework

4.1 Need for a CRM Framework in India

According to India's 2nd National Communication to the UNFCCC, a majority of its population is vulnerable to climate change and its impacts (Figure 12).[5] The economy is closely tied to climate sensitive sectors such as agriculture, forestry and water among others, as well as to its natural resource base, thereby increasing its exposure and sensitivity to changes in existing climatic conditions.

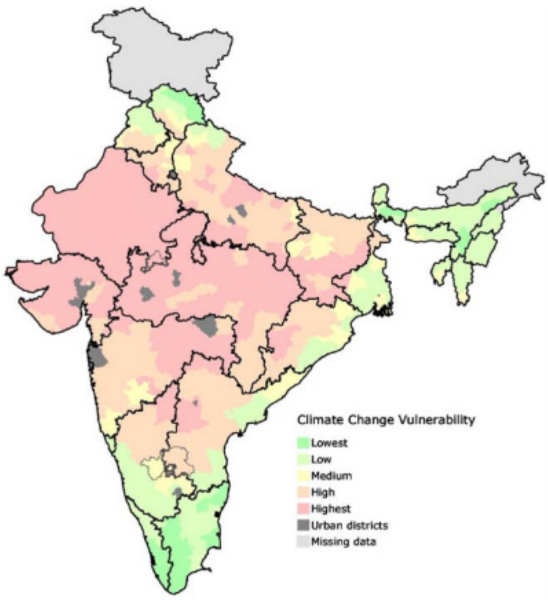


Figure 12: District-level mapping of climate change vulnerability, measured as a composite of adaptive capacity and climate sensitivity under exposure to climate change

Exposure and sensitivity to climate change is exasperated by the fact that nearly 18% of the world's population is occupying only 2.3% of the world's land area. Thus, there is an immense stress to harness indigenous resources efficiently while ensuring a sustainable development pathway.

The country's distinct topography and geographic features results in a wide range of climatic conditions across different regions. These climatic aspects continue to influence the biological, cultural and economic conditions. However, the climatic variability and geographic features also result in various forms of disaster occurrences such as cyclones, earthquakes, landslides and flooding among others.

Thus, given the confluence of climatic vulnerabilities and disaster risks, there is a clear and present need for India to develop a robust CRM framework which can be utilized to help make decisions in tackling both these issues.

4.2 Requirements for a CRM Framework in India

As discussed earlier, in order to assess risk comprehensively, there is a need to understand the interaction between climate change and disaster risks. In order to develop a robust and extensive CRM framework, there is a need for various data inputs.

Commonly implemented Disaster Risk Reduction (DRR) approaches, usually comprise of an assessment of the interaction of a vulnerable society with the hazards of the disaster event to determine the social, environmental and physical risk factors.

5 Mapping vulnerability to multiple stressors: climate change and globalisation in India, O'Brien et al, 2004, pp307, Accessed at: https://www.researchgate.net/profile/Robin_Leichenko/publication/222564691_Mapping_Vulnerability_to_Multiple_Stressors_Climate_Change_and_Globalization_in_India/links/0046352b455c18ae07000000.pdf

On the other hand, Climate Change Adaptation (CCA) approaches follow the IPCC guidelines defining vulnerability as:

> **"The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt."6**

The framework would need access to the following key data inputs:

- Information about the climatic hazard, including current climatic variability and future, long-term projections
- Information about vulnerability and exposure
- Information about the past disaster occurrences including its magnitude, frequency, location, returning period and duration
- Information on physical damage caused, repair and rehabilitation costs along with the financial capacity of the existing institutions to absorb an L&D event
- Access to past, present and projected socio-economic data
- Information on the existing DRR, CCA and other government and social institutions
- Information on the technical skill sets and capabilities of existing resources to absorb innovative global best practices

These inputs can be further accessed further at a regional level, to identify the precise system of interest to implement the framework. In the following sections, a broad assessment of India's current climate and disaster profile has been carried out to illustrate the information that needs to be gathered as part of Step 1 to provide a detailed picture of India's current status with respect to climate change and disaster management.

6 IPCC AR5, Climate Change 2014: Impacts, Adaptation and Vulnerability. Accessed at http://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-IntegrationBrochure_FINAL.pdf

4.3 India's Climate Profile

India's vulnerability to climate change can be elaborated further by breaking down the country into regions susceptible to changes in climatic conditions and frequency of disaster occurrences. According to the 4*4 Assessment report prepared by INCCA[7], India primarily has four climate sensitive regions namely:

- Himalayan Region
- Western Ghats
- North-Eastern Region
- Coastal Region

Himalayan Region

This region spreads across the North and North-eastern part of India. The states of Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Meghalaya and two states partially i.e. the hill districts of Assam and West Bengal are a part of this region.

Some of the potential climate change impacts predicted for 2030 are:

- This region could witness an increase in temperature, increase in rainfall intensity and the number of rainy days.
- Increase in temperature could result in increased forest fires and glacier melts.
- Flash floods due to varying temperature changes could result in large scale landslides and hence loss of agriculture area affecting food security.

Figure 13: Himalayan Region

7 Climate Change and India: A 4*4 Assessment, INCCA, 2010, Accessed at: http://www.moef.nic.in/downloads/public-information/fin-rpt-incca.pdf

- Projected increase in glacier melts could result in increased summer flows in some river systems for few decades, followed by a reduction in flow as the glaciers disappear.

Western Ghats

This region is the eroded precipitous edge of the Deccan Plateau, located along the western southern part of India. This region includes states of Maharashtra, Goa, Karnataka, Tamil Nadu and Kerala.

Some of the potential climate change impacts predicted for 2030 are:

- The temperature in the Western Ghats is projected to increase.
- The Northern part is expected to experience increased rainfall while southern areas will remain unaffected.
- Increased rainfall could result in increased flooding and soil erosion on a large scale.
- Number of rainy days are likely to decrease along the entire Western coast.
- A wide variability in the precipitation change will be observed at the west and east coast region

Figure 14: Western Ghats

North-Eastern Region

This region is very vulnerable to water-induced disasters because of its location in the eastern Himalayan periphery, fragile geo-environmental setting and economic under-development. It includes the 'Seven Sister' states namely Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura along with Sikkim.

Some of the potential climate change impacts predicted for 2030 are:

- There is a projected increase in the surface air temperature.
- An overall decrease in winter precipitation and increase in intensity of summer precipitation has been projected for the region.
- This will cause increase in runoff and landslides during summer precipitation and decrease in yields during winters.
- Number of rainy days is projected to decrease while rainfall intensity is projected to increase.

Coastal Region

Figure 15: North-Eastern Region

India's coastline extends to 75,500 km as per the notification CRZ, 2010. This region is divided into Eastern Ghats including states of West Bengal, Orissa, Telangana, Tamil Nadu and Western Ghats including states of Gujarat, Maharashtra, Goa, Karnataka and Kerala.

Some of the potential climate change impacts predicted for 2030 are:

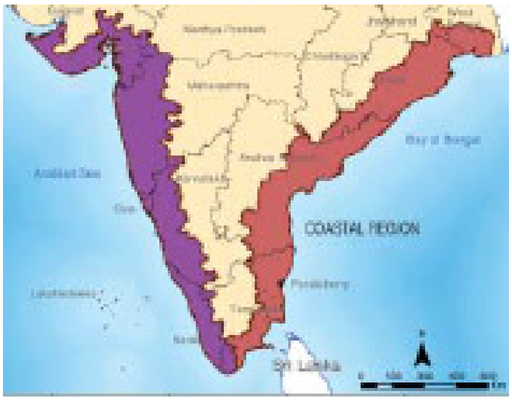


Figure 16: Coastal Region

- An increase in sea surface temperatures and rain fall intensity is projected for the region.
- There is a projected decrease in number of cyclonic disturbances, however, cyclonic systems and storm surges might be more intense in the future, especially in the east coast.
- An increase in sea level along the coastline is estimated.

This analysis highlights the climate change related projections across India. However, we would need to understand the disaster occurrences also in order to assess the L&D potential in India. The next section highlights India's disaster profile thereby showcasing the extent of hazard exposure and sensitivity of these climate sensitive regions.

4.4 India's Disaster Profile

According to various disaster management agencies in India, disasters can be categorized as natural and human-induced. This can be further classified into water and climate related disasters; Geological related disasters; chemical, industrial and nuclear related disasters; accident related disasters; and biological related disasters.

The National Disaster Management Authority (NDMA) has drafted a National Disaster Management Plan[8], which categorizes disaster occurrence due to various triggers. Some of the typical disaster occurrences in India are captured below:

- **Droughts:** In India around 68% of the country is prone to drought in varying degrees.
- **Floods:** India is one of the most flood prone countries in the world, with 1/8th country facing floods annually
- **Tropical Cyclones:** India with a coastline of about 7516 km is exposed to nearly 10% of the world's tropical cyclones.
- **Heat Wave:** Abnormally high temperatures have been observed across the country.
- **Earthquakes:** The Indian sub- continent situated on the boundaries of two continental plates is very prone to earthquakes.
- **Landslides:** 30% of world's landslides mainly affect the Himalayan region and the Western Ghats of India.
- **Tsunami:** The east and west coasts of India and the island regions are likely to be affected by tsunamis.
- Thunderstorm, Hail, Dust storm and Cold Wave & Fog

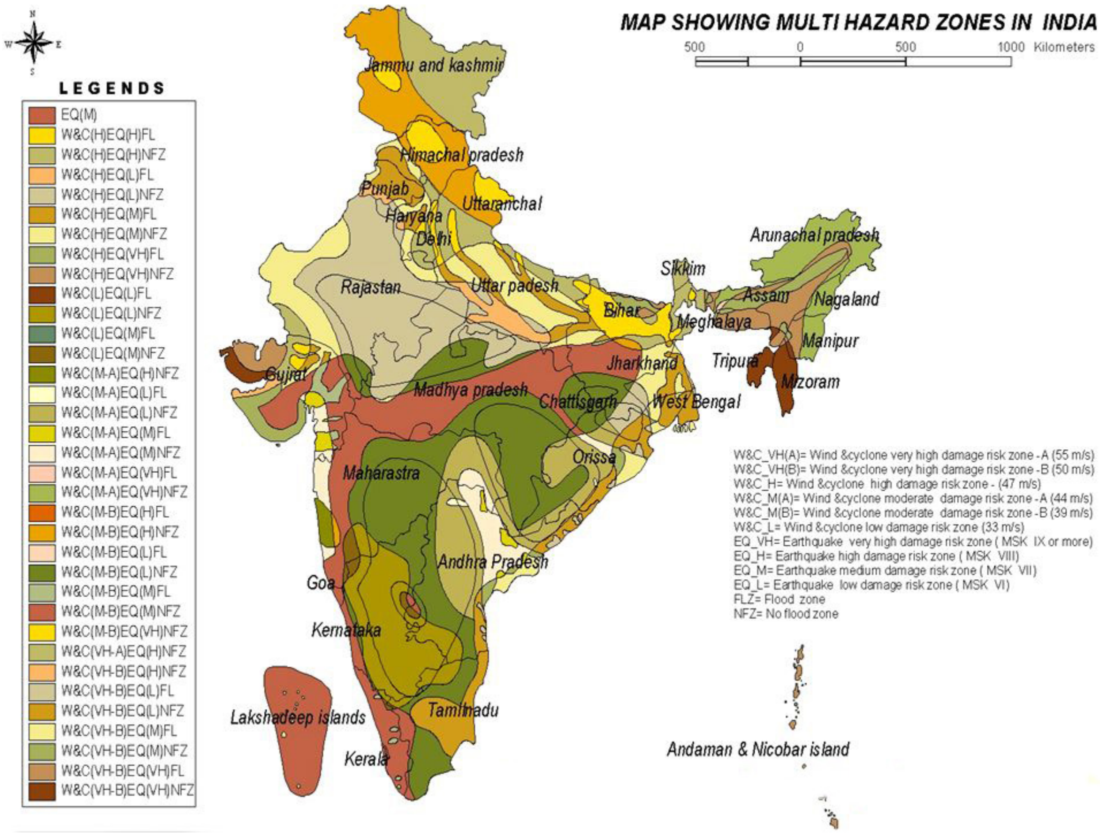
The map[9] (Figure 17) highlights the multi-hazard zones across the country. Changes in climatic conditions could potentially increase the frequency and intensity of current extreme weather events and could give rise to new vulnerabilities with differential spatial and socio-economic impacts on communities. The unprecedented increase is expected to have severe impacts on the hydrological cycle, water resource, droughts, flood, drinking water, forest and ecosystems, sea level/coastal area losses of coastal wetlands and mangroves, food security, health and other related areas.

As discussed earlier, for an overall framework to be developed, there is a need for mapping the CCA and DRR data requirements.

8 National Disaster Management Plan, NDMA, 2016, Accessed at: http://ndma.gov.in/images/policyplan/dmplan/National%20Disaster%20Management%20Plan%20May%202016.pdf

9 Disaster Management in India, Ministry of Home Affairs, 2011, pp12, Accessed at: http://ndmindia.nic.in/disaster_management_in_india_09052017.pdf

Figure 17: Multi-hazard map of India



Along with this data, there is also a need for institutions operating in the field of CCA and DRR to be identified and linkages established.

Even India's Nationally Determined Contributions[10] (NDC) acknowledges the importance of the link between "adaptation, disaster risk reduction and loss and damage" and explains that India has laid down the Sendai Framework for Disaster Risk Reduction in response. However, it expresses that there remains "an urgent need for finance to undertake activities for early warning system, disaster risk reduction, loss and damage and capacity building at all levels.

4.5 India's Climate Change and Disaster Management Institutional Framework

As mentioned earlier, there is an intrinsic relationship between climate change vulnerability and disaster risk management when dealing with the development of a robust L&D framework. It thus becomes imperative to explore plausible interlinkages between DRR and CCA institutional setups within the country, which can then be used to establish a distinct institutional framework for L&D in India

10 India's Nationally Determined Contributions, UNFCCC, 2015, Accessed at: http://www4.unfccc.int/submissions/INDC/Published%20Documents/India/1/INDIA%20INDC%20TO%20UNFCCC.pdf

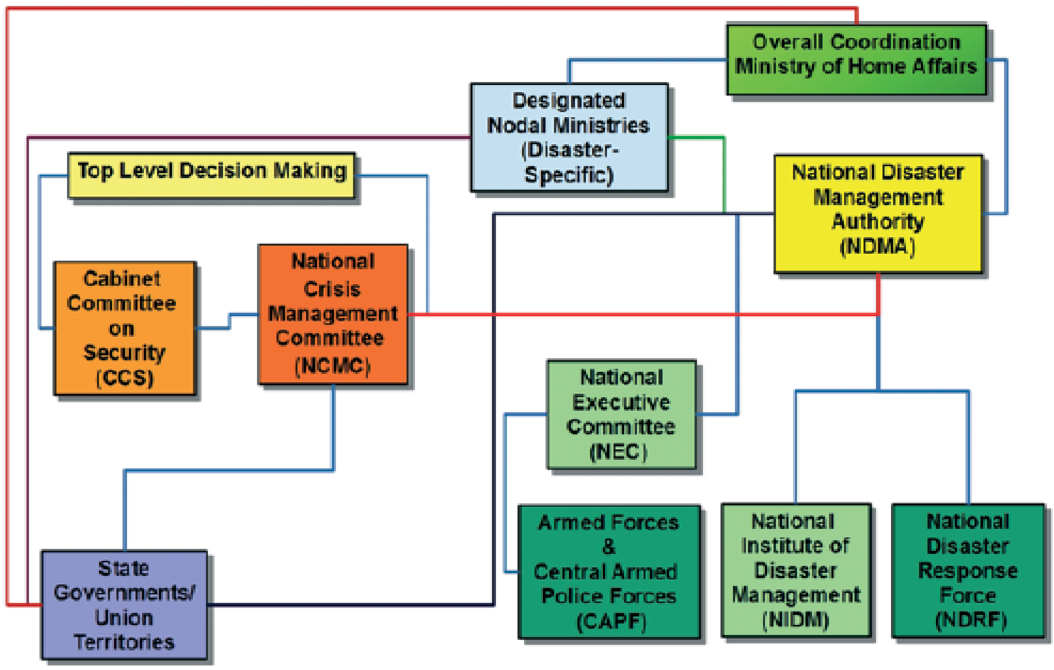


Figure 18: National Disaster Management Institutional Framework

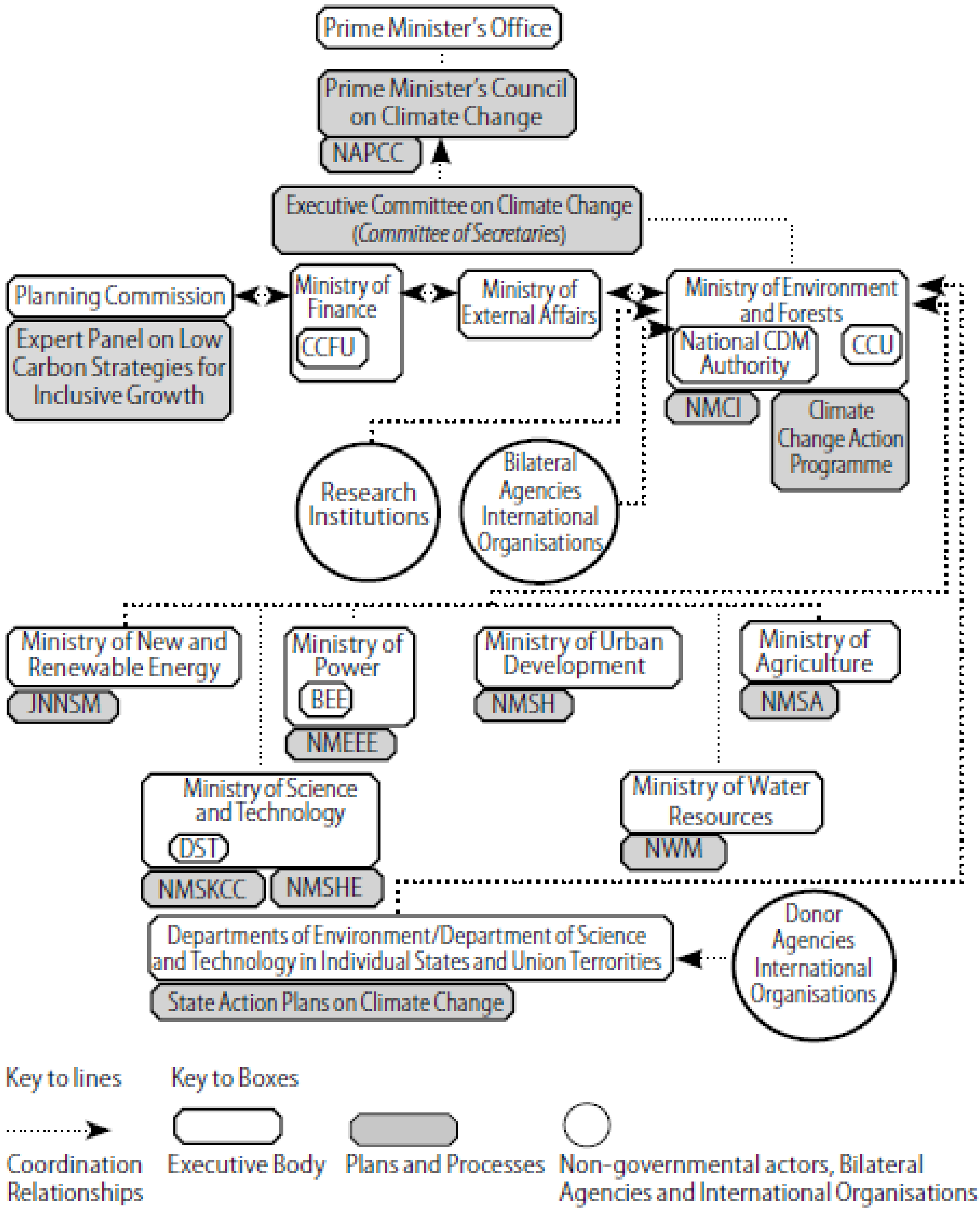
The DRR framework in India is well established and has strong connections with the local government departments. Thereby the country's DRR policies, plans and institutions have also been established much before CCA policies and institutions. The Ministry of Home Affairs (MHA)[11] is responsible for the overall coordination activities of Disaster Management (DM) across India as depicted in Figure 18[12]. MHA is nationally supported by the Cabinet Committee on Security (CCS) and the National Crisis Management Committee (NCMC). A National Disaster Management Authority (NDMA) has been established as the national level agency responsible for preparation and implementation of DM plans and functions. India's National Disaster Management Plan (2016), draws on the need to address hazard/disaster specific vulnerability and risk dimensions, and the plan further needs to be transformed into an implementable mechanism of factoring multi-hazard safety and sustainability risk mitigation along with climate resilience, into the planning and actions of all the sectors. As recommended by the Prime Minister's (First in Agenda 10 on Disaster Risk Management) sector based mainstreaming of DRR, with 9 agenda points as complimentary (to the first Agenda) implicitly address for priorities of Sendai Framework for Disaster Risk Reduction (SFDRR), to which India is a signatory and its integration with Paris Climate Agreement and Sustainable Development Goals (SDGs) (PIB 2018).

Primarily all disaster related work is undertaken by the state government with support (on request) from the central government. Each state has its own disaster management institutional framework set up. The guidelines developed by NDMA will assist state governments develop their respective state DM plans. NDMA has been empowered to authorize rescue and relief provisions and procurement at the time of disasters. Additionally a National Disaster Response Force (NDRF) has been set up to provide assistance to the relevant State Government/ District Administration in the event of an imminent hazard event or in its aftermath.

11 National Disaster Management Plan, NDMA, 2016, Accessed at: http://ndma.gov.in/images/policyplan/dmplan/National%20Disaster%20Management%20Plan%20May%202016.pdf

12 National Disaster Management Plan, NDMA, 2016, Accessed at: http://ndma.gov.in/images/policyplan/dmplan/National%20Disaster%20Management%20Plan%20May%202016.pdf

Figure 19:
Climate Change Institutional Framework



On the other hand, CCA institutions (Figure 19) and policies are relatively new, and some policies are still under review. It was in 2008 that a National Action Plan on Climate Change[13] (NAPCC) was developed, which comprises of eight national missions targeting different sectors such as Solar, Energy Efficiency, Sustaining the Himalayan Ecosystem and building Strategic Knowledge on Climate Change among others. Simultaneously the Ministry of Environment and Forests (MoEF) was handed the additional responsibility of climate change[14] and renamed to Ministry of Environment, Forests and Climate Change (MoEFCC).

This assessment of India's climate and disaster risk profile coupled with the existing institutions and their linkages will help prepare the foundation for an L&D framework.

13 National Action Plan on Climate Change, MoEFCC, 2008, Accessed at: http://www.moef.nic.in/sites/default/files/Pg01-52_2.pdf

14 Navroz Dubash and Neha Joseph, January 16, 2016, Evolution of Institutions for Climate Policy in India, Economic & Political Weekly, Accessed at: http://www.cprindia.org/sites/default/files/articles/Dubash_Joseph_Evolution_of_Institutions_for_Climate_Policy_in_India.pdf

5. IDENTIFY SYSTEM OF INTEREST

Once the overall objectives of the framework have been defined there is a need to define the boundary for implementation of the framework in a region. Step 2 hence identifies the system of interest (SOI) where the framework is to be deployed. The SOI can be national, subnational or local, depending on the objectives of the framework and can be defined based on an assessment of the various climate change hotspots, i.e. areas of the region most likely to be subjected to the effects of climate change through multi-criteria analysis.

Based on stakeholder consultations, a decision was made to utilize state boundaries as the system of interest for the current project. Step 2 will now involve detailed climate-related risk and capacity analysis which will result in identification of suitable states as illustrative systems of interest, also called hot-spots, which will be used as test grounds for the framework.

In the previous step, we identified the various climate sensitive regions in India wherein it was determined that each region varies in terms of climatic conditions and related risks, natural features, nature of infrastructure requirements, and local economy and livelihoods. Therefore, states in each region are subjected to various selection criteria to assess their feasibility as a suitable system of interest for implementation of the CRM framework being developed.

As discussed earlier, institutions identified at a national level, have corresponding institutions operating at state and district level. Each state has a State Disaster Management Authority (SDMA) and a District Disaster Management Authority (DDMA) with partnerships with local research and academic institutions for knowledge gathering and data collection and dissemination. As per the NAPCC, each state has to develop a State Action Plan on Climate Change (SAPCC) and install a State Climate Change Cell as well as a State Knowledge Centre on Climate Change. The newly installed CCA institutions can take support from the existing DRR institutions, which are already embedded at a local district/ block level.

5.1 System of Interest Criteria

Based on data availability, the following criteria have been termed appropriate to assess the qualifying requirements for a system of interest. These criteria can change depending on the aim and objective of the framework as defined by users in Step 1:

Table 2: Criteria for Selection of System of Interest

Criteria	Description	Examples
Climate Risks	• In order to select a system of interest it is imperative to understand the potential climate risks in each of the region. Alterations in weather patterns can increase the probability of extreme events. • Therefore, understanding these risks can help classify areas into high risk areas and low risk areas	• For instance, in the Himalayan region, glacier melts and erratic precipitation may result in floods / flash floods, landslides and drought events among others. • Similarly, along the coastlines, increase in cyclone intensity, sea level rise and droughts are projected to increase.
Disaster occurrence	• Natural and anthropogenic climatic variability can result in increased disaster occurrences. • Hence, there is a need to understand the region specific disaster profile. • Thus, it becomes important to differentiate between natural and anthropogenic induced disasters and not combine both catalysts.	• For instance, in 2015, heavy incessant rainfall led to flooding in the coastal states of Andhra Pradesh and Tamil Nadu. The floods were so severe that an economic loss of a total of USD 7 billion was incurred. • However, on the other hand, Delhi (NCR) region regularly faces flooding during the monsoon season but this flooding can be attributed to anthropogenic activities (use of storm water drains as sewage drains, inefficient solid waste management) rather than climate change.
Extent of impact on agriculture, forests, water, health and local economy of the region	• Changes in climate conditions increases impacts of risks and disasters on various sectors in a region • The key sectors in each identified region should be prioritised and analysed before selecting a system of interest.	• For example, droughts can lead to water shortages, reduction in soil moisture along with decrease in agriculture productions. • Similarly, heavy rainfall leads to landslides in mountainous regions and flooding in the plains. • Cyclones and flooding can cause damage to infrastructure and severely impact the health of the people. • Health impacts are also observed due to heat stress giving rise to vector borne diseases, water borne diseases and malnutrition. • Heat stress could also lead to a reduction in the forest area.

Criteria	Description	Examples
Institutional maturity of established climate change and disaster management installed	• While shortlisting a system of interest, assessment of presence of strong and mature institutions is of utmost importance. • Institutions such as climate change cells, disaster management units, environment and departments on agriculture, energy, fisheries, forest, housing, etc. should be well established and should have adequate capacity. • Capacity assessment should not only include the number of institutions in a region, but also by the knowledge and experience of personnel in the areas of climate change and disaster management. • A good data management system should also exist within each institution. • Preference should also be given to regions having knowledge and research institutes providing inputs on the matters relating to climate change and disaster management. • Presence of a well-established network of institutes will ease the process of data collection in the selected region and enable better impact analysis.	• For instance, there is a visible absence of a dedicated and robust climate change and disaster management cell in Maharashtra even after lying in a High to Moderate damage zone of cyclone and tsunami – Zone IV and III earthquake intensity zones. Being a coastal state with several river basins it is also affected by annual floods. Additionally, the Vidarbha zone is highly susceptible to extreme droughts and dry spells. • Availability of Monitoring stations, knowledge centres for dissemination of information and dedicated personnel who are appropriately trained and equipped with the current and best practices related to DRR and CCA.
Availability of relevant information	• In spite of having a mature and strong institutional structure, many regions lack a comprehensive database to enable organisations to understand the key climate risks and their impacts and project their impacts. • Similarly, the information on hazard probabilities, evolution of infrastructure and economy of a region should be well mapped and plotted to develop a trend analysis of the evolution of assets and community growth in that region.	• For example, if Maharashtra's disaster management unit, which is currently at a nascent stage, is developed in a systematic and comprehensive manner could capture and provide valuable inputs in the near future. • This could provide detailed climate variability models and simulations thereby increasing the state's adaptive capacity and increase its tolerance to annual disaster events.
Organisation's presence in the region	• Presence of the organisation, selected to conduct vulnerability assessment, in the region is significant as this can lead to a greater hold in the region in terms of institutional support, data collection and stakeholder engagement to understand the key impacts in the area. This should be one of the key parameters in selection of the area. • In case of lack of presence, the framework approach could be modified to include either institutional establishment or institutional linkages with existing regional institutions to better implement the framework.	• For example, a well-established organisation in a region can increase interactions with the local stakeholders as well as the local decision/ policy makers, thereby ensuring better implementation of the framework in that system of interest. • GIZ's presence in certain states of India, can provide better local level information from stakeholders as well as state departments at a regional/ district level.

5.2 Prioritisation of Criteria for System of Interest

Once the system of interest is assessed on the aforementioned criteria, there is a need to prioritise each criterion specific to that shortlisted region. Prioritisation should be done based on the importance and relevance of the criteria to the region. Understanding the climate risk and disaster occurrence is the first and foremost step in the identifying the systems of interest, as areas highly affected by these will face more loss and damage. Therefore, more weightage and a higher ranking should be given to these criteria. Another important criterion is institutional maturity, as a strong and well-established network of institutions signifies a highly growing and developing region. Performing data collection exercise, vulnerability assessments and stakeholder engagements will become easier and efficient. A higher ranking should be given to area having a strong institutional base.

The next important criteria are assessment of availability of information and a preliminary understanding of the existing and future impacts in the region. Higher importance should be given to the region, where there is vast and diverse information availability especially comprising of a preliminary assessment of the potential impacts in the region. Presence of the selected organisation in the region is also one of the important factors that should be considered during assessments, as a strong hold in the region would facilitate smooth implementation of the framework. .

Prioritising these criteria will help in understanding the key vulnerable regions or hotspots within a larger area.

5.3 Selection of Boundary of System of Interest

Understanding the key vulnerable regions within an area will help an organisation in defining the boundary for further assessments. The boundary could be a small area, block/ward, city, district or even a state depending upon the rankings achieved through preliminary analysis. Drilling down to the lowest level for assessment will better support the process of identification of a system of interest. For instance, sometimes chances of availability of information at a block level is greater than at a district level which will give the block a higher ranking as compared to the district. Also, at the block level, since the government departments will not change depending on the political scenario, it will become easier to identify the gaps in required information for framework development.

For example, in the case of Telangana, which was recently bifurcated from Andhra Pradesh, the new state may not have collated data specific to each of its districts, which was earlier in captured as a part of the data collection for Andhra Pradesh. However, the data for each district would still be available at a district/ block level, since although the district might have been placed in the new state, it still retains its name.

All the aforementioned steps are key to identifying a system of interest. Not being able to perform any one step could lead to a change in methodology.

Furthermore, stakeholder interactions have resulted in additional sources for relevant data collection, which are listed below:

- As per the MoEFCC, it is mandatory for every Indian state to develop a Vulnerability and Hazard Risk Assessment Report, which should capture all state specific historical hazard events as well as related impacts to various sectors such as agriculture, forests etc. The state Department of Science and Technology (DST) also maintains a hazard specific sectoral level database, which would provide a benchmark to measure all data points for past and future trend analysis and simulation.

- Similarly, each state maintains a Geographic Information Systems (GIS). These systems capture, analyse and store spatial/ geographic data and are used to identify glacial shifts, extent of forest cover, shifting of river flows among others. The Indian Space Research Organisation (ISRO) also has a GIS system which uses various inputs and proxy variables and could be accessed for additional information.
- Social organisations and government departments (urban and rural departments) conduct Participatory Rural Appraisal (PRA) on a regular basis. PRAs can generate social-economic factors and provide primary information of climate and disaster related data sources. Each state also develops a Human Development Report (HDR) and Sustainable Development Goals (SDG) Framework Report, which could provide information on the existing infrastructure and vulnerabilities of communities residing in each state.

5.4 Application in India: Illustrative Selection of System of Interest

A prioritisation exercise was conducted based on the above criteria, and scaled down to two system of interests namely Himachal Pradesh and Tamil Nadu as illustrated in Figure 20.

Once the climate sensitive regions were identified, each region's states were evaluated against the selection criteria defined in Table 2 which resulted in Himachal Pradesh, Tamil Nadu, Sikkim and Maharashtra being shortlisted from each of the four climate regions. In addition to vulnerability to climate related and disaster risks, these states had mature and well-defined CCA and DRR institutional capacities built-in. They were then subjected to a prioritisation exercise, based on which, Himachal Pradesh and Tamil Nadu were considered more vulnerable to disasters and climate change impacts. Further, on assessing the maturity of CCA and DRR institutions, availability of climate and hazard specific data and GIZ's presence in these states, they were determined to be appropriate choices as the system of interests for implementation of the framework.

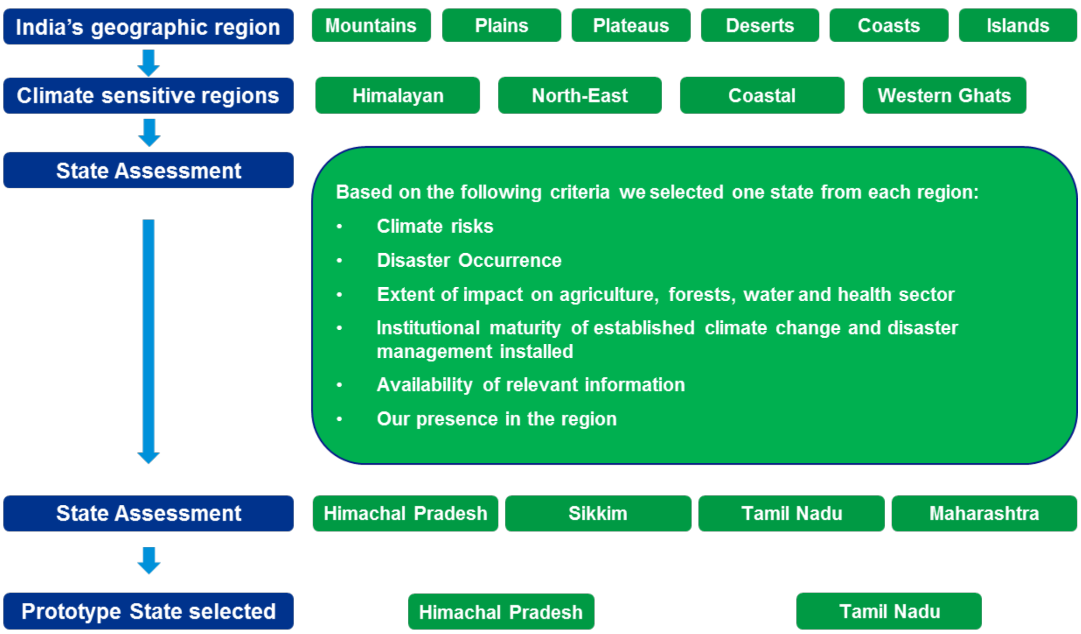


Figure 20: Illustrative Selection of System of Interest

6. DEVELOP A CONTEXT-SPECIFIC METHODOLOGY

In order to implement the framework at the system of interest, an appropriate methodology composed of multiple methods and customized to the local conditions and stakeholders is to be developed. The appropriate methodology to be used depends on the product to be generated, on stakeholder needs identified, the overall objectives of the assessment and the agreed use of results.

6.1 Background

There are several approaches and methodologies available in the field of DRR and CCA, for calculating impacts and assessing risks. For the purpose of CRM the three types of products and methodologies can be identified as shown below. The specific tools used in these products can be drawn from both DRR and CCA. Recommendations of few are given in the table below.

Product incl. Methods and Tools	Purpose	Resource and Time Commitment	Expertise Required	Application
Informational, impact-focused study (use available information, on hazards and impacts)	Provide a broad overview of past hazards, losses and damages	Small – Person-weeks	Climate science and policy, empirical skills, statistics	Himachal Pradesh
Backward-looking climate risk analysis (broad risk assessment and scenarios using **available** data and information on risk)	Overview of past and future risks building on reported loss and damage	Moderate Person-months	Climate science and policy, risk management, economics, statistics	Tamil Nadu
Forward-looking climate risk analysis including new climate scenarios (detailed risk assessment and scenario generation, attribution assessment, more scientific)	Detailed climate scenario-based risk analysis building on risk modelling determined by hazard, exposure and vulnerability analyses	Substantial Person-months up to person-year	Climate science and policy, risk management, economics, statistics, climate modelling	NA

Table 3: Types of assessment studies and current application

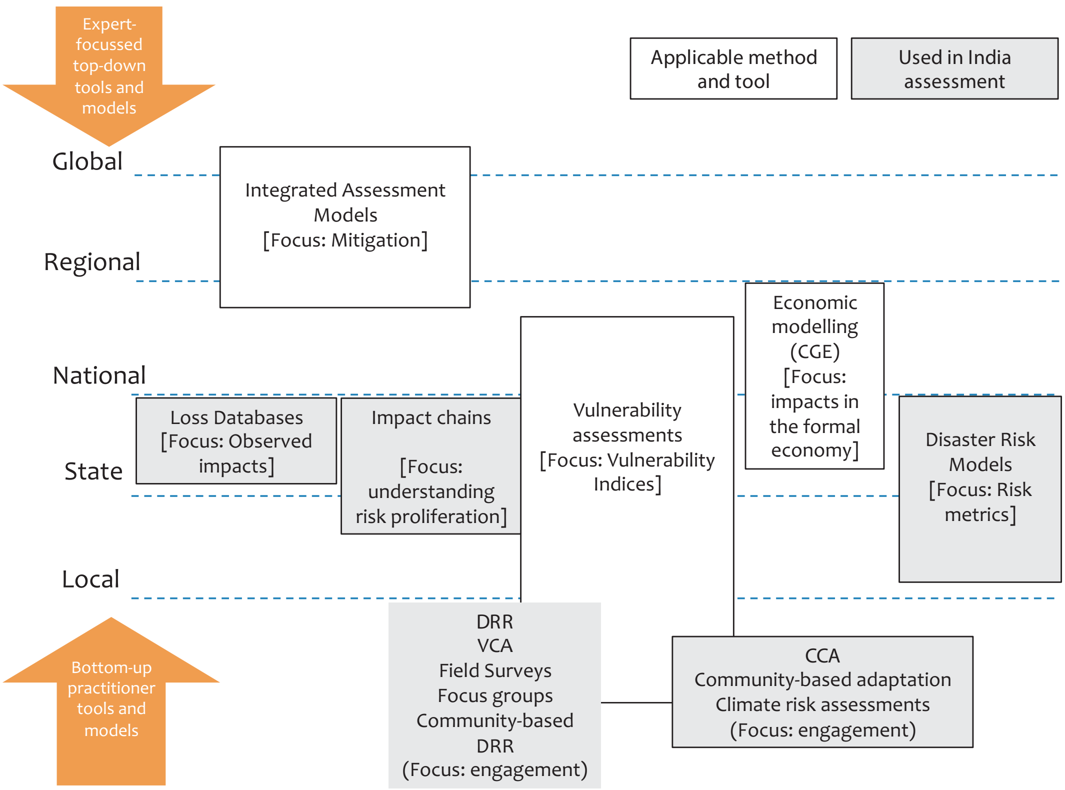
The **informational study** is mostly a generalized study that provides a broad overview of hazards, impacts and damages. In order to take the analysis forward into a risk assessment, two approaches can be applied. In a less rigorous and less data-intensive **backward-looking assessment**, past damages build the basis for a general understanding of risk and potential damages. For measuring risk and the benefits arising due to risk reduction in a **forward-looking scenario-based manner**, a risk analytical process is to be followed for understanding hazard, vulnerability and exposure, conduct scenario generation and attribution assessment as well as the benefits due to risk reduction.

As shown in figure 18, there is a broad set of methods and tools for assessing risk cutting across scales from regional to national to state and local. Models predominantly used at higher levels have strong expert appeal and are used often in **top-down fashion**, where experts work out insight and options, this includes integrated assessments, CGE modelling. At meso scale, loss databases, impact chains, vulnerability assessments and disaster risk modelling can be used. A more **localised, bottom-up perspective** seeks to strongly co-generate local insight with those at risk with methods and tools such as Vulnerability Capacity Assessments (VCA), field surveys and focus groups, and community-based disaster risk reduction and climate adaptation tools. All perspectives and associated models and tools are valid entry points for analysis yet need to be able to respond to the specific contexts that they are applied to (see Figure 21).

6.2 Application in India

Our application of the CRM framework to India makes use of a set of models and tools, particularly emphasising the use of analytical elements that respond to stakeholder needs and can be used in participatory process. We strongly build on prior work done at community-level in the state of Tamil Nadu (and Odisha) (Adelphi and GIZ, 2015). As one important method, the impact chains method has been applied to scope out the various direct and indirect impacts and

Figure 21: Methods and tools across scales and tools used for the India application. Note: in blue-methods and tools used for the India assessment.



Box 2: Impact chains for understanding drivers of direct and indirect impacts and risks

An impact chain is an analytical tool that helps you better understand, systemise and prioritise the factors that drive risk in the system of concern. The structure of the impact chain developed according to the IPCC AR5 approach is based on the understanding of risk and its components (see Figure 4). For detailed information on these components refer to the Conceptual Framework of this document. In accordance with the IPCC AR5 definitions, we understand 'impacts' as the basic building blocks of cause-effect chains from hazard to risk (see Figure 22 below). A climate signal, e.g. a heavy rain event, may lead to a direct physical impact, e.g. a flood, causing a sequence of intermediate impacts, which finally lead to the risk. A chain is composed of risk components (hazard, vulnerability, exposure) (see coloured containers in the Figure 22) and underlying factors (white boxes). The hazard component includes factors related to the climate signal and direct physical impact. The vulnerability component consists of sensitivity and capacity factors. The exposure component is comprised by one or more exposure factors (no subdivision within this component). For simplicity, the relationships from all factors directly leading to the risk without relationships to other factors are summarized by bold arrows on the bottom of the respective components. In contrast to these three components, intermediate impacts are not a risk component by themselves but merely an auxiliary tool to fully grasp the cause-effect chain leading to the risk. By definition, they are a function of both hazard and vulnerability factors, which means that all impacts identified which do not only depend on the climate signal but also on one or several vulnerability factors need to be placed here.

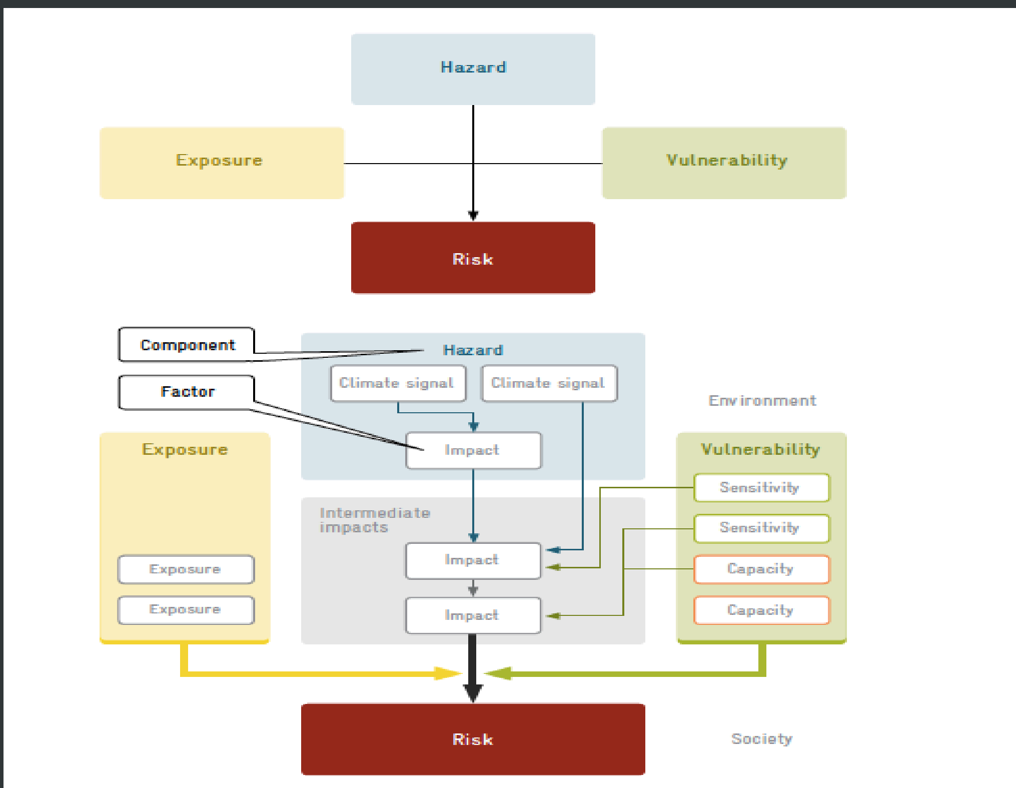


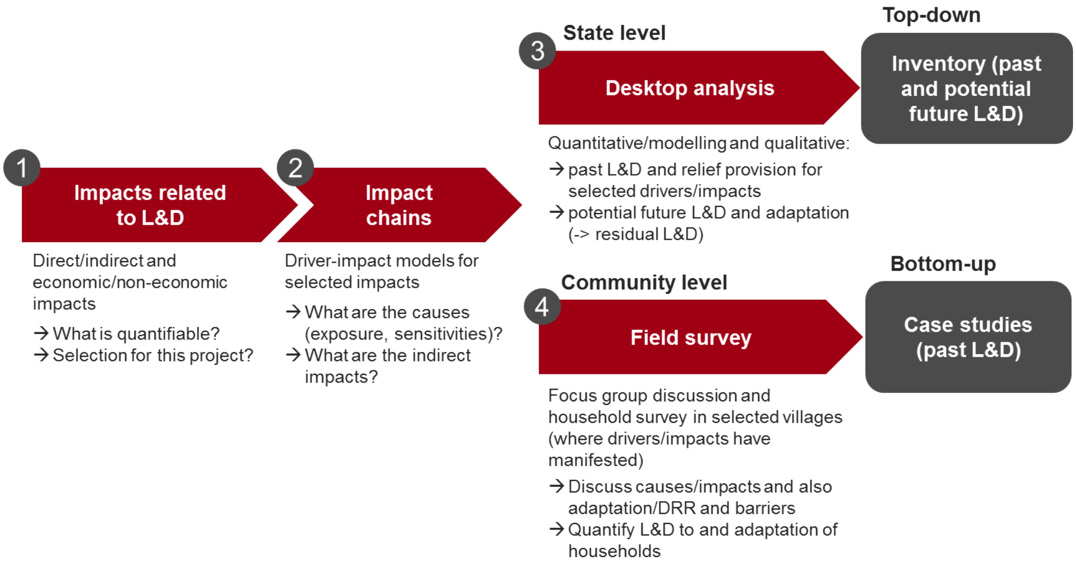
Figure 22: Impact chain approach. GIZ/Eurac, 2017

risk. It builds on desktop analysis including inventories of observed and modelled losses and damages, as well as field surveys and stakeholder engagement (including focus groups) at household and farm levels (see box 2). The assessment approach used for this project employed impact chains that gather together economic and non-economic L&D and describe the linkages between them, the contribution of climatic drivers, and human-induced factors. For potential future L&D, adaptation scenarios are compared to business-as-usual scenarios. In line with the proposed L&D concept, the overall aim of this specific study has been to (a) test the assessment approach used for the two state-level case studies on Tamil Nadu and Odisha, accompanied by verification at the community level, and (b) to provide recommendations on how approaches for assessing and dealing with L&D can be operationalised.

Our application and further discussion to the two prototype states building on available material, makes use of the approaches as follows:

- **For Himachal Pradesh,** the information mostly focuses on trends in hazards, and little is available in the way of quantitative risk information
- **For Tamil Nadu,** our report post-processes available data and information along a backward risk analysis approach

Figure 23: Risk assessment approaches. Top-down and bottom-up. Adelphi and GIZ, 2015



7. IDENTIFY CLIMATE CHANGE RISKS

Building on framing risk as a function of hazard, exposure and vulnerability, climate risk assessments go through a structured process for calculating risks and the benefits of any adaptation measures. Such a process can generally be termed **risk identification**. Potentially, there are a large number of impacts, in actual practice however, only a limited amount of those can be (and are usually) assessed due to data gaps, resource, time and expertise limitations.

7.1 Background

Table 4 presents the major categories of impacts and risks for which usually, at least some data can be identified/found in order to map impacts and risk across different sectors. The list is structured around the three broad categories of social, economic and environmental. Potential effects comprise direct or indirect and they are originally indicated in monetary or non-monetary terms.

- **Direct impacts** refer to those impacts occurring as an immediate consequence of an extreme event or slow-onset event (e.g. human casualties, damages to infrastructure etc.)
- **Indirect impacts** are not provoked by the climatic hazard itself but by its follow-on consequences (e.g. increasing poverty due to human casualties or loss of property)

Regarding the economic and non-economic impacts, non-economic impacts can be broadly understood as all losses that are not traded on markets and cannot be quantified in monetary terms, such as these negatively affect human welfare and may even be more substantial in developing countries than economic losses. Examples include human life, health, identity, culture, livelihoods and traditions, knowledge and other social capital, values and aspects of sovereignty as well as ecosystems and biodiversity. These examples show that non-economic loss can be material or immaterial.

Table 24:
Summary of quantifiable disaster impacts. Mechler, 2005

Category	Monetary Impact		Non-Monetary Impact	
	Direct	Indirect	Direct	Indirect
Social				
Households	-	-	• Number of casualties • Number of injured • Number affected	• Increase of diseases • Stress symptoms
Economic				
Private Sector				
Households	• Housing damaged or destroyed	• Loss of wages • Reduced purchasing power	-	• Increase in poverty
Public Sector				
Education Health Water and Sewage Electricity Transport Emergency Spending	• Assets destroyed or damaged: buildings, roads, etc.	• Loss of infrastructure services	-	-
Economic Sector				
Agriculture Industry Commerce Services	• Assets destroyed or damaged: buildings, roads, etc.	• Losses due to reduced production	-	-
Environmental				
Environmental	-	-	• Loss of natural habitat	• Effects on bio-diversity

7.2 Application in India: Impacts in Tamil Nadu

Table 5 lists potential direct and indirect, economic as well as non-economic impacts gathered for Tamil Nadu arising from sudden onset extreme events and slow onset gradual processes. Extreme event risk comprises e.g. cyclonic storms, riverine and coastal flooding or landslides. Gradual changes include impacts from sea level rise or saltwater intrusion. Most important impacts and risks that the local studies focussed on were. Table 5 informs about data availabilities and quantification potentials of the different climate-related risks in Tamil Nadu.

Impacts Related to L&D	Extreme Events	Gradual Changes	Remark on Quantification and Attribution
Direct Economic L&D			
Damage to house (private)	Y	-	1
Loss of agricultural crops	Y	Y	1
Reduction in quality and quantity of crop production	Y	Y	3
Loss of land	Y	Y	1
Cattle & Livestock lost and affected	Y	-	1
Damage to public properties (e.g., road infrastructure, drinking water supply, school building, hospital, etc.)	Y	-	1
Damage to nets & boats of fishermen	Y	-	1
Loss and damage to assets and amenities	Y	-	3
Land degradation and desertification	Y	Y	1
Investments to reduce sensitivity of various entities	Y	Y	3
Risk/ loss minimizing credit (e.g., crop insurance)	Y	-	1
Loss management credit (e.g., selling livestock)	Y	Y	3
Indirect Economic L&D			
Loss of 'net revenue' up to the situation back to normalcy	Y	Y	3
Reduction in tourism revenue	Y	-	3
Loss of money in the process of reversible degradation and land reclamation	Y	Y	3
Cost involved in purchasing water for drinking and irrigation purposes	Y	Y	3
Impact on income due to increasing prices of food items	Y	Y	3
Direct Non-Economic L&D			
Human casualties	Y	-	1
People affected	Y	-	1
Displacement of households	Y	Y	3
Salinisation of groundwater	Y	Y	2
Destruction of cultural heritage	Y	-	3
Impact on ecosystems and biodiversity (including impact on mangrove forest)	Y	Y	3
Indirect Non-Economic L&D			
Water borne diseases due to water salinity	Y	Y	3
Malnutrition and underweight children due to shortage of food	Y	Y	3
Mental wellbeing, happiness, Psycho-social stress due to loss of income, assets and amenities, debt, migration, etc.	Y	Y	3

Table 5: List of relevant and observable impacts for Tamil Nadu. Adelphi and GIZ, 2015.
Note: (A) 'Y' means yes, and '-' refers to no; (B) 1- quantifiable in principle and attribution is also feasible; 2- data available but not easy to quantify, attribution is also not straight forward; and 3- not quantifiable mainly due to data constraints

Impacts Related to L&D	Extreme Events	Gradual Changes	Remark on Quantification and Attribution
Impact on reproductive health of women in the cyclone year and long-term impact on children born in this year	Y	-	3
Migration (permanent/ seasonal)	Y	Y	2
Value given by people for a particular place identity	Y	Y	3
Absenteeism of children in school	Y	Y	3
Increasing crime rate	Y	Y	3
Trust and cooperation among the households	Y	-	3
Inequality in accessing various benefits provided by government and civil society	Y	-	3
Social conflict resulting from resource management	-	Y	3
Access to sanitation and good quality water for drinking	Y	Y	3
Damage to crop-diversity	Y	Y	3
Damage to habitat of various fisheries, wildlife, flora & fauna	Y	-	3

The impact chains approach (exemplified in Figure 24 for the case of cyclonic storms in Tamil Nadu) highlights and assesses the consequences induced by climate stimuli, taking into consideration socio-economic and environmental sensitivity factors. From direct bio-physical impacts, via resulting direct socio-economic impacts this approach eventually shows the follow-on indirect socio-economic and human development impacts.

7.3 Understanding Key Hazards, Impacts and Risks in Tamil Nadu

Key risks reported for Tamil Nadu are cyclone and flood risk and salinisation due to predominantly coastal flooding.

Cyclone and Flood Risk in Tamil Nadu

Focusing on the impacts of cyclonic storms and follow-on floods in Tamil Nadu, Adelphi and GIZ (2015) carried out an ex-post analysis of losses and damages related to extreme climate-related risks at the sub-national level. In order to control for socio-economic development over time (e.g. population growth, income growth, household growth and inflation) the research study normalized reported economic impacts by employing both the Pielke and Landsea method as well as the Collin and Lowe method.

As one example, table 6 lists the reported and normalized economic losses from cyclonic storms in Tamil Nadu. It is found that normalized economic loss figures, i.e. controlling for increasing number of people and household and amount of wealth exposed to cyclonic storms over the years, are always higher than that of reported impacts. The results show that expected direct economic damages of past cyclonic storms (e.g. 1972 or 1977) would be higher if they were to occur in the base year (here 2011) than more recent ones (e.g. 2001 or 2011). This would imply that past trends in cyclonic storm risk has been mainly driven by socio-economic development and not by changes in the climate stimuli.

Year	Reported economic impacts (INR million)	Normalized economic impacts (INR million)	
		PL Method	CL Method
1972	400	91,747	112,361
1977	1,550	215,753	261,847
1978	50	6,515	7,892
1984	30	1,755	2,079
1990	121	2,833	3,246
1991	3,400	67,446	76,865
1992	5,300	90,249	102,384
1993	4,000	55,891	63,118
1994	612	7,279	8,183
2001	5,000	25,338	27,590
2011	15,000	15,000	15,000

Table 6: Reported and normalized economic impacts from cyclonic storms in Tamil Nadu. Adapted from Adelphi and GIZ, 2015 Note: PL Method – Pielke and Landsea Method; CL Method – Collin and Lowe Method.

A limitation of the analysis by Adelphi and GIZ (2015) is that their normalisation methods do not take into consideration changes in vulnerability. Disaster risk reduction, prevention as well as adaptation measures that have been taken over the period 1972-2011 might have substantially contributed to the relative decrease of normalized economic damage estimates. Moreover, the study finds an upward trend in the frequency of occurrence of cyclonic storms over the study time period, which could even be intensified by climate change in the future and thus may lead to an increase of economic impacts also in normalized terms, particularly when additionally controlling for changes invulnerability.

Salinisation

Salinisation, a slow onset phenomenon particularly determined by coastal flooding as amplified by sea level rise, has been reported as the other important impact category. Yet, there is not comprehensive database on the extent and subsequent impacts of salinisation. More than 95% of households report that salinisation is adversely affecting agriculture and that impacts are on the rise. While losses mainly to paddy crop due to salinisation have been reported in instances to exceed 50% of total yield, across all districts in Tamil Nadu, a total loss for 2013-2014 of around 2% of total state rice production (77,000 tonnes) has been attributed to salinisation (adelphi and GIZ, 2015). As one response, farmers are leaving land uncultivated in both districts surveyed in Tamil Nadu. Also, 88% of respondents reported salinisation to impair drinking water quality, and many mentioned health, livestock and fishery impacts (80%, 71% resp. 49%).

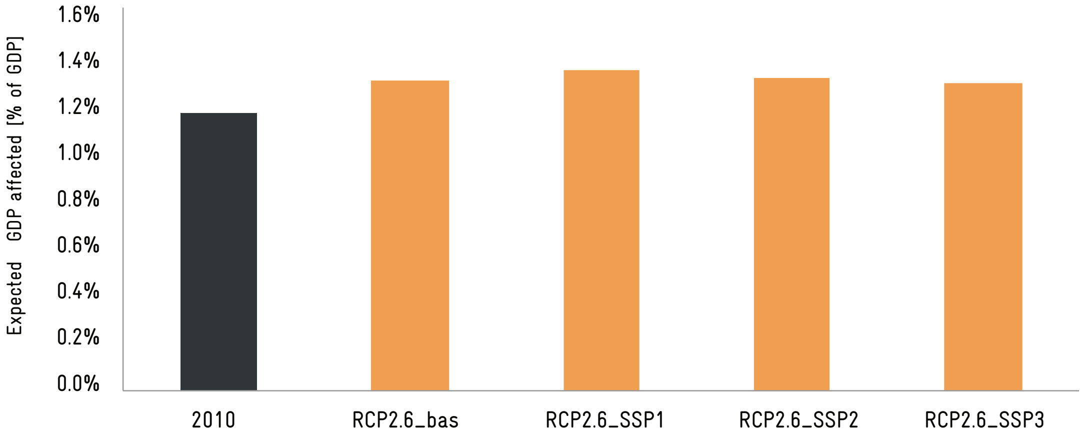
Understanding Risk

While the analysis focussed on reported impacts provides an insight as to what happened in the past, risk-based assessments develop an estimate of future risk, which requires some sort of modelling. We build on available global flood risk modelling (GLOFRIS), as well as statistical modelling done for Tamil Nadu for the adelphi and GIZ study.

Risk Identification at The National Level, Building on Hydrological Models: Riverine Flood Risk in India to Urban Structures

Based on synthetic risk modelling, the GLOFRIS model calculates riverine flood risk at national and subnational levels globally for future time periods, such as 2030 and 2080 for different socio-economic and climate-change scenarios. Here results for a stabilisation scenario (Representative Concentration Pathway-RCP2.6) is used, where global warming is limited to less than 2°C of warming until 2100, an optimistic assumption. The climate scenarios are

Figure 25: Expected urban damage due to riverine flood risk in India (in % of GDP) in 2010 and 2030 for different combinations of RCPs and SSPs. The range of the results always



integrated with scenarios of socio-economic development (Shared Socioeconomic Pathways) SSP1, SSP2 and SSP3, which build on different assumptions of future socio-economic development, here importantly future economic development.

For India (as well as for most other countries, the analysis suggests that the main driver of flood risk in India currently is the potential socioeconomic development (here indicated according to the SSP1, SSP2 and SSP3 socio-economic pathways informing climate scenarios). Future and stronger warming beyond 2°C is likely to add significantly to flood risk (IPCC, 2014).

Risk Identification at State Level Building on Statistical Model: Storm Damage to Housing

For the adelphi and GIZ study in Tamil Nadu statistical modelling was undertaken building on the reported damages to understand the potential to avoid and reduce future cyclone-related damage. The statistical modelling approach assesses combined impact of wind velocity and storm surge in a region. Based on available historic information, three categories of storms with maximum wind velocities of 120 km/h, 180 km/h and 220 km/h were considered for the analysis. The analysis considered a BAU and SCEN, with the number of non-engineered structures across districts in BAU taken as per 2011 census and in SCEN taken as 10% below the 2011 census figures. Future developments in the climate stimulus have not been considered, which means that the sole driver of cyclone risk in this assessment are the assumed changes in socioeconomic exposure, i.e. the number of non-engineered structures.

The approach assesses the percentage of non-engineered houses at the risk of damage due to cyclonic storms (Das and Crépin, 2013),

Figure 26: Distribution of urban damages due to riverine flooding in India in 2030 across different return periods. Blue bars: climate and socioeconomic drivers; Orange bars: only climate drivers. GLOFRIS, 2017

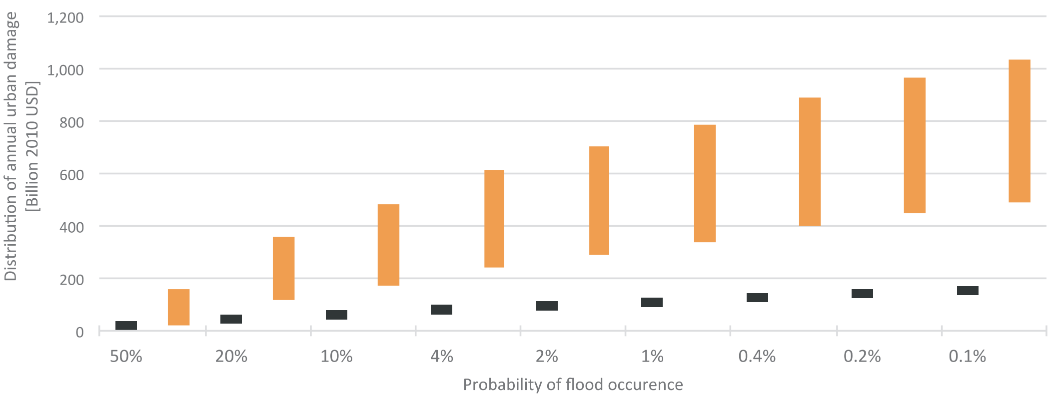


Figure 27 visualizes direct economic damages due to cyclones in Tamil Nadu over the near future (Adelphi and GIZ, 2015). The economic losses reflect repair costs of damaged houses and vary depending on whether the damaged houses are located in the rural or urban sector. Considering an average repair cost of INR 50.000 for rural houses and INR 150.000 for urban houses, respectively, the estimated direct economic damages range (depending on the landfall location of the storm) between INR 11 to 86 billion under Business as Usual (BAU) and between INR 9 to 52 billion under a Development Scenario (SCEN) that assumes a lower number of non-engineered houses at risk to storm damages. Overall, depending on wind speed and assumptions, a maximum of 30% of damages may be reduced by storm-proofing housing.

Overall, the risk analysis compiled for the report (building in available data and modelling), shows that risk is on the increase due to climate change, but also socio-economic changes (currently the stronger contribution. Furthermore, part of the risk (maximum 30%) can be reduced by storm-proofing housing), so substantial residual risk would remain.

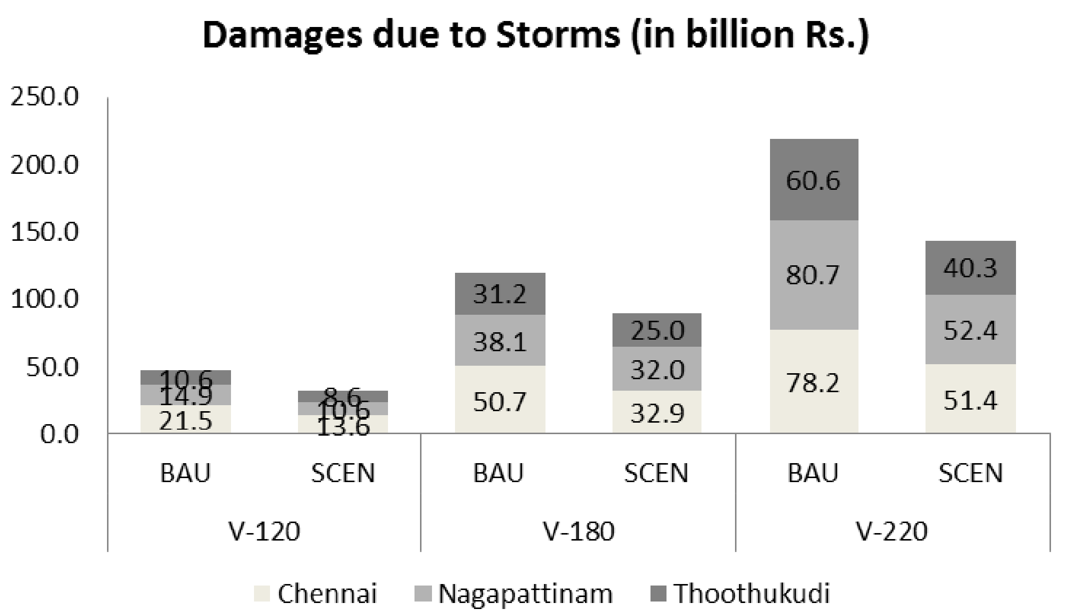


Figure 27:
Economic damages from storms in Tamil Nadu for a baseline and a scenario with adaptation. Adelphi and GIZ, 2015 Note: BAU: baseline as usual (no additional adaptation); SCEN: adaptation-storm proofing homes

8. EVALUATE RISK TOLERANCE AND LIMITS TO ADAPTATION

The risk identification step is followed by conducting an evaluation of respective risk tolerance and limits to adaptation measures. The evaluation of risk is concerned with categorizing risks in terms of risk coping capacity, i.e. understanding actors' abilities to reduce or accept risks given their objectives. While risk identification assesses risks in monetary and/or non-monetary terms, risk evaluation, involving socioeconomic analysis, helps to identify capacities and responsibilities to act around risk management at appropriate scales from local to international.

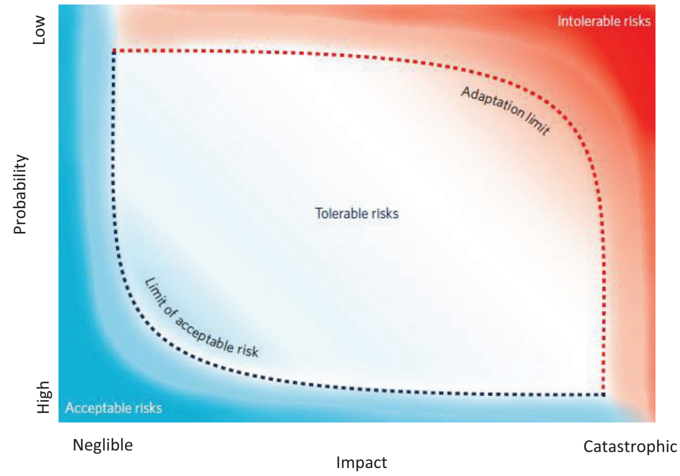


Figure 28: Framing risk acceptance and tolerance. Based on Dow et l., 2015 and Renn (2002)

8.1 Theoretical Background

The process of risk evaluation examines agents' (households, private and public sectors) ability to respond to risk, also termed risk tolerance. Economics has distinguished risk preference around risk aversion, neutrality and risk loving (Eeckhoudtet al. 2005). Risk analysis, e.g. Dow et al. (2013), building on Klinke and Renn (2002), conceptually define risk tolerance as **acceptable** (no formal intervention necessary), **tolerable** (risk reduction measures are necessary, depending on resources) and **intolerable** risk going beyond a limit, defined as "the point at which an actor's objectives or system's needs cannot be secured from intolerable risks through adaptive actions." (See figure 28 for a visualisation and box 3 for definitions).

While risk evaluation is important because it helps to identify suitable risk management options, what constitutes acceptable, tolerable, and intolerable risk is strongly determined by social, cultural, and economic factors and often requires subjective judgment (Dow et al. 2013); e.g., IPCC Working Group II in 2014 used expert judgement for determining levels of low, medium and high risk in its regional risk assessment. On the other hand, risk analysis has developed analytical procedures for segmenting risk according to differential ability to bear risk to which risk policy instruments can be tailored to - termed risk layering (Mechler et al. 2014).

Box 3: Definitions of Adaptation Opportunities, Constraints, and Limits

IPCC's 5th assessment report in chapter 17 (Klein et al., 2014) brought forward the following definitions to define soft and hard limits to adaptation.

- **Adaptation Opportunities:** Factors that make it easier to plan and implement adaptation actions that expand adaptation options, or that provide ancillary co-benefits. These factors enhance the ability of an actor(s) to secure their existing objectives, or for a natural system to retain productivity or functioning. For instance, increased public awareness and support for adaptation, availability of additional resources from actors at other levels of governance to overcome constraints and soft limits, and interest in acquiring co-benefits.
- **Adaptation Constraints:** Factors that make it harder to plan and implement adaptation actions. Adaptation constraints restrict the variety and effectiveness of options for actors to secure their existing objectives, or for a natural system to change in ways that maintain productivity or functioning. These constraints commonly include lack of resources (e.g., funding, technology, or knowledge), institutional characteristics that impede action, or lack of connectivity and environmental quality for ecosystems.

Constraints (alone or in combination) can drive an actor or natural system to an adaptation limit, which is defined as:

- **Adaptation Limit:** The point at which an actor's objectives or system's needs cannot be secured from intolerable risks through adaptive actions.

Hard and soft limits can be distinguished as follows:

- **Hard Adaptation Limit:** No adaptive actions are possible to avoid intolerable risks.
- **Soft Adaptation Limit:** Options are currently not available to avoid intolerable risks through adaptive action.

8.2 Expert-Judgment Based Approach vs. Model-Based Approach

Two basic approaches can be identified:

- **Approach 1: Expert-judgement based approach** building on multiple lines of evidence, such as survey or focus group information, which is then summarized using expert judgment.
- **Approach 2. Model-based approaches** which comprise of building on economic framing of risk preferences.

A third approach known as the **Mixed Approach** can be formulated as a combination of the above two approaches. However, this method has not been used for the purpose of this project.

8.3 Approach 1: Eliciting Expert Judgment

To summarize results from its multiple lines of evidence, IPCC in its fifth assessment report, developed a sort of 'climate risk language' to visualise the relevance of risk and the space for options to reduce risk (Field et al.,

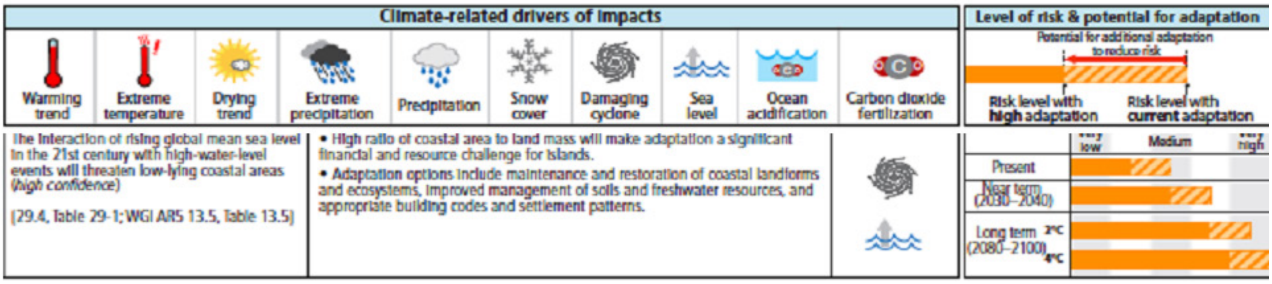


Figure 29: Risk from sea level rise & high-water events in Small Island States. Nurse et al., 2014

2014). Building on IPCC's multiple lines of evidence philosophy, such as collating empirical evidence on impacts and risks with information on adaptation options, and the modelling of future risks, as well as using expert judgment, this visualisation succinctly summarises climate risk (from low to high) and the potential (as well as the limits) for adaptation for key risks and three time steps (present, near-term and long-term 2°C and 4°C). For example, figure 29 visualizes risks from sea level rise and high-water events as well as the corresponding adaptation potential in Small Island States. Building on identifying the key hazard drivers, sea level rise and cyclones interacting with high tide events, it finds the level of risk, essentially for coastal flooding, to currently be at medium levels and increasing with future warming to very high levels, particularly for the 4°C warming scenario. While the risk bar shows overall risk (given adaptation actions taken),

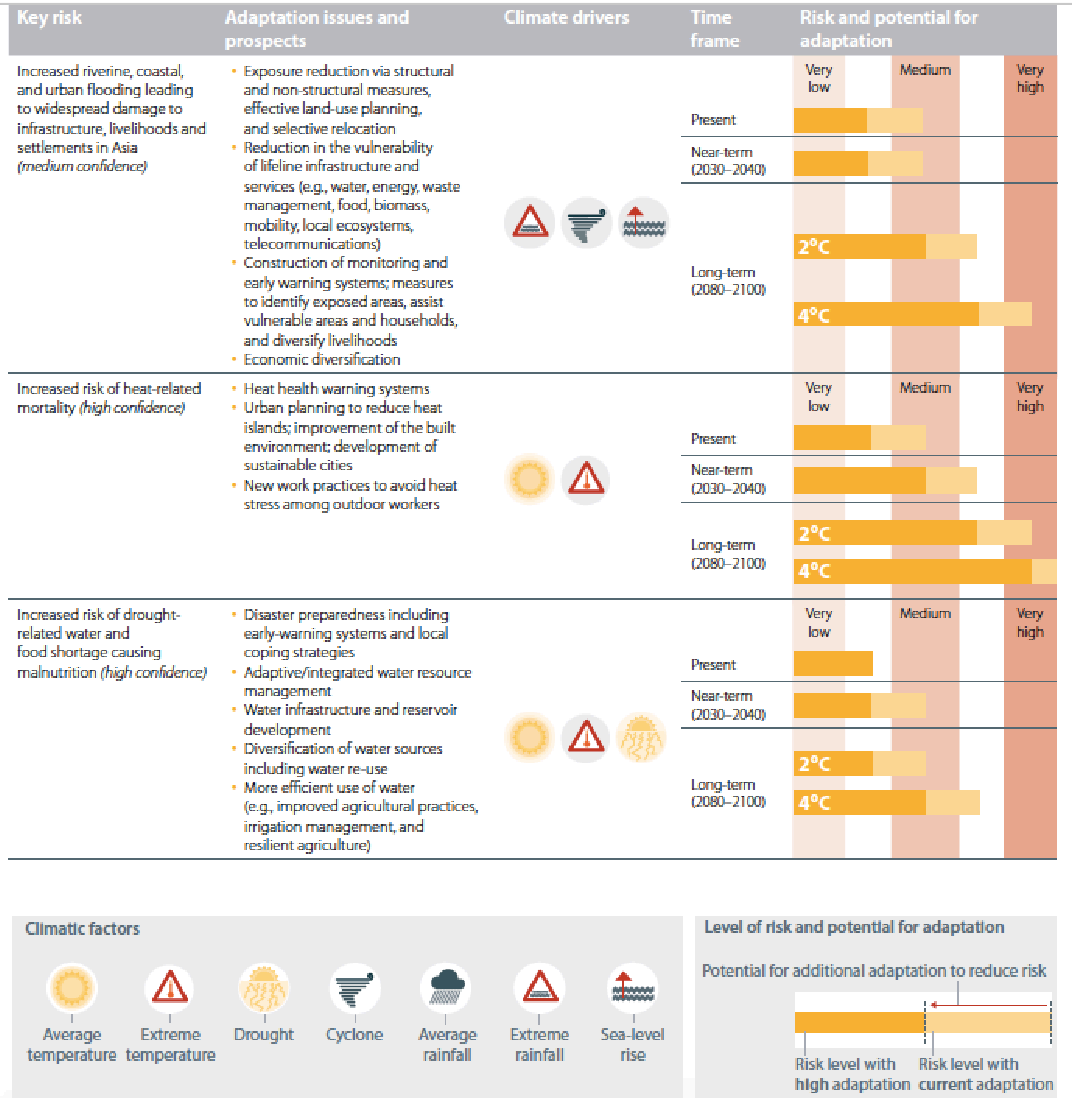


Figure 30: Summary for South Asia (ODI and CDKN, 2014 based on IPCC (Hijioka et al., 2014))

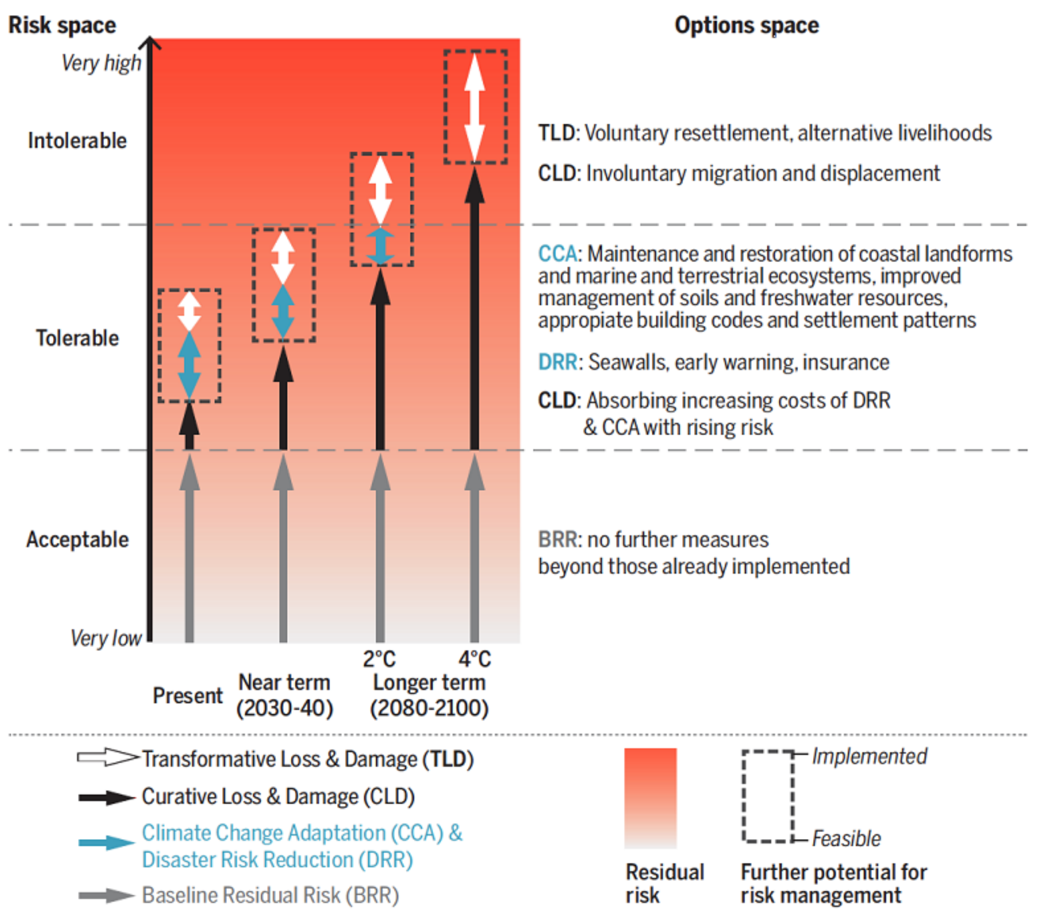
this 'language' also teases out the potential for additional adaptation efforts in terms of further reducing risk (the shaded area exhibited in figure 29).

Such risk synthesis is available for all world regions. Figure 30 visualizes key risks and feasible risk management for the South Asian region including India (ODI and CDKN, 2014 based on IPCC (Hijinks et al., 2014)). While the risk bar shows overall risk (given adaptation actions taken), this 'language' also teases out the potential for additional adaptation efforts in terms of further reducing risk (the shaded area exhibited in Figure 29).

The IPCC risk synthesis categorized risk from low-high but stopped short of identifying systems' needs or actors' objectives. Mechler and Schinko (2016) took this analysis further by **identifying SIDS' objective in the face of sea level rise to maintain physical integrity.** Synthesising available literature, in particular building on IPCC assessments and the UNFCCC stocktake on the long-term goal that led to defining the Paris ambition of 1.5°C respectively 2°C of change as the upper global warming limit (UNFCCC, 2015b), the authors propose that sea level rise coupled with high tides at 2°C of warming would likely endanger existence (pending expensive physical protection), while at 4°C there would be certainty in terms of losing islands to the sea (lacking physical options at high levels of sea level rise).

The summary chart shows stylised past, present, and future climate-related risk levels and corresponding climate risk management portfolios for the set of small island states, whose risk profile is characterised by severe climate risk today and expecting further increases in risk due to climate change.

Figure 31: Summary for South Asia (ODI and CDKN, 2014 based on IPCC (Hijioka et al., 2014))



8.4 Approach 2: Model Based Approaches

Another approach is to use modelling approaches that define objectives and criteria under which risk is acceptable or tolerable and becomes intolerable. We discuss two methodologies: building on economic framing of risk preference for defining fiscal risk tolerance and the adaptation pathways method.

A Case Study on Model-Based Assessment of Fiscal Tolerance in Bangladesh

As one example the Catastrophe Simulation (CATSIM) developed by IIASA (Hochrainer, 2006; Mechler et al., 2006) is a simulation model for understanding the development consequences of disaster risk. As one key application, CATSIM can be used to assess fiscal risk tolerance of governments to extreme events and assist policy makers in developing risk management strategies for disaster risk. CATSIM defines fiscal resilience as a country's ability to access domestic and external savings. Given the objective of fiscal authorities to maintain fiscal integrity in the face of disaster events (as amplified by climatic change), combining fiscal resilience with financial risks (probabilistic disaster losses) allows for calculating a nation's fiscal tolerance, which we define as the lack of access of a government to domestic and foreign savings for financing reconstruction investment and relief post-disaster.

For the Bangladesh example, building on hydrological and socio-economic modelling, flood risk from 1 to 100 year flood return periods is estimated to increase from today to 2020 to 2050, e.g. a 100 year event today would cost about USD 4.7 billion, and increase to more than USD 20 billion in the absence of additional risk management measures. In addition, we find that fiscal risk tolerance, i.e. the intolerable part

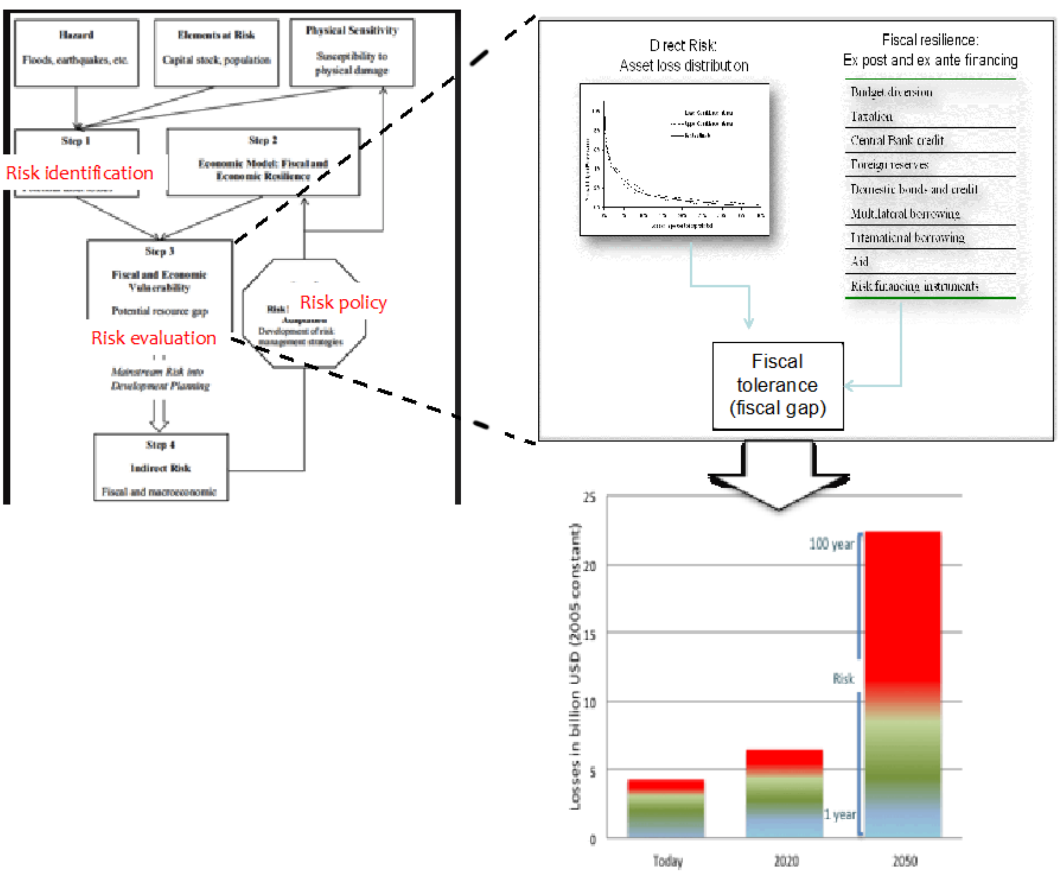


Figure 32: Assessing fiscal tolerance to extreme climate-related events: case of Bangladesh. Based on Mechler et al., 2014; Mechler and Bouwer, 2015

Table 7: Impact of risk and shocks experienced by the survey households. Adelphi and GIZ, 2015

Risk and Shocks	Very High & High		Moderate		Low & Very Low		No Response	
	No.	%	No.	%	No.	%	No.	%
Cyclonic Storms	14	21.54	21	32.31	17	26.15	13	20.00
Floods (Storm Surge)	8	12.31	13	20.00	23	35.38	21	32.31
Salinisation	13	20.00	6	9.23	40	61.54	6	9.23
Health Problem	22	33.85	6	9.23	18	27.69	19	29.23
Price shock	29	44.62	9	13.85	9	13.85	18	27.69
Marriage	0	0.00	12	18.46	3	4.62	50	76.92
Others	0	0.00	1	1.54	5	7.69	59	90.77

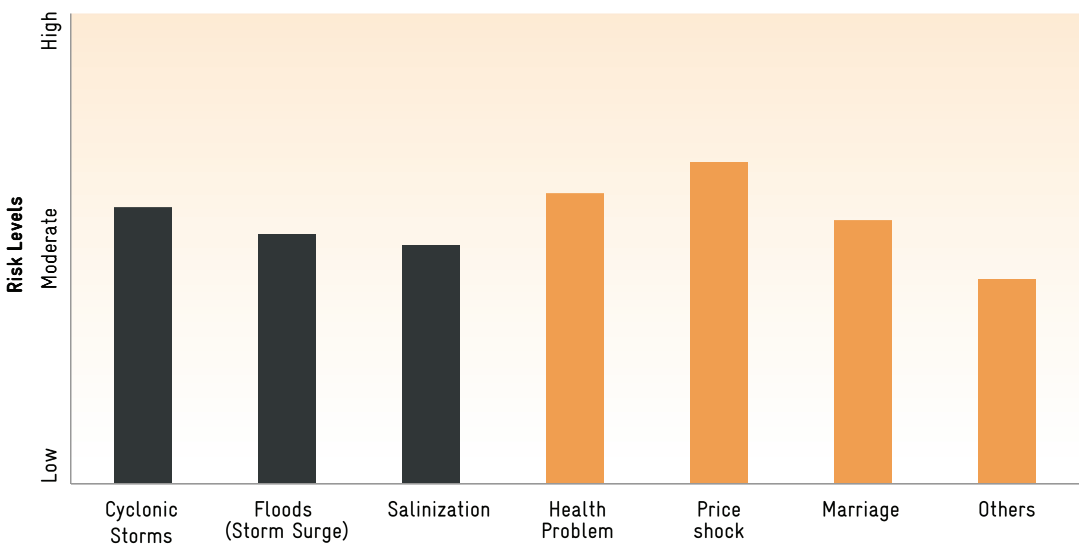
of risk (risk beyond countries capacity to absorb by national means and international disaster assistance), is already exceeded today at events with a return period of about 55 years, and that this fiscal risk threshold is expected to move down to even lower return periods. Risk layering thus not only allows for identifying appropriate measures for tackling different layers of climate-related risk but also provides an opportunity to investigate how risk layers will change in the future and eventually become intolerable.

8.5 Application in India: Surveys in Tamil Nadu to Inform Risk Tolerance

We build on the survey conducted in the villages in Tamil Nadu, where perceptions of risks as well as options to be taken are reported. While objectives and needs of the households queried are not clearly known, we report on their risk levels and compare with other risk classes using expert judgment.

As one way to compare across the climate-related risks (as well as other risks mentioned as importantly affecting respondents), we calculated the mean response in the respective category for the different risk sources (figure 33). We find that climate-related risks can overall be considered to be moderate. These collective/covariate risks are evaluated a little less severe than the idiosyncratic risks from price shocks, health and marriage, which are well known to generally affect household's wellbeing (see WDR, 2014).

Figure 33: The risk space in Tamil Nadu as evaluated from household responses (mean)



9. IDENTIFY FEASIBLE OPTIONS TO ADDRESS POTENTIAL LOSS AND DAMAGE

The previous steps will establish the methodology with a detailed process of risk identification and evaluation. Before testing the framework in the system of interest, it is important to understand that there is a wide spectrum of potential risk reduction, preparedness and risk financing measures that can be taken in order to reduce or finance risk as well as deal with uncertainty. Figure 34 lists a selection of these risk management measures that reduce risk (prevention and preparedness) or transfer and spread risk to a larger basis (risk financing). Step 6 consists of identification of possible feasible options to address potential climate-related risks and associated L&D. Identifying applicable and acceptable options generally requires close consultation of stakeholders at national to local scales.

9.1 Background

As shortly presented above (see figure 34 on learning frameworks), O'Brien et al in IPCC's SREX report. (2012), group options into whether they are incremental, fundamental or transformative as follows:

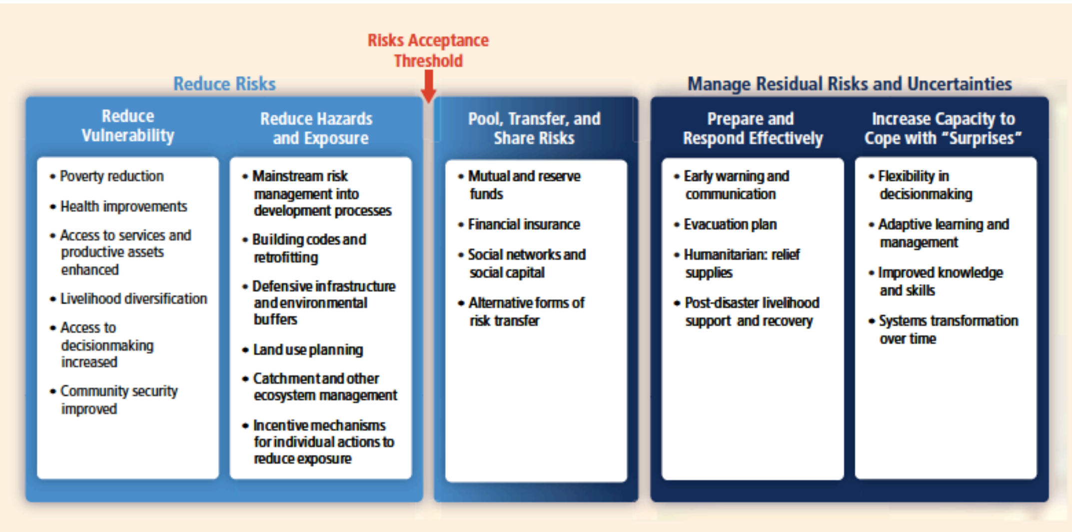


Figure 34: Spectrum of climate risk management options. Lal et al., 20112 (IPCC SREX)

- **Incremental Interventions:** Standard DRR and CCA interventions directly addressing specific risks, e.g., raising dikes
- **Fundamental Interventions:** Non-standard interventions in the system of interest, e.g., opening floodplains instead of dike
- **Transformative Interventions:** Interventions that change fundamental attributes of the system, i.e. "doing things differently, either voluntarily to work towards improved outcomes, such as options and action focussed on broadly building resilience e.g., migration from floodplains to cities to provide alternative livelihood opportunities via access to new labour and other markets; or options taken by force, such as forced displacement.

Options can generally be chosen using decision analysis, strongly building on participatory decision-methods including cost-benefit analysis, multi-criteria assessment, robust decision-making and adaptation pathways (see table 8; box 4) (Mechler, 2016).

Economic efficiency, underlying CBA, is only one decision-making criterion of relevance for prioritizing risk management investments. Decisions on investment to are likely to be made based on a number of criteria, some of which are more or less transparent. Criteria such as risk-effectiveness, robustness, equity and distributional concerns, and acceptability have been found to be key for deciding on implementing risk management projects.

There are other decision support techniques such as cost-effectiveness analysis (CEA), multi-criteria analysis (MCA), robust decision-making and adaptation pathways approaches. The different decision-support tools are applicable for different objectives and circumstances and it is also possible to combine approaches. Decision-support tools can be used to inform various types of decisions in many different contexts, including: Project appraisal; Evaluation; Informational/ advocacy study; Iterative decision-making.

Table 8 summarizes the key advantages, challenges and applicability of CBA, CEA, MCA, robust approaches and pathways approaches. The table illustrates that no one tool is perfect for every situation. Each has its strengths and weaknesses and is suited to different decision-making contexts. Overall, different decision tools have different applicability depending on context and stakeholder needs.

Table 8: Characteristics and applicability of different decision-support tools for assessing risk management options. Adapted from Mechler, 2016.

Note: CBA-Cost Benefit Analysis; CEA-Cost-Effectiveness Analysis; MCA-Multi-Criteria Analysis.

Decision Tool	Opportunities	Challenges	Application
CBA	Rigorous framework based on comparing costs with benefits	Need for monetising all benefits, difficulty in representing plural values	Well-specified hard-resilience projects with economic benefits
CEA	Ambition level fixed, and only costs to be compared. Intangible benefits part. loss of life does not need be monetised	Ambition level needs to be fixed and agreed upon	Well-specified interventions with important intangible impacts, which should not be exceeded (loss of life etc.)
MCA	Consideration of multiple objectives and plural values	Subjective judgments required, which hinder replication	Multiple and systemic interventions involving plural values
Robust approaches	Addressing uncertainty and robustness	Technical and computing skills required	Projects with large uncertainties and long timeframes
Adaptation pathways	Scenario-based decision-making at decision points depending on future system changes	Considerable investment into scenarios and stakeholder interaction	Flood risk management

Box 4: Adaptation Pathways - A Planning Process to Define Feasible Actions and Tipping Points

Addressing various uncertainties involved in climate risk management applications, the **adaptation pathways** methodology has emerged as a decision-making paradigm that adaptively supports taking decisions under risk and uncertainty. The methodology builds on a planning framework that identifies various types of actions which help to understand where, when and if adaptation is needed and feasible and possible. Over time and the risk space, the methodology supports to define possible options that respond to alternative states of the external environment (Hassnoot et al., 2013).

As a central element of adaptation pathways, **adaptation tipping points** describe the conditions under which actions cannot anymore satisfy the pre-specified objectives, thus constituting hard or soft adaptation limits. A scorecard describes how key attributes of the options are met (or not). Beyond tipping points, additional, new actions are required leading to a pathway for operating within the risk space (figure 35).

The figure below shows an adaptation pathways map for the River Rhine - Waal Branch (Haasnoot 2013). The actions that are planned to be carried out in the near future consist of some dike strengthening and actions aimed at lowering of the water level by giving more space to the river (grey line). These actions are insufficient to control the flood risk over a longer time span. Therefore, five policy options were defined. The first option consists of actions that result in lowering of the water level during a flood by giving more space to the river (e.g. lowering of flood plains; orange lines).

Figure 35: An exemplary application of an Adaptation Pathway map to the case of adaptive plan for long-term water management of the Rhine Delta in the Netherlands. Hassnoot et al., 2013

9.2 Application in India

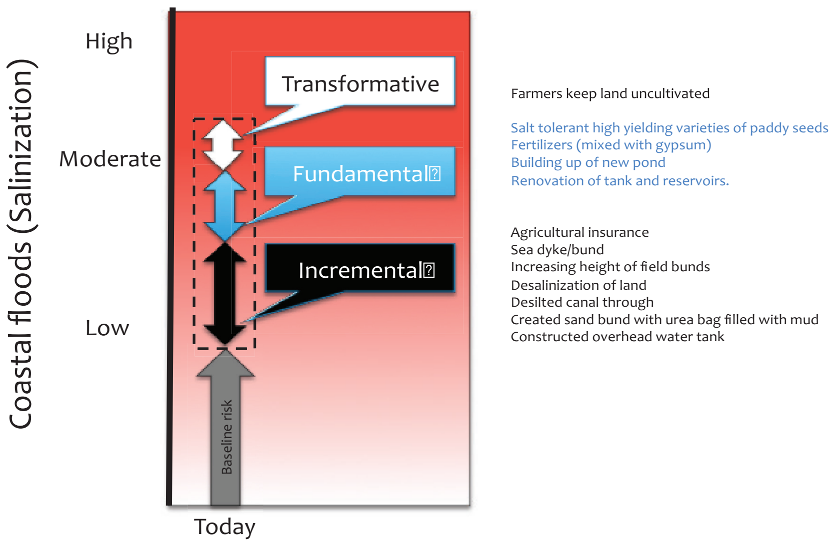
In the Tamil Nadu application, a number of options under implementation or consideration have been identified through a survey, which we use to group risk actions using the learning loop framework and criteria. Table 9 reports the options for farmers, non-farming households and the public sector as organised around the adopted continuum of risk management actions.

Consequently, for farm level responses, the following schematic can be worked out building on our risk classification and options categorisation (figure 36). Actions for farming households to contain increasing coastal flood risks including salinisation ranges from incremental to fundamental and transformative. In particular the (negatively) transformative action of leaving land uncultivated highlights that farmers already today are in need to think about risks 'beyond adaptation.'

Table 9: Options for dealing with Loss and Damage due to Cyclonic Storms and Salinisation in Tamil Nadu. Adelphi and GIZ, 2015. Note: Study villages were in Nagapattinam and Thiruvarur districts.

Characteristics	Options	Category
Farm Level	• Farmers keep land uncultivated	Transformative: Negative Coping
	• Salt tolerant high yielding varieties of paddy seeds • Fertilizers (mixed with gypsum)	Fundamental: Non-standard actions for managing risks
	• Agricultural insurance • Sea dyke/bund • Increasing height of field bunds • Desalinisation of land • Desilted canal through • Created sand bund with urea bag filled with mud • Constructed overhead water tank • Building up of new pond • Renovation of tank and reservoirs	Incremental: Actions out of DRR and CCA toolbox
Household Level	• Availing both formal and informal loans to smoothen both income and consumption	Fundamental: Non-standard actions for managing risks
	• Repair the damaged nets and boats	Incremental: Actions out of DRR and CCA toolbox
Public Sector	• Public provision of insurance (agriculture and cyclones) • Compensation scheme (only cyclones and during rough season for loss of life, boat and net for fishermen	Incremental: Actions out of DRR and CCA toolbox

Figure 36: The risk and current options space for farming households in Tamil Nadu.



Non-farming households exposed to cyclone and flood risks mostly deploy incremental and fundamental actions such as repairing damaged nets and boats (incremental) and using informal and formal loans to smoothen income and consumption (fundamental).

Finally, the public sector acting via DRR and CCA institutions operates well within its remits and provides insurance (agriculture and cyclone) as well as offers compensation schemes (only cyclones and during rough season for loss of life, boat and net for fishermen (figure 37).

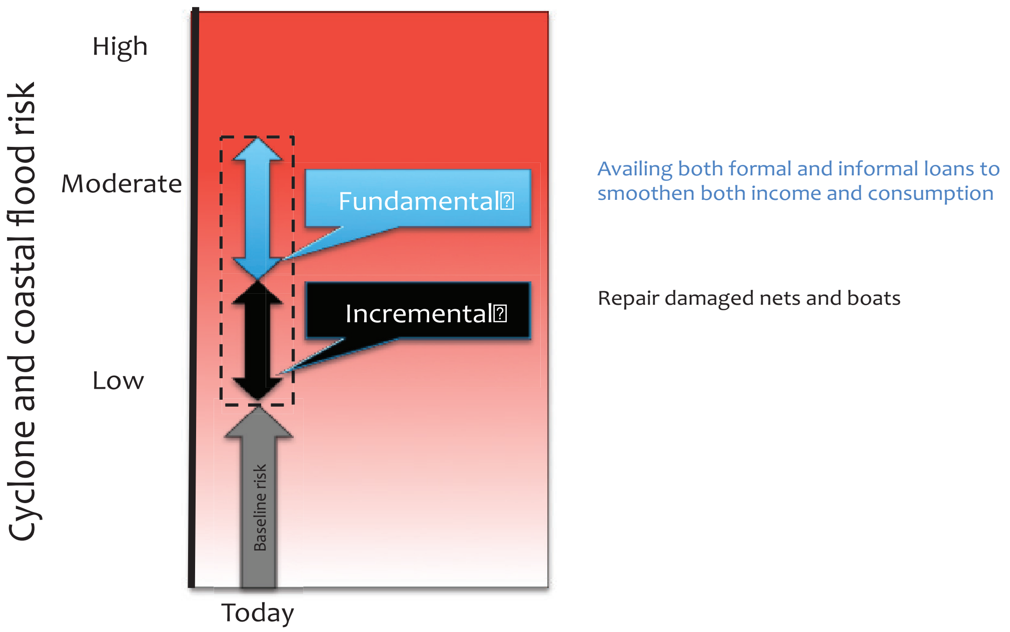


Figure 37: The risk and current options space for non-farming households in Tamil Nadu

Our assessment, which is based on post-processing available information, did not currently go into selecting options and interventions using decision-metrics, which would require stakeholder consultation in line with the proposed learning framework. Future work may set up a process for discussing the findings and appropriate actions to be taken at scales from national to local, as well as international.

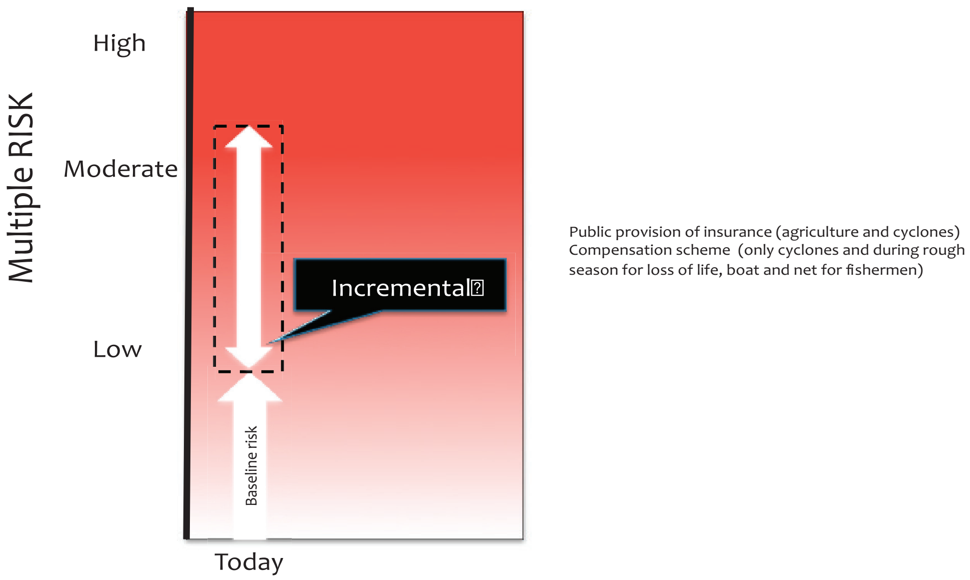


Figure 38: The risk and current options space for public sector in Tamil Nadu.

10. CONCLUSIONS AND IMPLICATIONS

10.1 Conclusions

This report has laid out a comprehensive Climate Risk Management (CRM) framework generically developed for two systems of interest (prototype states Tamil Nadu and Himachal Pradesh). The methodology is meant to support national institutions (and, when applied to other contexts, other governments) to assess and determine their response to climate-risks at the national as well as the state level dealing with large scale climate vulnerabilities as well as residual risks that could contribute towards climate-related loss and damage. The generic comprehensive climate risk analytical approach helps to operationalise decision-support at scale and is defined by the following key characteristics:

- Comprehensive climate risk management focuses on the short and medium time horizon and up to the period of 2030/40 and synergistically informs Disaster Risk Reduction (DRR), Climate Change Adaptation (CCA), and policy and actions that deal with residual risk.
- Comprehensive climate risk management and policy comprises incremental (standard DRR and CCA interventions directly addressing specific risks, e.g., raising dikes), fundamental (non-standard interventions in the system of interest, e.g., opening floodplains instead of dike) and transformative (interventions focussed on broadly building resilience e.g., facilitating voluntary migration from floodplains to cities to provide alternative livelihood opportunities via access to new labour and other markets) interventions. We suggest L&D particularly needs to look into fundamental and transformative actions beyond traditional DRR and CCA measures, and foster transformative capacities of communities at risk.
- A comprehensive approach needs to align top-down insight from expert-based methods and tools with bottom-up information on households' and communities' risks gathered through participatory processes.

We identified the key components of a climate risk management process such as risk identification, risk evaluation to identify acceptable, tolerable and intolerable risks, evaluation of risk management options. Thereby embedding a learning framework for identifying appropriate actions and adjusting these dynamically over time with increased knowledge.

The six step CRM process operationalises climate-related risk management at scale while being linked to a learning framework, which allows for updating decisions over time with mounting evidence and insights. Outcomes of each individual step feed into succeeding steps contributing towards the development of the comprehensive CRM framework for the country. The outcomes of each individual step are the following:

- The overall objective of the CRM framework is defined at **Step 1,** wherein we showcase the need to develop interlinkages between CCA and DRR, not just in terms of the assessment of risks and vulnerabilities and associated data but also in regard to institutions.
- **Step 2** takes the debate from a more general level to more specific levels. This step identifies the concrete system of interest by conducting climate-related risk hot spot and capacity analysis.
- **Step 3** develops a context specific multi-method approach customized to the system(s) of interest to assess potential climate-related impacts.
- **Step 4** builds on the framing of risk as a function of hazard, exposure and vulnerability. The climate risk assessments would go through a structured process for calculating risks and the benefits of relevant adaptation measures.
- **Step 5** sets out to evaluate the identified risks by establishing risk tolerance thresholds, segregating the risk space into acceptable, tolerable and intolerable segments.
- **Step 6,** identifies and conducts an evaluation of potential risk management and policy options. These options will support averting, minimizing and addressing potential loss and damage. There is a wide spectrum of potential risk reduction, preparedness and risk financing measures that can be taken in order to reduce or finance risk

10.2 Implications

The exemplary application of the comprehensive CRM framework to India and the states of Tamil Nadu and Himachal Pradesh served to test the methodological approach and glean its usefulness at state and local levels. The methodology is meant to support public sector institutions (and, when applied to other contexts, other governments) in order to assess and determine their response to climate-related risks at the national as well as the sub-national level. The application to India largely consisted of a backward-looking climate risk analysis for the state of Tamil Nadu, for which information developed for a prior project was post-processed according to our six-step climate risk management process.

Our assessment for Tamil Nadu showed that risks are significant and on the rise. As well, incremental, fundamental and transformative actions are already being taken by farmers and households exposed to cyclone and flood risks, indicating links to the Loss and Damage debate. Government institutions work well within their remit to provide incremental support, yet are usually not charged to deal with fundamental and transformative options. Thus, the options space needs more attention and deliberation with those at risk and in charge to further deploy interventions with public support from state, national to international levels. As argued in the literature (see e.g. Mechler and Schinko, 2016), the CRM framework and associated L&D debate is largely about extending support for (negatively or positively) transformative options.

We suggest the different policy regimes at national and international levels would deal with the categories of risk management options as follows:

- **Incremental options:** National and state-level DRR and CCA related policy options.
- **Fundamental options:** National and state-level DRR and CCA related options, international levels to deal with L&D related actions.
- **Transformative options:** Predominantly international levels for L&D related actions.

Identification and evaluation of feasible options (interventions, measures, policies, among others) for addressing potential climate-related loss and damage will result in better implementation of the six-step CRM framework in the system of interest, to be further scaled up to address climate risks and L&D in regional, state and national boundaries.

While traditional DRR and CCA policy typically acts within an incremental adjustment learning loop, climate-related risks discussed in the context of L&D may not only require new innovative response measures, but particular attention has to be paid to locally-applicable techniques for understanding risks and risk management interventions, such as through Vulnerability Capacity Assessments (VCAs) and community-led focus groups.

10.3 Disaster Risk Reduction: Critical Pathway in Climate Risk Management

Interestingly and very importantly, the GAR report 2019 (GAR 2019) expressed serious concerns over damage and loss due to extreme events and disasters caused or exacerbated by the unsustainable economic growth patterns "unsustainable patterns of economic activity hide the build-up of systemic risks across sectors citing for example, dangerous overdependence on single crops in an age of accelerating global warming". The environment-disaster-development nexus, therefore, attains central place in approach to achieving SDGs, where the integration of climate actions and disaster risk reduction strategies are warranted. This is in direct sync with the proposed framework of Climate Risk Management (CRM) to address loss and damage contexts across key sectors of development, covering urban, rural and industrial settings.

India being signatory to the three global strategies- Sendai Framework for DRR, Paris Climate Agreement and SDGs, has to delineate an integrated strategy-cum-mechanism, as the land and people being commonly affected (beneficiary) of such interventions of safety and sustainability together. Over the decade there are reported pilot/localized and sector specific interventions of integrating DRR and climate resilience into development in many countries including India. However, the efforts may be built upon the past ones and taking advantage of the good practices across the world and especially in developing countries, using pathways and approaches of DRR mainstreaming into developmental planning and local actions.

India has already taken big strides to address both – climate change issues through the National Action Plan on Climate Change and with the Disaster Management Act and Framework, but separately. The eleven national missions of climate change offer significant opportunities for holistic and systemic approach of disaster risk reduction for benefits towards climate risk management. However, despite of policy level and academic understanding, integration of the two has not yet taken place at sub-national planning and ground actions level. The proposed CRM framework envisages to effectively enable mainstreaming of climate resilience and DRR into developmental planning and actions at all levels.

Accordingly action plans that integrate climate adaptation, disaster resilience and SDGs into one framework at state and sub-state level will be critical for sustainable inclusive development. However implementation on the ground, of such approach, would need effective use of technology, communication and local actions by addressing knowledge and capacity gaps through systematically designed programmes.

REFERENCES

Adelphi and GIZ (2015). Climate-related loss and damage in India. Results of a rapid assessment in Tamil Nadu and Odisha. Internal report.

Das, S. and Crépin, A.-S. (2013): Mangroves can provide protection against wind damage during storms. Estuarine, Coastal and Shelf Science 134: 98-107. Available online at (last accessed 29.10.2015): http://dx.doi.org/10.1016/j.ecss.2013.09.021

Dow, K., Berkhout, F., Preston, B., Klein, R., Midgley, G., Shaw, M. (2013). Limits to adaptation. *Nature Climate Change* 3, 305–307

Fritzsche, K., Schneiderbauer, S., Bubeck, P., Kienberger, S., Buth, M., Zebisch, M., Kahlenborn, W. (2014). Vulnerability Sourcebook. Guidelines_for_assessment. Adelphi, EURAC, GIZ.

UN Global Assessment Report on Disaster Risk Reduction (GAR), 2019 https://gar.unisdr.org/

GIZ and EURAC 2017: Risk Supplement to the Vulnerability Sourcebook. Guidance on how to apply the Vulnerability Sourcebook's approach with the new IPCC AR5 concept of climate risk. Bonn: GIZ.'

Haasnoot, M., Kwakkel, J.H., Walker, W.E., ter Maat, J. (2013) Dynamic adaptive policy pathways: A method for crafting robust decisions for a deeply uncertain world. Global Environmental Change 23, 485-498.

Hijioka, Y., E. Lin, J.J. Pereira, R.T. Corlett, X. Cui, G.E. Insarov, R.D. Lasco, E. Lindgren, and A. Surjan (2014). Asia. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1327-1370.

Hochrainer-Stigler, S., Mechler, R., Pflug, G., Williges, K. (2014). Funding Public Adaptation to Climate-related Disasters. Estimates for a Global Climate Fund. Global Environmental Change 25: 87-96

IPCC (2012). Summary for Policymakers. In: Field, C.B., Barros, V., Stocker, T.F., Qin, D., Dokken, D.J., Ebi, K.L., Mastrandrea, M.D., Mach, K.J., Plattner, G.K., Allen, S.K., Tignor, M., Midgley, P.M. (Eds.), Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge and New York, pp. 3–21.

IPCC (2014). Summary for Policymakers. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate

Change. In: Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R., White, L.L. (Eds.), Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1–32.

Jeuken, A., Haasnoot, M., Reeder, T., Ward, P. (2015). Lessons learnt from adaptation planning in four deltas and coastal cities Journal of Water and Climate Change Dec 2015, 6 (4) 711-728; DOI: 10.2166/wcc.2014.141

Klein, R.J.T., G.F. Midgley, B.L. Preston, M. Alam, F.G.H. Berkhout, K. Dow, and M.R. Shaw (2014). Adaptation opportunities, constraints, and limits. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 899-943.

Lal, P., Mitchell, T., Aldunce, P., Auld, H., Mechler, R. Miyan, A., Romano, L., Zakaria, S. (2012). Chapter 6. National Systems for Managing the Risks from Climate Extremes and Disasters. In: Intergovernmental Panel on Climate Change Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C. B., Barros, V., Stocker, T.F., Qin, D., Dokken, D., Ebi, K.L., Mastrandrea, M. D., Mach, K. J., Plattner, G.-K., Allen, S., Tignor, M. and P. M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA: 339-392

Lavell, A., M. Oppenheimer, C. Diop, J. Hess, R. Lempert, J. Li, R. Muir-Wood, and S. Myeong, 2012: Climate change: new dimensions in disaster risk, exposure, vulnerability, and resilience. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 25-64.

Mechler, R. Bouwer, L., Linnerooth-Bayer, J., Hochrainer-Stigler, S., Aerts, J., Surminski, S. (2014). Managing unnatural disaster risk from climate extremes. Nature Climate Change 4: 235-237

Mechler R. and Bouwer, L. (2015). Reviewing trends and projections of global disaster losses and climate change: Is vulnerability the missing link? Climatic Change 33 (1) : 23-35

Mechler, R. and T. Schinko (2016). Identifying the policy space for climate loss and damage. Science 354: 1-3.

O'Brien, K., M. Pelling, A. Patwardhan, S. Hallegatte, A. Maskrey, T. Oki, U. Oswald-Spring, T. Wilbanks, and P.Z. Yanda (2012). Toward a sustainable and resilient future. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate

Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 437-486.

ODI and CDKN (2014). IPCC AR5-What's in it for South Asia.

Press Information Bureau (PIB), (2018) https://mha.gov.in/sites/default/files/PRESSRELEASE_090720180942.pdf

Roderick, P. and Verheyen, R. (2008). Beyond Adaptation - The legal duty to pay compensation for climate change damage. WWF-UK, Climate Change Programme discussion paper 2008.

Schäfer, L. and Balogun, K. (2015). Stocktaking of climate risk assessment approaches related to loss and damage. UNUEHS Working Paper, No. 20. Bonn: United Nations University Institute of Environment and Human Security.

Serdeczny, O., Waters, E., Chan, S., 2016. Non-economic loss and damage in the context of climate change (Discussion Paper 3/2016). German Development Institute (DIE), Bonn.

Souvignet, M., Wieneke, F., Mueller, L., Bresch, D. (2016). Economics of Climate Adaptation (ECA) - Guidebook for Practitioners. A Climate Risk Assessment Approach Supporting Climate Adaptation Investments. KFW, UNU.

Surminski, S., Lopez, A., Birkmann, J., Welle, T. (2012). Current knowledge on relevant methodologies and data requirements as well as lessons learned and gaps identified at different levels, in assessing the risk of loss and damage associated with the adverse effects of climate change, UNFCCC, background paper.

UN (2015). Making development sustainable: the future of disaster risk management. Global assessment report on disaster risk reduction. United Nations Office for Disaster Risk Reduction (UNISDR), Geneva.

UNFCC (2017). Five-year rolling workplan of the Executive Committee of the Warsaw International Mechanism for Loss and Damage associated with Climate Change Impacts

Verheyen, R., 2012. Tackling Loss & Damage–A New Role for the Climate Regime. Climate Development Knowledge Network.

Winsemius, H. C., Aerts, J. C. J. H., Van Beek, L. P. H., Bierkens, M. F. P., Bouwman, A., Jongman, B., Kwadijk, J. C. J., Ligtvoet, W., Lucas, P. L., Van Vuuren, D. P., Ward, P. J. (2016). Global drivers of future river flood risk. Nature Climate Change, 6 (4), 381-385

World Bank. 2013. World Development Report 2014: Risk and Opportunity—Managing Risk for Development. Washington, DC: World Bank. doi: 10.1596/978-0-8213-9903