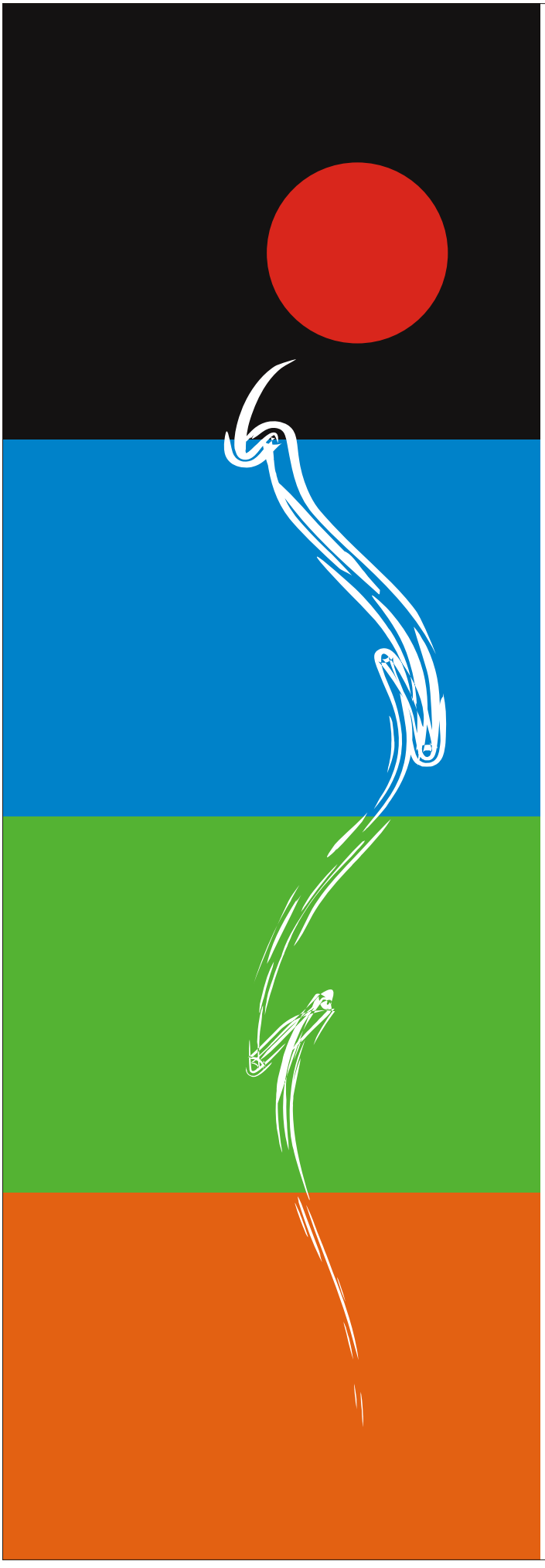

Climate Resilient Development

Synthesis Report

Towards adaptation to climate change

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Confederation suisse
Confederazione Svizzera
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Swiss Agency for Development and Cooperation SDC

inter cooperation
Natural Resource Management
Rural Economy
Local Governance and Civil Society

V&A

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Main Authors

B Ramkumar, Vishnu Sharma, K Bhavana Rao, Rupa Mukerji

Contributors

Peer Group Members

Dr. S C Mahnot, Dr. S L Seth, Mr. T Pradeep, Dr. K R Viswanathan, Dr. N R Jagannath, Dr. Balasubramanium, Ms. Sushma Iyengar, Dr. Rukmini Rao, Mr. Sunil Dhingra, Mr. Othmar Schwank, Ms. Annet Witteveen

Intercooperation -India

Devanshu Chakravarti

Partners

ANTHRA, BAIF, ISCB, Keystone Foundation, MARI, MSSRF, MYRADA, PRAWARDA, Sahajeevan, Sahyog Santhan, Samuha, SURE, TIDE

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Acronyms

AER	agro-eco regions
AESR	agro-eco subregions
AWC	available water capacity
BAIF	Bharatia Agro-Industries Foundation (India)
CAIT	International Center for Tropical Agriculture, Colombia
CRYSTAL	Community-based Risk Screening Tool - Adaptation & Livelihoods
CSE	Centre for Science and Environment
DFID	Department for International Development, Government of UK
FAO	Food and Agriculture Organisation of the United Nations
HID	Human and Institution Development
IC	Intercooperation
ILRI	International Livestock Research Institute
IPCC	Intergovernmental Panel on Climate Change
ISCB	Indo Swiss Collaboration in Biotechnology
ISPWDK	Indo-Swiss Participatory Watershed Development Programme, Karnataka
LGP	Length of Growing Period
MARI	Modern Architects for Rural India
MSL	Metres above Sea Level
MSSRF	MS Swaminathan Research Foundation
MYRADA	Mysore Resettlement and Development Agency
NAPCC	National Action Plan for Climate Change
NGO	non-governmental organisation
NRM	Natural Resources Management
NTFP	Non Timber Forest Produce
ORCHID	Opportunities and Risks of Climate Change and Disaster
PRAWARDA	Participatory Rural and Watershed Development Agency
PRECIS	Regional Climate Modelling (RCM) system
RLS	Rural Livelihood Strategy
SDC	Swiss Agency for Development and Cooperation
SLA	Sustainable Livelihoods Approach
SURE	Society for Upliftment of Rural Economy
TAR	Third Assessment Report
TERI	The Energy Resources Institute
TIDE	Technology Informatics Design Endeavour
UNCB	United Nations Convention on Biodiversity
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UN-ISDR	United Nations International Strategy for Disaster Reduction
USAID	United States Agency for International Development
VDS	Village Development Societies

Foreword

Climate change is possibly the greatest global environmental threat the world is facing today. It is likely to much more drastically affect the economy, infrastructure, natural resources and local livelihoods in developing countries.

Countries may be confronted to increasing extreme climatic events such as droughts, hurricane and heavy rainfall. These phenomena will notably affect human health, food production, water supply, biodiversity, as well as natural ecosystems. The poorest and most vulnerable will also be the most affected the world over. It is the responsibility of the international community as well as national governments to develop holistic global as well as national and local strategies to adapt to climate change, and to support their effective implementation. Responses to climate change must promote environmental sustainability and ecological security of the physical resource base on which livelihoods of the poor is dependent, and should be integrated into development policy making, notably in specific country poverty reduction strategies. India's National Action Plan on Climate Change (NAPCC), released in June 2008, focuses on a vision together with appropriate strategies to effectively address impact of climate change.

The sharing of good practices in adaptation to climate change constitute an important part of the knowledge base necessary for the development of relevant multi-level adaptation policies and strategies required to guide implementation of the NAPCC. In an attempt to add to such knowledge, SDC decided to review experiences made in the Natural Resources Management projects it supported over many years in India, from the perspective of their contribution to adaptive capacities to climate change. The task of analysing and documenting such experiences was assigned to Intercooperation, a Swiss Foundation, which has been actively involved in livestock based livelihoods and natural resource management in India for a long time, as the implementing agency for SDC supported projects in these fields. A Peer Group, comprising thematic experts, including some colleagues from SDC, was responsible for effectively guiding the data collection and analysis process and ultimately developing the present document.

This publication very clearly and effectively highlights a number of good practices in the implementation of adaptive measures to climate change risks in some key areas of natural resources management such as: harnessing biotechnology for enhancing crop resistance, up-gradation and improvement of livestock, tank rehabilitation, mangrove restoration, ethno veterinary practices, etc.

This publication is designed to add to the knowledge-base made available to contribute to the deliberations during the National Policy Dialogue on Adaptation to Climate Change scheduled in November 2008 in Delhi, as a concluding event of the SDC supported pilot project on "Vulnerability assessment and enhancing adaptive capacity to climate change in semi-arid areas in India".

We wish to sincerely thank all those who were associated with the development of this publication for their hard work and most valued contribution. We very much hope that the publication will bring information strategically relevant to all stakeholders involved in formulating the much needed policies to guide the design and implementation of adaptation initiatives and also prove useful to all the institutions and organisations involved in designing and implementing projects and programs on adaptation to climate change.

Francois E. Binder
Country Director
Swiss Agency for Development and Cooperation
Swiss Foreign Ministry

5th November, 2008

Acknowledgements

Just as adaptation is a process that occurs at the local level, our work and lessons too began with communities in several locations covered by the case studies in this document. We thank these communities for the generous sharing of their time and insights, often of actions going back several years in the past. Without this generosity, into which we dip time and again, this knowledge harvesting task would have been quite incomplete.

NGO partner organizations, responsible for implementation of the case study projects and programmes, were most responsive to our queries and supported us extensively with documents, discussions, insights and their participation in our field exercises. We gratefully acknowledge the support of all the team leaders and their field staff. We hope the documentation of case studies and the analysis in this report help to further their good work.

The Peer Group comprising experts in various thematic domains guided this process with their wisdom and expertise, also respecting the demanding timeline of this task. Dr. S L Seth, Dr. Mahnot, Mr. T Pradeep, Dr. Balasubramanian and Dr. Othmar Shwank deserve a special mention for their support.

We thank Dr. K R Viswanathan and Dr. N R Jagannath of the Swiss Agency for Development and Cooperation (SDC) for their firm faith in the value of this exercise and the methodology adopted. They contributed extensively as Peer Group members and also facilitated our access to information from the SDC system. This task would have been very difficult without their unstinted support. Our colleague Ms. Annette Witteveen, also a member of the Peer Group, reviewed many drafts of the cases and always added to their value, building on her own experiences with development programmes in India. We acknowledge the contribution of Mr. Devanshu Chakravarti for writing the ISPWDK case study.

Mr. Francois Binder, Country Director, SDC India provided moral, financial and intellectual support to this task. This unique combination brings the added value embodied by SDC, to development cooperation. We thank him and SDC for giving us this opportunity.

Finally, we wish to thank all our colleagues and friends for their ideas, suggestions and encouragement. It would be appropriate to acknowledge the Climate Change Safe Space Alliance (CASSA) as a small community of practice here. We hope you will come across them more often in our collective endeavor to make development more climate resilient.

Vishnu Sharma
B Ramkumar
K Bhavana Rao
Rupa Mukerji

Executive Summary

Climate change is a global phenomenon that is likely to have widespread impact on the social and natural environments in the twenty-first century. Over 700 million people in India are directly dependent on climate sensitive sectors and natural resources for their survival. Their adaptive capacities to the negative impacts of climate change are very low. Recognising this, India's National Action Plan for Climate Change (NAPCC, 2008) identifies development and poverty eradication as the best forms of adaptation to climate change.

The Swiss Agency for Development and Cooperation (SDC) has supported several development initiatives in India in the fields of natural resource management and energy, among others, over the past 40 years. Under the frame of the Partnership Programme India, SDC's support in the future would be more on adaptation, energy and climate. Recognising that several of the past interventions have contributed towards enhancing local adaptive capacities to climate change, SDC commissioned this study to draw lessons from a set of case studies of its past partnerships. This would contribute to building emerging strategies on past experiences and lessons learnt. This study complements the lessons from a pilot programme on `Vulnerability Assessment and Enhancing Adaptive Capacities to Climate Change' in Semi Arid India supported by SDC and implemented over the period of 2005 to 2008.

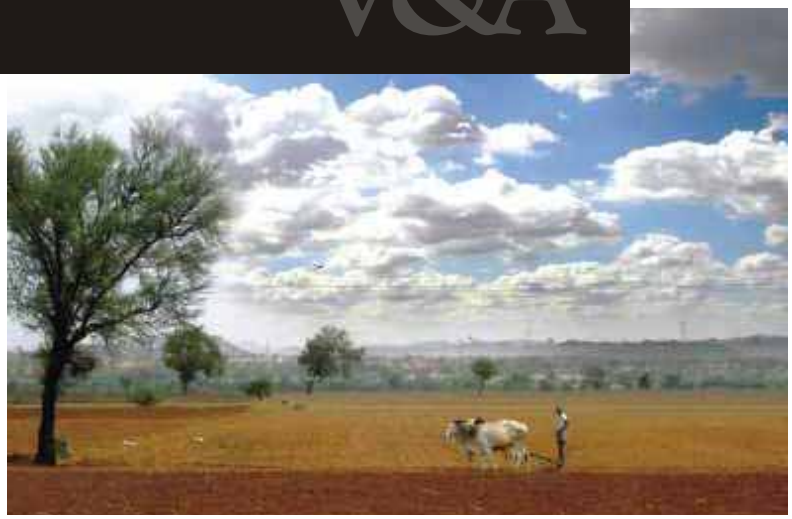
This document is based on three premises: it recognizes that while climate change is a global phenomenon, adaptation is essentially a local process and much can be learnt from experiences of past and ongoing development programmes. Further, while recognizing the large overlap between development and adaptation, there is a need to identify specific elements and approaches that help vulnerable communities and livelihoods to deal better with the additional risks of climate change. Finally, while there is a large body of knowledge about global processes and many individual case studies, there is a knowledge gap with regard to processes that link individuals and communities at the local level with meso level actors who can support them through knowledge and resources towards vulnerability reduction and improved adaptation. The cases explore such interventions and processes drawing lessons on the themes of water management, bio technology, livestock development, energy and bio-diversity.

Executive Summary

This Synthesis Report is complemented by individual case study leaflets that present information about the specific geographic and climatic context in which the project interventions were situated. They also provide information on the socio-economic drivers of vulnerability. The interventions are then analysed for their impact using approaches that enable a holistic understanding. The cases rely largely on secondary information as the methodology did not permit the collection of new and comparable primary data. Most of the findings are based on ex-post observations and may be validated by more extensive empirical analysis.

The intended readership of this document is development professionals who seek to gain an understanding of climate resilient development approaches and strategies. Project designers and policy makers would also find the analysis of the continuum between development and adaptation and the identification of additional elements that contribute to adaptation useful for designing strategies for the future. There is an emphasis on providing climate baseline data and analyzing the impact and relevance of the interventions from a climate change perspective as this is a new challenge for most development professionals. We see this document as a step towards equipping this community with tools and approaches to bridge the gap between development and climate change adaptation.

1 The Context



1.1 Introduction

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

The IPCC Fourth Assessment Report concludes that studies have allowed a broader and more confident assessment of the relationship between observed warming and impacts than was made in the Third Assessment Report which had concluded that there is high confidence that recent regional changes in temperature have had discernible impacts on physical and biological systems. Interseasonal, interannual and spatial variability in rainfall trend has been observed during the past few decades all across Asia (Cruz et al. 2007).

Evidence indicates that more frequent and more intense extreme weather events (droughts, heat and cold waves, heavy storms, floods), rising sea levels and increasing irregularities in seasonal rainfall patterns (including flooding) are already having immediate impacts on not only food production, but also food distribution infrastructure, incidence of food emergencies, livelihood assets and human health in both rural and urban areas.

The projected climate change under various scenarios is likely to have implications on food production, water supply, coastal settlements, forest ecosystems, health, energy security, etc. The adaptive capacity of communities likely to be impacted by climate change is low in developing countries. High reliance on natural resources in developing countries has been noted to account for high levels of vulnerability and low adaptive capacity to climate variability and change (World Bank, 2000).

1.2 Climate Change Impacts in India

India is a large developing country with nearly 700 million rural population directly depending on climate-sensitive sectors (agriculture, forests and fisheries) and natural resources (such as water, biodiversity, mangroves, coastal zones, grasslands) for their subsistence and livelihoods

(Sathaye et al., 2006). Further, the adaptive capacity of dryland farmers, forest dwellers, fisherfolk, and nomadic shepherds is very low. Most regions of India experience adverse impacts of climate variability at frequent intervals that lead to reversal in development achievements.

Climate change is likely to impact all the natural ecosystems as well as socio-economic systems as shown by the National Communications Report of India to the UNFCCC. The latest high resolution climate change scenarios and projections for India, based on a Regional Climate Modelling (RCM) system, known as PRECIS developed by Hadley Center and applied for India using IPCC scenarios A2 and B2 shows the following (Sathaye et al., 2006):.

- An annual mean surface temperature rise by the end of century, ranging from 3 to 5 degrees Celsius under A2 scenario and 2.5 to 4 degrees Celsius under B2 scenario, with warming more pronounced in the northern parts of India is expected.
- A 20% rise in all India summer monsoon rainfall and further rise in rainfall is projected over all states except Punjab, Rajasthan and Tamil Nadu, which show a slight decrease.
- Extremes in maximum and minimum temperatures are also expected to increase and similarly extreme precipitation also shows substantial increases, particularly over the west coast of India and west central India.

Floods, droughts and cyclones are the main extreme climatic events in India. The total flood prone area in India is about 40 million ha or 12.16% of total land area (Sharma et al., 2006). 19% of India's area and 12% of the population (more than 100 million people) is affected by drought annually.

Western parts of Rajasthan and the Kutchh region of Gujarat are chronically drought affected. Drought conditions have also been reported in Karnataka, Andhra Pradesh, Orissa and Bihar states (Sharma and Smakhtin, 2004).

Some projections on climate change impacts

- More recent studies suggest a 2 to 5% decrease in yield potential of wheat and maize for a temperature rise of 0.5 to 1.5^{0}C in India (Aggarwal, 2003).
- Agriculture will be adversely affected not only by an increase or decrease in the overall amounts of rainfall, but also by shifts in the timing of the rainfall. For instance, over the last few years, the Chattisgarh region has received less than its share of pre-monsoon showers in May and June. These showers are important to ensure adequate moisture in fields being prepared for rice crops (Ramakrishna et al. 2002).
- Agriculture will be worst affected in the coastal regions of Gujarat and Maharashtra, where agriculturally fertile areas are vulnerable to inundation and salinisation. Standing crop in these regions is also more likely to be damaged due to cyclonic activity (O'Brien et al. 2001).
- In Rajasthan, a 2^{0}C rise in temperature was estimated to reduce production of pearl millet by 10-15% (Ramakrishna et al. 2002).
- According to some studies, soybean yields could go up by as much as 50% if the concentration of carbon dioxide in the atmosphere doubles. However, if this increase in carbon dioxide is accompanied by an increase in temperature, as expected, then soybean yields could actually decrease. If the maximum and minimum temperatures go up by 1^{0}C and 1.5^{0}C respectively, the gain in yield comes down to 35%. If maximum and minimum temperatures rise by 3^{0}C and 3.5^{0}C respectively, then soybean yields will decrease by five per cent compared to 1998 (Lal et al. 1999).
- Changes in the soil, pests and weeds brought by climate change will also affect agriculture in India (TERI, 2002). For instance, the amount of moisture in the soil will be affected by changes in factors such as precipitation, runoff, and evaporation (Anon, 2002).
- All along the western Indian coastline, tropical ecosystems and species such as mangroves and coral reefs are threatened by changes in temperature, rising sea levels and increased concentrations of carbon dioxide in the atmosphere. Ecosystems and species such as mangroves and coral reefs are threatened by changes in temperature, rising sea levels and increased concentrations of carbon dioxide in the atmosphere.

Source: Fact sheet, Global Environmental Negotiations, CSE

1.3 Vulnerability and Adaptation (V&A)

Vulnerability is defined as the extent to which a natural or social system is susceptible to sustaining damage from climate change. Vulnerability is a function of the sensitivity of a system to changes in climate (the degree to which a system will respond to a given change in climate, including beneficial and harmful effects), adaptive capacity (the degree to which adjustments in practices, processes, or structures can moderate or offset the potential for damage or take advantage of opportunities created by a given change in climate), and the degree of exposure of the system to climatic hazards (TAR, IPCC).

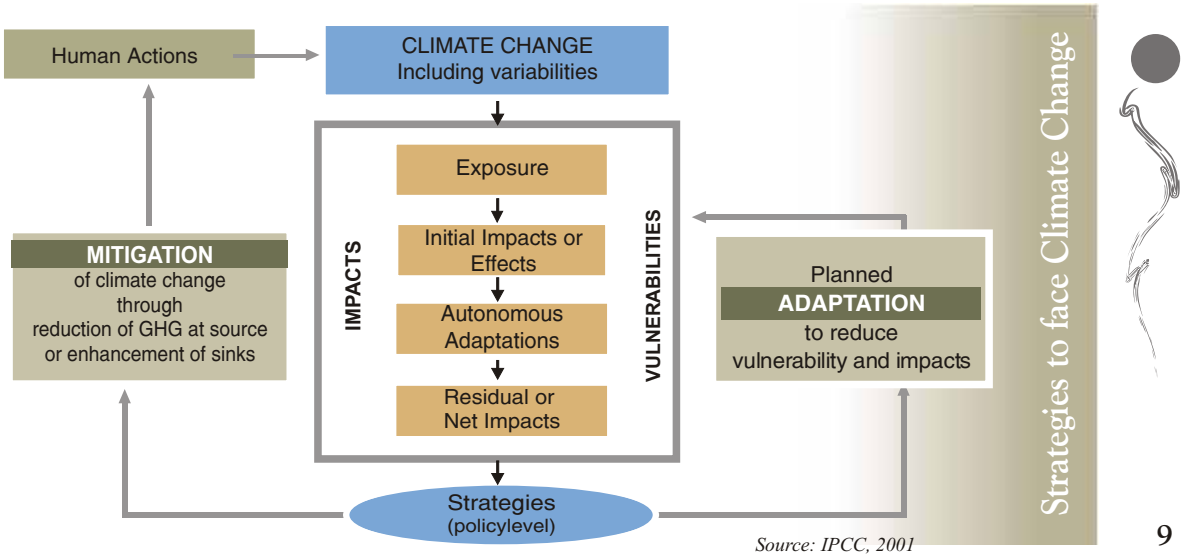
Vulnerability relates to social and natural systems and is delineated as such (TAR-Asia, IPCC). The issues of social and physical vulnerability to climate change are directly related because the major sensitivities of ecological and natural systems across the regions of Asia translate into risks to socioeconomic systems. Social vulnerability is defined as the degree to which individuals or groups are susceptible to impacts (Adger, 1999).

In developing countries, adaptation responses are closely linked to developmental activities. Consequently, there is a large spillover effect between adaptation policies and developmental activities.

Six reasons to adapt to climate change (Burton, 1996)

- Climate change cannot be totally avoided.
- Anticipatory and precautionary adaptation.
  is more effective and less costly than forced, last-minute, emergency adaptation or retrofitting.
- Climate change may be more rapid and more pronounced than current estimates suggest. Unexpected events are possible.
- Immediate benefits can be gained from better adaptation to climate variability and extreme atmospheric events.
- Immediate benefits can also be gained by removing maladaptive policies and practices.
- Climate change brings opportunities as well as threats. Future benefits can result from climate change.

Adaptation to climate change involves deliberate adjustments in natural or human systems and behaviours to reduce the risks to people's lives and livelihoods. Mitigation of climate change involves actions to reduce greenhouse gas emissions and sequester or store carbon in the short term, and development choices that will lead to low emissions in the long term.



Source: IPCC, 2001

1.4 Strategies to face Climate Change

Adaptations are essentially bottom-up processes that come in a variety of forms. The commonly used distinctions are purposefulness and timing. Autonomous or spontaneous adaptations are reactive responses (after initial impacts are manifested) to climatic stimuli. Planned adaptations can be either reactive or anticipatory (undertaken before impacts are apparent).

The projected increases in mean temperatures and precipitation will not manifest through constant gradual changes, but will instead be experienced as increased frequency, duration and intensity of hot spells and precipitation events. Whereas the annual occurrence of hot days and maximum temperatures are expected to increase in all parts of the globe, the mean global increase in precipitation is not expected to be uniformly distributed around the world. In general, it is projected that wet regions will become wetter and dry regions dryer (FAO, 2008).

Current adaptation strategies with clear applications to climate change in agriculture include moisture-conserving practices, hybrid selection, crop substitution, conservation of specific stress tolerant breeds, improved management practices etc. In the water resources sector, current management practices often represent useful adaptive strategies for climate change. Similarly in the energy sector, interventions that improve the efficiency of devices, reduce the pressures on declining biomass resources and help in preservation of carbon sinks represent sound adaptation strategies.

While there is a substantial body of knowledge on global dimensions of adaptation and a large number of case studies that dwell upon local issues, the role of grass root institutions and their linkages to meso level processes towards helping the most vulnerable groups adapt to climate change, has only recently come into focus (Agarwal, 2008). Much can be learned from development programmes on ways to support greater institutional partnerships to translate policies into meaningful actions that help the poor, mechanisms to enhance capacities of local institutions, target resources to the weakest sections and lessons from involvement of local institutions to coordinate adaptation actions.

1.5 Study Background and Objectives

The Swiss Agency for Development and Cooperation (SDC) has in the past supported several development initiatives in the fields of NRM, energy, rural finance, rural housing, HID etc. Under the frame of the Partnership Programme India, the focus of SDC in India in the future would be more on adaptation, energy and climate. This would, among other things, mean supporting interventions that augment adaptive capacities of communities to climate change.

Several of the past interventions might have contributed positively towards enhancing local adaptive capacities to climate change. New and emerging strategies need to be, therefore, built on past experiences gained and lessons learnt.

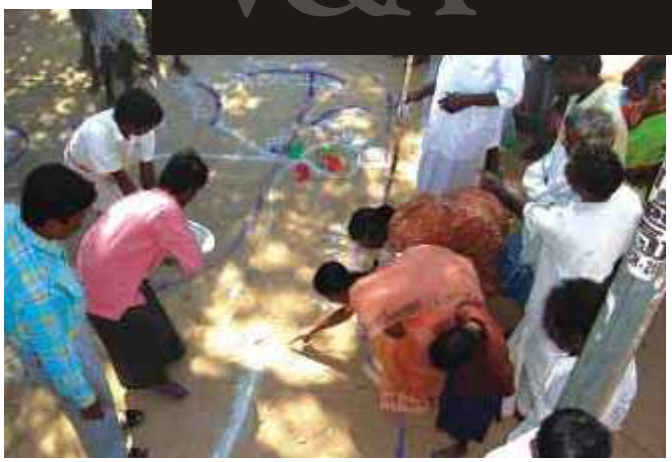
In this regard, SDC commissioned Intercooperation (IC) to undertake the project "Capitalization of past NRM Experiences - Vulnerability and Adaptation to Climate Change Perspective". The main purpose of this study was to capitalize past experiences of SDC supported programmes from the standpoint of climate change (vulnerability and adaptation). The study examined the development initiatives carried out in the past and their contribution towards enhancing local adaptive capacities.

This study complements the lessons from a pilot programme on Vulnerability Assessment and Enhancing Adaptive Capacities to Climate Change supported by SDC (V&A programme) from 2005 to 2008. The pilot programme started with situation analyses based on which four hypotheses or `theories of change' were formulated which in turn led to the identification of field level interventions in the areas of agriculture, water, livestock and energy. The learning hypotheses were context specific and helped in ensuring that the field interventions provided the expected lessons. They also served as the basis for designing the monitoring and evaluation system. The case studies selected for this study go beyond the four learning hypotheses and seek to widen the set of lessons generated from the pilot programme. Where relevant, the lessons from the cases are linked to these hypotheses.

This study also seeks to provide evidence based inputs to SDC and other donors to help them converge their programmes and activities with the various missions under the National Action Plan for Climate Change of the Government of India.

The products from this process comprise a set of detailed case studies and this synthesis report. The case studies provide information on the specific geographic and climate context in which the project interventions were made and other factors of vulnerability. The interventions are then analysed using a set of tools that are described in greater detail in the next section of this report, and finally conclusions are drawn about the relevance of the interventions from a climate change adaptation perspective.

Methodology 2



The study used a consultative approach and structured instruments for information collection and analysis. The case studies are representative of the geographic and thematic diversity in the SDC portfolio and were selected with a specific focus on vulnerability of regions to climate change impacts and the climate relevance of the interventions. Secondary information was analysed followed by field visits and intensive discussions with project staff and members of the community. The cases were peer reviewed by experts in each thematic domain. Each step in the methodology is described below.

2.1 Peer Group

A peer group of thematic experts was formed to guide the process, comment on the procedure for designing the framework for analysis and its application leading up to the development of the final product.

2.2 Selection of Projects

The criteria applied for the selection of projects under this study included: Duration of project (at least 3 years); geographical location (State / ecosystem / climate related risks of an area); and climate relevance of the activities. A checklist was developed to ensure that short listed projects cover a wide range of themes. Since the team had to rely largely on secondary information for analyzing the projects, the availability of adequate documentation also became a criterion.

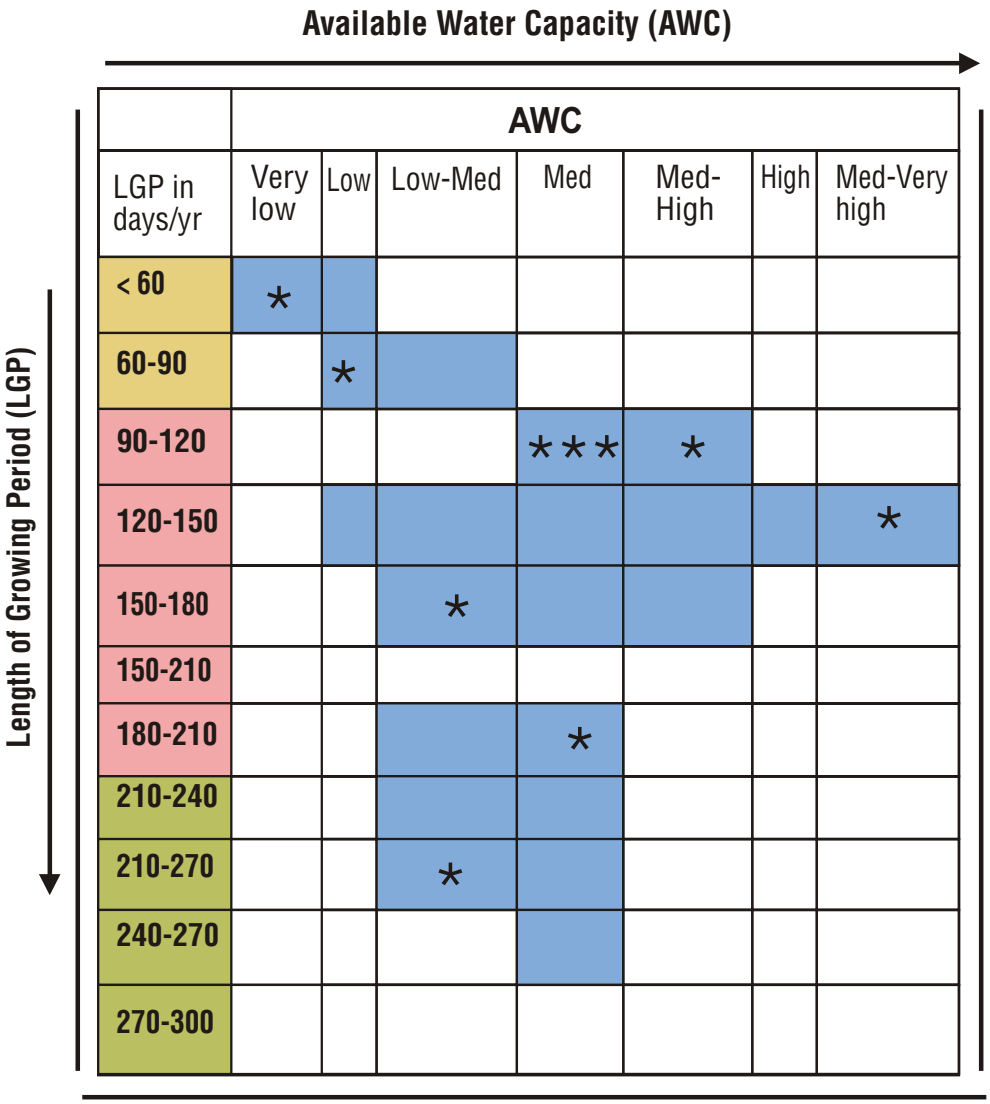
Projects were initially filtered based on their duration. Further shortlisting of the projects was done to get representation of themes and spread of agro-ecological regions. Climate relevance of the themes and vulnerability of a region to climate risks were given priority while selecting the projects for the study.

The Agroecological zone

Agro-climatic zone is a land unit with similar climate and length of growing period (moisture availability period) (FAO, 1983) whereas an agro-ecological zone is the land unit carved out of an agro-climatic zone superimposed on landform which acts as modifier to climate and length of growing period (LGP). Agro-ecological regions encompass relatively homogenous regions in

terms of soil, climate, physiography and conducive moisture availability periods i.e. length of growing period (LGP). Depending upon the soil, bioclimatic type and physiographic situations, India has been grouped into 20 agro-eco regions (AER) and 60 agro-eco subregions (AESR) (Gajbhiye and Mandal, 2006).

The shaded cells in the figure given below, illustrate broadly the geographical spread of the projects and programmes funded by SDC in India. A majority of them are concentrated in the arid and semi-arid regions of the country (low-medium AWC and short LGPs). SDC funded several programmes, large and small, covering a wide range of themes. The interventions examined in this study are discrete projects that may be a part of larger programmes implemented over a period of time in several phases. Even though a discrete set of interventions was examined, each of them had multiple inter-related activities.



	AWC						
LGP in days/yr	Very low	Low	Low-Med	Med	Med-High	High	Med-Very high
< 60	*						
60-90		*					
90-120				***	*		
120-150							*
150-180			*				
150-210							
180-210				*			
210-240							
210-270			*				
240-270							
270-300							

Note: Shaded areas indicate zones wherein SDC programmes were carried out
* Indicates location of projects examined (as cases) in this study.
The Biotechnology project is cross cutting across various regions and is therefore not plotted

2.3 Framework for Analysis

A variety of tools and processes have been developed to improve decision making in order to reduce risks and avail opportunities associated with climate variability and change (Geneva Workshop proceedings, 2007). Tools range from broad information providers on climate projections (eg PRECIS), disasters (eg UN-ISDR) and on vulnerability (eg CAIT, ILRI-et al), through to those targeting project design (eg CRYSTAL, UNDP, ADAPT, USAID Guidebook). Other tools focus on creating spaces / platforms for decision support, while some others take a screening approach to evaluate portfolios and justify design changes (eg DGIS, ORCHID).

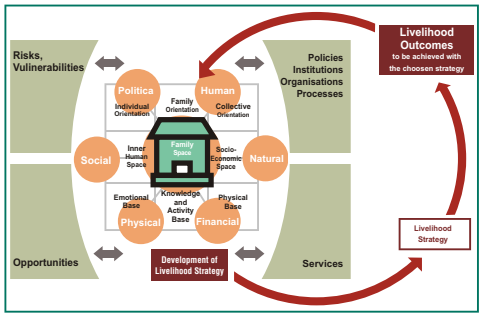
In this study an effort was made to develop a framework for analysis based on the Sustainable Livelihood Approach, at the project level to review and analyse past experiences of the partner organizations from a vulnerability and adaptation perspective. The Nine Square Mandala (Ruedi Baumgartner and Ruedi Hogger, 2004) analysis was used at the household level for selected cases. The project interventions were then placed on a continuum based on elements that contribute towards adaptation.

Selection of projects based on

Agroecological zones → Identification of climate related risks → Climate sensitivity of project activities

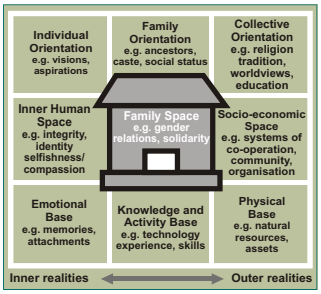
Sustainable Livelihood Approach (SLA)

SLA includes analysis of six categories of assets: Natural, Social, Human, Physical Financial and Political and their interaction with transforming structures and processes for different livelihood outcomes. This provides insights into the changes due to stresses, shocks as also external development interventions.



SLA will be used to examine the influence of project interventions on livelihood systems of communities with specific emphasis on adaptation to climatic changes.

Nine Square Mandala Approach

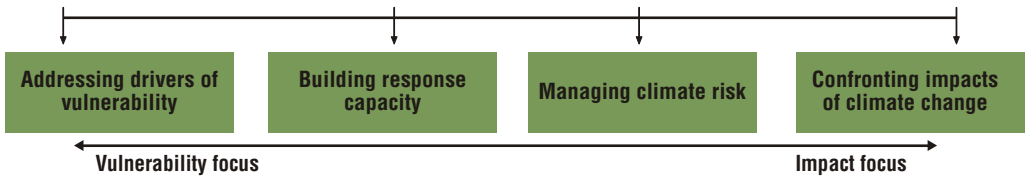


The Nine Square Mandala framework offers a way of structuring the exploration of decision-making by individuals and groups and for tracing material an non-material livelihood outcomes towards which people aim.

The results from such an analysis will provide insights into interventions that augment adaptive capacities and help in developing future strategies.

Summarize findings using the continuum approach

McGray et al. (2007) suggest a framework, which, rather than drawing sharp distinction between adaptation and development, places them on a continuum. The project-wise interventions will be analysed using the "continuum approach".



a) Sustainable Livelihoods Approach

Livelihoods can be defined as the bundle of different types of assets, abilities and activities that enable a person or household to survive (FAO, 2003a). These assets include physical assets such as infrastructure and household items; financial assets such as stocks of money, savings and pensions; natural assets such as natural resources; social assets, which are based the cohesiveness of people and societies; and human assets, which depend on the status of individuals and can involve education and skill. These assets change over time and are different for different households and communities. The amounts of these assets that a household or community possesses or can easily gain access to are key determinants of sustainability and resilience. It is usually people's few productive assets that are at greatest risk from the impacts of climate change. Physical assets can be damaged or destroyed, financial losses can be incurred, natural assets can be degraded and social assets can be undermined (FAO, 2008).

The main features of SLA are:

- Understand livelihoods and livelihood systems (assets, decision making, livelihood strategies) and their context.
- Multiple dimensions of poverty.
- Well adapted for projects working with rural communities.
- Possible use at different levels: from the micro (household) to macro (national).
- Holistic; integration of sectoral concerns, with wider development initiatives.

The SLA approach developed by DFID was used for this study to analyse project level interventions and their implications on livelihoods and potential capacity of the communities to cope with climate changes. "SLA provides a checklist of important issues and sketches out the way these link to each other; draws attention to core influences and processes; and emphasizes the multiple interactions between the various factors which affect livelihoods" (DFID Guidance sheets, 2005). The sustainable livelihoods approach sees poverty as vulnerability to shocks, and seeks to reduce vulnerability by building on the livelihood assets of households, increasing their access to a blend of assets and gradually building household resilience (Spanger-Siegfried et al. 2005).

The SLA was applied earlier to study such linkages. Spanger-Siegfried et al. (2005) hypothesized that sustainable livelihoods can fill the practical and conceptual gap that exists between local vulnerability to climate change and national / intergovernmental policy processes. They developed and used a set of quantitative and qualitative indicators around the five capital assets: human, financial, natural, physical and social capital.

b)The Nine Square Mandala (Rural Livelihood Strategy)

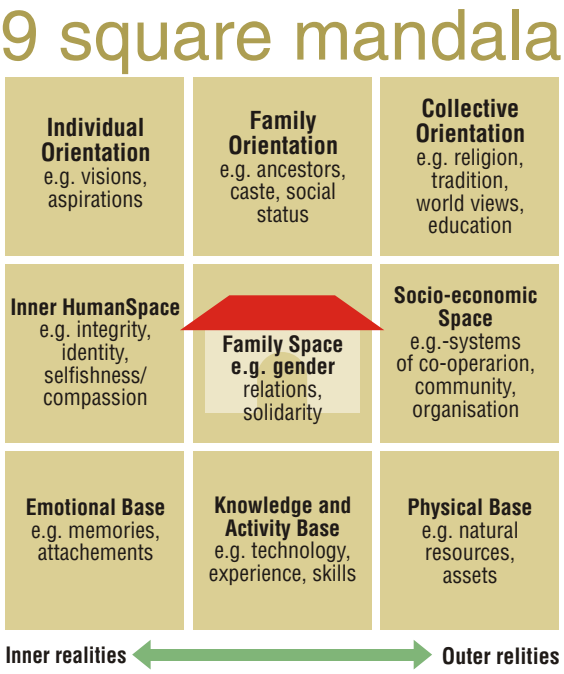
Livelihood strategies reflect the range and combinations of activities and choices that people make in order to achieve livelihood outcomes and goals.

Livelihood strategies evolve from decision-making at household level, which is informed by inner and outer realities of people's consciousness. Such strategies are diverse and in a constant process of change and adaptation. In order to analyse livelihood strategies and decision-making at an individual level, the Nine Square Mandala was used in the study for selected cases.

The RLS is an important tool that enables an understanding of individual motivations for actions such as resource sharing, conservation and social regulation which are not adequately understood using tools that fail to explore deeper individual and collective orientations.

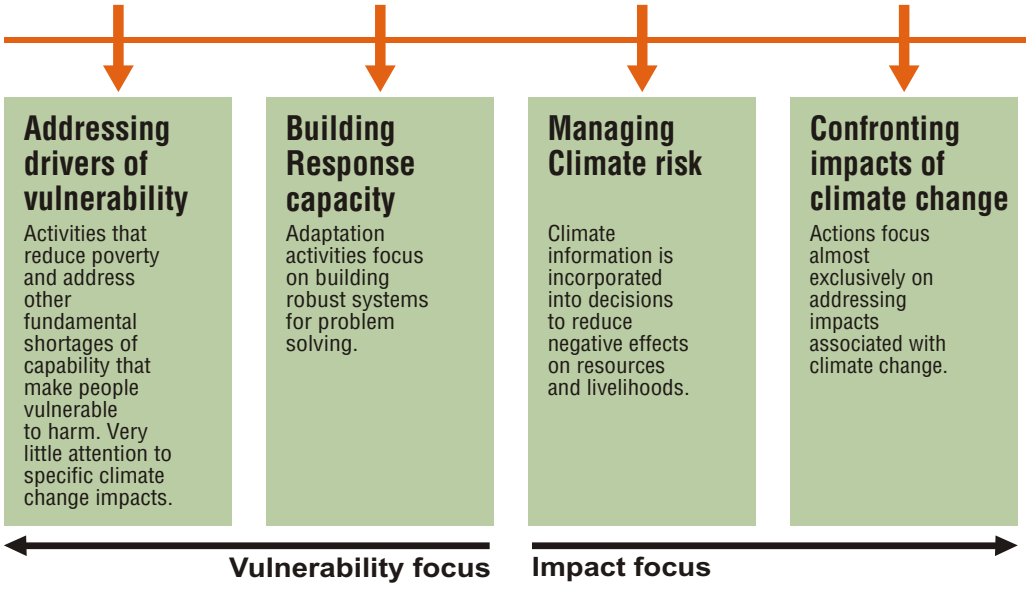
This framework offers a way of structuring the exploration of decision-making in a livelihood system and for tracing material and non-material livelihood outcomes towards which people aim. Understanding people's livelihood strategies means to explore the role of factors and forces determining the use of their resources, for example, the role of gender-relations, of collective or family based value-orientations and of individual ambitions.

Given their past experiences (individual and collective priorities and motivations), households and individuals differ in their response to new ideas, information, opportunities and risks. Understanding these motivations helps one appreciate reasons for participation of households in development programmes.



c)The Continuum Approach

McGray et al. (2007) proposed that the range of adaptation activities may be framed as a continuum of responses to climate change, from "pure" development activities on the one hand to very explicit adaptation measures on the other. The approach therefore helps in placing the interventions on a continuum rather than draw a sharp distinction between adaptation and



classical development per se.

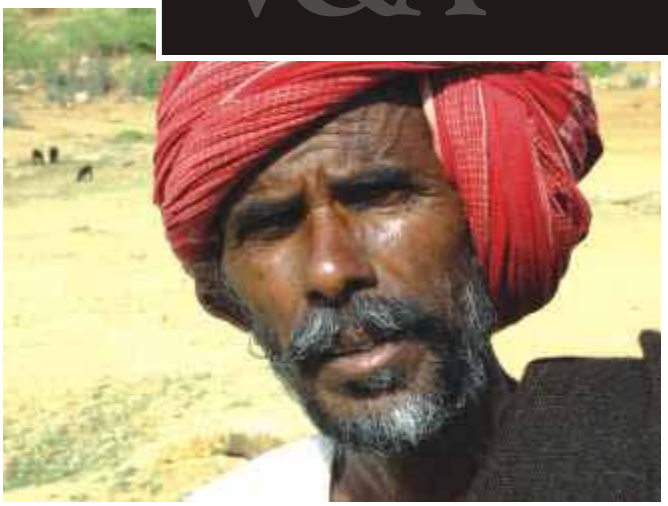
In the current study both discrete activities and processes have been analysed using the continuum. This is in recognition of the fact that capacity building, formation of community institutions and their linkages at the meso level have an important role in augmenting adaptive capacities, as do physical interventions.

2.4 Limitations of the study

The current study examines the project interventions and their influence on the different capitals without seeking to develop indicators for each as the projects cover a large spectrum of development interventions occurring in varied spatial and socio-economic contexts.

The cases relied on secondary information and the methodology did not permit the collection of new and comparable primary data. The study was constrained by a short time-span that limited extensive collection of data to develop systematic indicators at household level.

Summary Observations 3



The main sectors affected by climate change include: agriculture, water resources, human health, terrestrial ecosystems and biodiversity and coastal zones (UNFCCC, 2007). Adapting to climate change involves managing risk by improving the quality of information and its use, providing insurance against climate change risk, adopting known good practices to strengthen the resilience of vulnerable livelihood systems, and finding new institutional and technological solutions (FAO, 2008).

India's first National Action Plan on Climate Change (NAPCC) was released on June 30, 2008. The focus of NAPCC will be on promoting understanding of climate change, adaptation and mitigation, energy efficiency and natural resource conservation. The development interventions under the different projects examined in this study align with some of the National Missions specified under the NAPCC. The analyses provide insight into the elements of development interventions that contribute to adaptation measures in specific conditions.

SLA was used to examine the vulnerability context, the contributions of the project interventions to the asset base and their influence on the different capitals through review of project documents, case studies and other forms of literature developed by partner organisations. This was supplemented by field visits and discussions with partners and communities. Wherever needed primary data was also collected and analyzed. The Nine Square Mandala framework was used as a means of structuring the exploration of decision-making in a livelihood system.

Most NRM interventions contributed to strengthening the local livelihood base through increased physical and natural capitals. However, only when these increments were complemented with increased human and social capital, did they shape practices such as improved management, storage, communal pooling and diversification of resources over a sustained period of time. When these increments are seen together with the community based institutions' ability to use new information and link up with external opportunities during stress periods, it indicates enhanced capacities to adapt to adverse conditions including those induced by climate change.

3.1 The Case Studies

SDC and IC have supported several initiatives, both bilateral as well as through various NGO programmes. The cases examined in this study covered the following themes:

Themes covered

Theme 1	Theme 2	Theme 3	Theme 5	Theme 4	Theme 6
Water Management Watershed development, Community based tank management, and community managed improvement of natural resources.	**Biotechnology**	**Livestock Development** Large ruminants - Breed conservation Small ruminants - Breed improvement Ruminants and poultry - Ethno-veterinary treatment & Improved management practices	**Energy**	**Biodiversity** Mangroves, Forest based livelihoods	**Drought proofing**

Projects and partner organisations

Case Study No.	Project title	Location	Partner
Water Management			
1	Indo-Swiss Participatory Watershed Development Programme, Phase II, Karnataka	Bidar, Koppal, & Gulbarga, Karnataka	PRAWARDA, SAMUHA, MYRADA
2	Community managed improvement of natural resources for sustainable livelihoods	Udaipur, Rajasthan	Sahyog Sansthan
3	Community based tank rehabilitation	Warangal, Andhra Pradesh	MARI
Biotechnology			
4	Harnessing biotechnology for enhancing adaptive capacities to climate change risks	All India	ISCB
Livestock Development			
5	Conservation, up-gradation and improvement of Tharparkar breed	Barmer, Rajasthan	SURE
6	A pilot project of goat development through participatory approach	Bhilwara, Rajasthan	BAIF
7	Indigenous knowledge systems on animal health and ethno-veterinary practices	East Godavari, Andhra Pradesh	ANTHRA
Energy			
8	Improved oven for charaka reeling	Bangalore (rural), Kolar, Chamarajanagar, Karnataka	TIDE
Biodiversity			
9	Ecological rehabilitation of coastal areas - establishing mangrove and other coastal vegetation as bio-shields	Cuddalore & Thanjavur, Tamil Nadu	MSSRF
10	Improving livelihoods of indigenous communities in the Nilgiri Biosphere Reserve	Nilgiris, Tamil Nadu	Keystone Foundation
Drought Proofing			
11	The Drought Proofing Programme	Kutchh, Gujarat	Sahajeevan

Theme 1
Water management

Millennium development goals (1996-2015) include eradication of extreme poverty and hunger while ensuring environmental sustainability. The growing scarcity and competition for water, however, stands as a major threat to future advances in poverty alleviation.

The gross per capita water availability in India will decline from about 1,820 m3/yr in 2001 to as low as about 1,140 m3/yr in 2050 (Gupta and Deshpande, 2004). India will reach a state of water stress before 2025 when the availability falls below 1000 m3 per capita (CWC, 2001). The projected decrease in the winter precipitation over the Indian subcontinent would reduce the total seasonal precipitation during December, January and February implying lesser storage and greater water stress during the lean monsoon period (Cruz et al. 2007). Intense rain occurring over fewer days, which implies increased frequency of floods during the monsoon, will also result in loss of the rainwater as direct runoff, resulting in reduced groundwater recharging potential.

Water scenario (UNFCCC)

- The per capita availability of freshwater in India is expected to drop from around 1,820 m3 currently to below 1,000 m3 by 2025 in response to the combined effects of population growth and climate change.
- More intense rain and more frequent flash floods during the monsoon would result in a higher proportion of runoff and a reduction in the proportion reaching the groundwater.
- Agricultural irrigation demand in arid and semi-arid regions of East Asia is expected to increase by 10% for an increase in temperature of 1°C.

In India, rainfed areas constitute about 65 percent of arable land that are characterized by low productivity and about 70 percent of the population in these regions are dependent on agriculture (Joshi et al., 2004).

Watershed development

The various watershed programmes envisage a great opportunity for improving the productivity, profitability and sustainability of dry farming areas through social mobilization. A watershed is a hydrologic unit that can serve as a physical-biological unit and as a socio-economic and socio-political unit for planning and implementing resource management activities (Springate-Baginski et al. 2002).

In the context of watershed based development and management, the cases examined are as follows:

Case Study 1:
Indo-Swiss Participatory Watershed Development Programme, Phase II, Karnataka (ISPWDK)

The ISPWDK was based on a concept of 'watershed plus', encompassing sustainable agriculture, livelihood promotion activities, capacity building including the promotion of gender and equity, as well as bio-physical watershed interventions. The project covered three watersheds in the semi-arid region of Karnataka in the districts of Bidar, Koppal and Gulbarga. The outcome of these efforts included improved ground moisture that helped in reducing crop stress during long dry spells even in good rainy seasons and the provision of water for animals and humans in drought seasons which contributed to managing risks.

Promoting wage-based activities was helpful in drought mitigation and employment generation.

The focus on institutional building showed long term vision that went beyond the project period. The essence of the project was the development of legally registered village level institutions, namely, the Village Development Societies (VDS) that managed the watershed development activities. The ability of the communities to carry forward these institutions and the gradual movement of the human capital (leaders) into the mainstream local governance (i.e. Panchayat Raj Institutions) resulted in better delivery of services and indicated better capacity to manage resource that go beyond NRM.

Case Study 2:
Community managed improvement of natural resources for sustainable livelihoods - Sahyog Sansthan

In this case the focus was on community based natural resources management for sustainable livelihoods in selected villages of Udaipur district in South Rajasthan. The region is characterized by semi-arid climatic conditions and dominated by the tribal communities.

It was observed that the physical capital (soil and water conservation structures) created in the villages and the subsequent augmentation of natural resources (water, irrigated cultivated land, pastureland), as part of development initiatives, contributed to overall household incomes and food security. Most importantly, the investments in human capital resulted in a community with enhanced knowledge and increased awareness levels about the opportunities for livelihood security that can be tapped by linking with larger institutions.

The post-project continuity of the self-help groups by establishing linkages with government departments and banks to generate livelihood opportunities through lift irrigation and dairying indicate community initiative to identify and derive maximum benefit from opportunities.

The various bio-physical interventions, along with strengthening of local institutions with a specific focus on crop-livestock-environment aspects helped in enhancing capacities of the communities for risk management. The capacities of the community to collectively plan, negotiate and avail themselves of opportunities led to increased ability to adjust or cope with any adverse conditions, including climate related risks.

Community based tank management

Technological advancement in the form of availability of drilling equipment for tube wells resulted in increased dependency on groundwater. Individual ownership of water resources (tube wells) started to dominate over the collective approach in the management of resources (tanks). The importance and the role of tanks were ignored and the relationship between tanks and groundwater aquifer recharge was completely overlooked.

Case Study 3: Community based tank rehabilitation - MARI

This project was located in Warangal district in the semi-arid region of Andhra Pradesh. The goal of the project was to develop strong organisations of the resource poor and promote collective action for appropriate Natural Resource Management and sustainable livelihoods.

Community based tank management was part of these initiatives. The case examined physical rehabilitation of tanks as well as strengthening of tank management institutions. The social capital created during the rehabilitation process in the form of network of stakeholders to manage and utilise the water resources judiciously and equitably is of prime importance. It is especially true in adjusting to stress periods through certain social regulations on water use.

With a view to managing climate risks, efforts need to be invested in capturing rain runoff (including sporadic and uneven showers) by reviving traditional water harvesting structures and strengthening effective and efficient management systems also taking into consideration the traditional ones.

Theme 2
Biotechnology

The National Mission for Sustainable Agriculture proposed under the NAPCC aims to support climate adaptation in agriculture through the development of climate-resilient crops, expansion of weather insurance mechanisms, and agricultural practices. Biotechnology application in agriculture is considered to be crucial for adapting to climate change.

- Developing countries consistently face a substantial decrease of wheat production potential, according to all scenarios for the 2080s (in the order of 1545%); wheat is virtually disappearing from Africa (Fischer et al. 2002). Wheat-production potential is decreasing in South Asia (2075%), Southeast Asia (1095%), and South America (1227%).
- A prediction of minimum rise of 0.5 degree Celsius in winter temperatures is made due to accumulation of greenhouses gases in atmosphere which will cause 0.45 tonne per hectare fall in India's wheat production in the next 10 years.

Case Study 4:
Harnessing biotechnology for enhancing adaptive capacities to climate change risks - ISCB

The ISCB was initiated to promote sustainable rural development and livelihoods in India through establishment and strengthening of joint research partnerships and capacities between Switzerland and India in the area of biotechnology. The main focus was on increasing the productivity of wheat and pulses in semi-arid and rainfed agricultural systems through research on biofertilizers and crop varieties that are tolerant to stress and pests. The research activities also focused on environmental aspects that involve tracking pesticide residues using biosensors and bioremediation measures to reduce pesticide concentration in the soil. The case study captures the adaptation elements of activities.

The activities undertaken by ISCB can be considered as planned adaptation. Developing biotic and abiotic stress tolerant varieties and streamlining methodologies directly help in coping with future anticipated changes in climatic conditions. The results from different ISCB research projects are at various stages and have the potential to converge with the future demands for such products. From an adaptation to climate change perspective, it is important that appropriate technologies are available in ready-to-use status in the future to meet the changing conditions and demands.

Theme 3
Livestock development

Livestock is an important source of income and employment for millions of landless and small landholders particularly in the less favored environments and in general, livestock wealth is more equitably distributed than land (Birthal et al. 2002). Therefore growth in livestock production can be expected to reduce interpersonal and interregional inequities, and alleviate poverty. Livestock production not only serves the purpose of augmenting income, employment, and food security, but also acts as a storehouse of capital and an insurance against crop shocks (Parthasarathy Rao and Birthal, 2002).

The changing climate conditions are shown to have negative impacts on pastureland productivity and also on the pasture quality. Apart from this, animals will also experience temperature stress, reduced grazing time and reduced reproductive efficiency. Changes in precipitation intensity, humidity, wind, may reduce the immunity of animals.

Research conducted on pasture productivity under climate change confirms significant negative impacts of changing climate conditions (Bolortsetseg and Gantsetseg, 2003; Batima et al. 2006). Estimates show that the peak standing biomass will be reduced by up to 44.1% for the case in which temperature increases by 5°C. Under the present conditions of climate change, sheep, goat, and cattle weight have decreased by 4 kg, 2 kg and 10 kg, respectively for the period 1980-2002, and it is expected to decrease by more than 50% from the current level by 2080 (Bayarbaatar and Tuvaansuren, 2002).

Given the above context, it becomes important to conserve and promote animals that are tolerant and resilient to climate related stress.

Case Study 5:
Conservation, up-gradation and improvement of Tharparkar breed - SURE

This case examines the situation of a native breed of cows in Barmer, located in the arid region of the Thar Desert. Barmer has a climate that is highly erratic characterized by extreme temperatures, strong sand storms, soil erosion, rapid percolation of water and high evapo-transpiration rate and sparse vegetative cover. The Tharparkar breed of cow is adapted to these extreme conditions and forms an important source of livelihood security. But over a period of time, due to various political, socio-cultural and biophysical factors, the purity of the Thaparkar breed of cows declined to a large extent. At present, Barmer region has a large number of mixed breed cattle with low productivity (resulting from trans-human migration).

As such, breed conservation measures and upgradation have direct relevance to managing climate risks in the future and secure livestock based livelihoods in hyper-arid conditions.

Case Study 6:
A pilot project of goat development through participatory approach - BAIF

Sheep and goat (small ruminants) form an important source of household income especially for the economically weak and socially marginalised communities.

This case focuses on breed improvement in goats in Bhilwara district of Rajasthan. The project area lies in the hot semi-arid ecosystem in the central part of the Aravalli hill ranges in Central Rajasthan characterized by undulating and rocky terrain with shallow soils. There are more goats than sheep. The majority of the goat population is a non-descript type with a steady decline in productivity. Studies indicate that the Sirohi breed is known for its dual purpose (milk and meat) and is tolerant to stress, and is best suited to the agro-ecological conditions of these hill ranges.

Upgrading of local stock with selected 'Sirohi breeding bucks' in combination with periodical preventive health measures including better management practices offers opportunities for economically and ecologically viable goat production that are profitable under farming conditions as practiced along the Aravalli hill ranges in Rajasthan.

Case study 7:
Indigenous knowledge systems on animal health and ethno-veterinary practices - ANTHRA

This project seeks to document, undertake a social validation and apply indigenous knowledge in animal health and ethno-veterinary treatments. While livestock form an important part of the livelihood portfolio of the poor, climate change is expected to add new stresses with greater incidence of diseases and degradation of the quality of natural resources on which poor livestock rearers rely. An understanding of ethno veterinary practices and their improved integration into the mainstream veterinary health care system can improve the coping capacities of livestock rearing communities, particularly indigenous people who have a large repository of such knowledge which is being increasingly marginalised by the spread of the mainstream systems.

This project emphasises "social validation" involving members of the community and an independent set of experts who have developed a protocol to validate each treatment process towards making them credible for adoption by the mainstream systems.

Theme 4
Energy

One of the key provisions under the Integrated Energy Policy adopted in 2006 was to promote energy efficiency in all sectors. The NAPCC acknowledges that information or knowledge gap is more pronounced in small industries and "hand holding" will be required to help industries to install energy efficient technologies as well as to ensure their optimum performance through best operating practices.

Case Study 8:
Improved oven for charakha reeling - TIDE

The project focused on developing energy efficient prototypes of improved charakha (reeling machines) and cottage stoves for processing raw silk and promoting them through an entrepreneurial network. Studies indicated that the average efficiency of conventional stoves was very low (about 10-14%) and they consumed large quantities of biomass fuel resulting in high running costs. They also produced low quality silk as it was difficult to regulate the temperature.

In silk reeling activities, loose biomass fuel is used to generate thermal energy to heat water, produce steam and for drying. For every one kg of biomass burnt, 1.8 kgs of CO_2 is released into the atmosphere. The improved charakha stove uses less biomass with lower emissions.

Theme 5
Biodiversity

IPCC (2002) defines biodiversity as the numbers and relative abundance of different genes (genetic diversity), species and ecosystems (communities) in a particular area. This is consistent with the United Nations Convention on Biodiversity (UNCB) definition wherein biodiversity was defined as the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and ecosystems.

Mangroves are made up of salt-adapted evergreen trees; they are restricted to the intertidal zone along the vast coastlines of tropical countries in Asia and extend landward along tidal rivers. They play an important role in protecting lives and livelihoods in areas where they are endemic.

Mangrove forests are highly vulnerable to climate change-induced sea-level rise because that changes the salinity distribution and hence productivity. Large-scale changes in species composition and zonation in mangrove forests are also expected as a result of changes in sedimentation and organic accumulation, the nature of the coastal profile, and species interaction (Aksornkaoe and Paphavasit, 1993).

The Sundarbans in Bangladesh and adjacent areas in India, covering about 6,000 sq.km, are the largest mangrove forests in the world (Allison, 1998). Depletion of mangrove forests by anthropogenic pressures has become a serious problem (Farnsworth and Ellison, 1997).

While mangroves in certain areas could possibly adapt to low moderate sea level rise, a rise of more than one metre in the next century could cause serious losses. The mangroves are also threatened by the rise in temperature, which causes decreased tree height and leaf size. Besides sea level rise and temperature stress, mangroves are also threatened by drought.

Case Study 9:
Ecological rehabilitation of coastal areas: establishing mangrove and other coastal vegetation as bio-shields - MSSRF

This particular case looks at interventions in the Vellar-Pichavaram-Coleroon estuarine region in Cuddalore and Thanjavur districts, Tamil Nadu. The project goal was to manage mangroves and other coastal vegetation as bio-shields against climate hazards while addressing livelihood security of the coastal community.

Scientific, yet community based restoration and conservation activities in the mangrove wetlands were introduced and these continue to be effectively managed by the local communities. The canal method (a restoration technique) helps to maintain the mangrove wetlands by keeping the pH balance of estuarine waters at optimal levels and creating a favourable environment for the regeneration and growth of the mangroves.

The regeneration of mangroves has a positive impact on aquatic fauna thereby safeguarding livelihoods. It also controls the velocity of tidal waves and flooding reducing disaster risks.

Recognizing the benefits from this restoration method, the Forest Department, Tamil Nadu, through its Joint Mangrove Management Programme has promoted this measure in several other parts of the region.

Sustainable forest based livelihoods

Case study 10: Improving livelihoods of indigenous communities in the Nilgiri Biosphere Reserve - Keystone Foundation

The project is in the Nilgiri Biosphere Reserve (NBR) which is a contiguous unit of dense forest with wide ranging landscape, located in South West India at an altitude ranging between 300 m to 2,623 MSL. It represents one of the world's biodiversity hotspots with more than 3,700 plant species and 684 vertebrate species of which 156 are endemic.

The NBR is home to several indigenous communities that depend on natural resources for their livelihood. The local ecological balance has been under pressure for some time due to changes in natural processes and anthropogenic factors. This resulted in reduction of native bee colonies and biodiversity; mono crops replacing mixed cultivation systems affecting nutrition; reduced food security of the communities; and reduced water retention capacity of lands.

The project focus was on 4 main facets, namely, forest based livelihoods (NTFP, wild bee honey collection, and apiculture), biodiversity conservation, water resource management and reviving traditional agriculture systems.

A scientific approach through systematic resource assessment and ecological monitoring helps in understanding different levels of production and accordingly plan for harvesting honey even during stress periods (low and erratic rainfall and temperature fluctuations) wherein honey availability, in general, is reduced.

Theme 6
Drought proofing

Drought proofing embodies a long term vision as opposed to drought relief measures that provide short term support. In drought proofing, the communities themselves take on the responsibility of meeting scarcity conditions by undertaking productive works both during drought years as well as in normal years. As part of drought proofing, suggested activities include water conservation, fodder conservation and storage, management of common grasslands, grain banks and development of livelihood options etc., which are geared mainly at securing water, food, fodder and livelihoods over a time frame of 6-8 years. The NAPCC suggests drought proofing to promote overall socio-economic well being of resource poor and disadvantaged sections in drought prone areas.

Case Study 11:
The Drought Proofing Programme - Sahajeevan

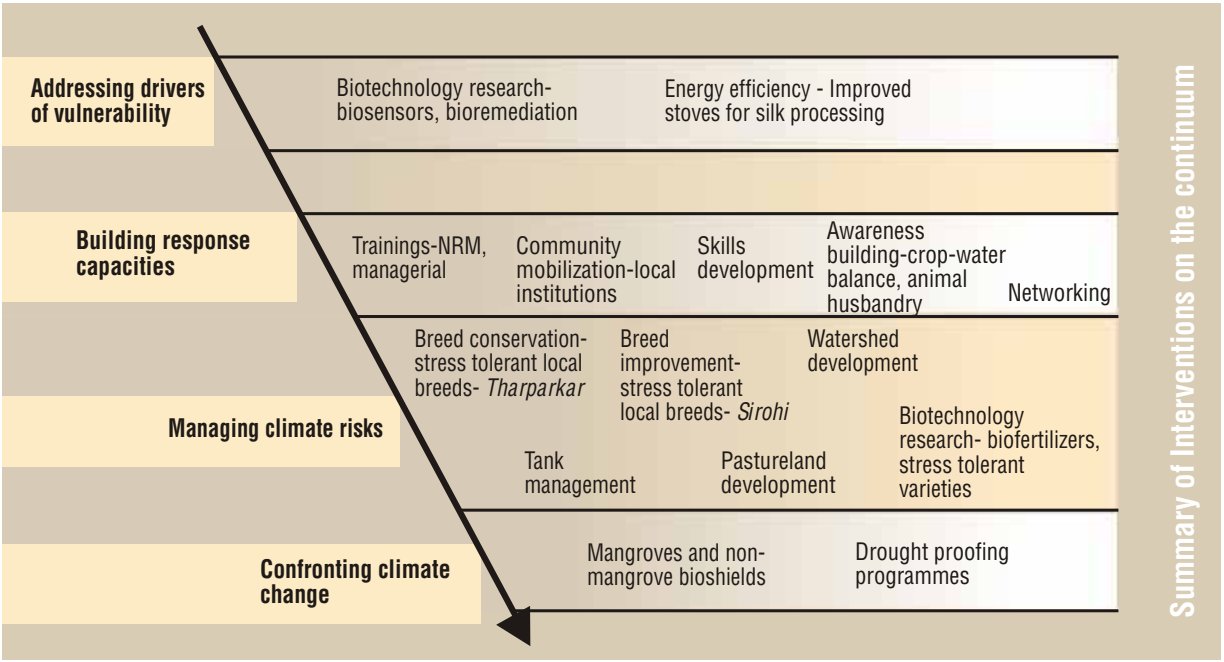
Kutchh region in Gujarat is characterized by arid climatic conditions. However, it supports very rich diversity of different habitats including saline lands, grasslands, arid forests, coastal and marine areas and mangrove forests. It is a chronically drought prone area with an average annual rainfall of 300mm and a long term average of 13 rainy days.

The main objective of the programme is to reduce dependency of village communities on government sponsored drought relief works and subsidies. The focus is on ensuring drinking water availability through water harvesting structures to recharge aquifers; fodder security through grassland development and establishment of fodder banks; and food security from the irrigation dams that irrigate 50-300 acres of land. These are complemented through improved capacities of the community to develop, augment and manage their resources, and active decision-making of women and vulnerable families in the process.

For this, village communities, NGOs and setus (local nodal agencies) coordinated by Kutch Nav Nirman Abhiyan (KNNA), are making a collective effort with support from the Ministry of Rural Development, GoI, Department of Rural Development, Government of Gujarat and Sahajeevan / SDC. Such a network helps in efficient information management (i.e. identifying local issues, needs and accordingly mobilising support from external agencies for appropriate and timely action). This contributes to efficient and effective planning of programme interventions.

4 Summary of Interventions on the Continuum

The diagram shows the various interventions examined in this study on the continuum. Majority of the interventions have elements that lead to climate risk management elements as observed from changes and responses in the case studies.



Most of the NRM interventions started as development initiatives but comprise adaptation elements inherently embedded in them. In general, the common components of all the projects include community mobilisation, enhancing skills and awareness building through training and access to information. These, coupled with NRM activities such as watershed development and management, breed conservation and improvement, fodder resource management have a direct bearing on managing risks in the future by the increased ability of the communities to manage available resources prudently.

Biotechnology research projects directly help in managing climate risks in the future by making available stress tolerant varieties in ready-to-use status. Since research and development of new products is a time consuming process, making a head start and reducing the time lag, greatly reduces future risks to uncertainties and secures the livelihoods of the farmers.

The paradigm shift from drought relief to drought proofing by investing in NRM is a step towards managing climate risks and when done in a integrated manner, in confronting climate change. The networking approach adopted with emphasis on knowledge management and information access to all offers a unique way to sustain water, fodder and food security, building from strong micro level institutions to a meso level network that accesses information and resources from macro level processes and institutions.

Conclusions

5

The cases examined as part of this study provide insights into the various development activities that positively contribute to the community's efforts directed towards adaptation to climate variability at the local level. These also complement the findings from V&A programme. The hypotheses developed during the V&A programme relate to the themes of land use, water, livestock and energy.

In the context of policy advocacy /planning, some conclusions drawn from the cases examined have direct relevance and these are given below.

Land use

The concept of 'Watershed development' is a proven approach for dryland agriculture. The in situ soil and water conservation measures taken up as part of watershed development programmes are also relevant outside the watershed context when viewed from an adaptation perspective. This is clearly witnessed and well demonstrated in pastureland development and wasteland development initiatives. Land use should also support livestock development. For example, in the hilly and undulating terrains, it would be good to focus on pastureland development. Silvi-pasture is a viable option under such conditions.

It is important that stress tolerant crop varieties being developed using modern tools such as biotechnology are available in ready-to-use status (after testing for performance and environmental impacts), in the future, to meet the changing conditions and demands. Combined with improved weather prediction systems new crop varieties should lead to the development of option sets for farmers for different weather codes.

The land use hypothesis of the V&A programme states that `Village level land use maps can provide a basket of options for different rainfall scenarios (drought, normal, excess). They can lead to stabilisation of yields from rain-fed farming, greater food and economic security'. Investments in in-situ soil and water conservation, pastureland development and stress tolerant crops, all help in developing livelihood option sets for the future.

Water

The water related hypothesis of the V&A programme states `Community's access to weather monitoring and prediction data combined with community managed water resource systems can lead to greater water use efficiencies and improved adaptive capacities.' In the V&A programme weather monitoring stations have been set up in the villages and the hypothesis seeks to develop a link between the data generated by them and the water management practices of community based institutions.

In the case of MARI there was no investment in creating weather stations but the capacity of the village institutions to plan water usage based on rainfall patterns is well illustrated. It indicates that if existing community based institutions develop clear resource management strategies and have access to weather information, they can develop strategies that help them adapt to changing conditions. They need to be supported by macro level policies which recognize the legitimacy of their management norms and through meso level support in accessing capital for investments, information and new opportunities.

In general, evapotranspiration losses are usually more in the case of surface water collection and storage systems. Therefore, priority ought to be given to increase groundwater potential through water conservation measures building on locally available knowledge and resources and improving them with linkages to new technologies and options (eg. Subsurface water harvesting structures).

Revival of the traditional water management systems such as community based tank management emphasize on collective action and inclusiveness of all stakeholders. These initiatives, together with improved ability to analyse weather information and social regulations for use of groundwater provide for water security. The formal recognition of their role and dovetailing information and inputs through such institutions provide avenues for targeting adaptation knowledge and resources to the most vulnerable regions and sections of the society.

Animal husbandry

The livestock related hypothesis of the V&A programme states `Livestock rearing is an important coping strategy in the face of enhanced climate variability. Buffer stocks of fodder (including tree fodder) and good breeds of livestock can be important risk reduction strategies and can enhance adaptive capacities'. The three livestock related cases provide concrete examples of how risk reduction has been achieved in different agro ecological zones and with different species of livestock.

Breed conservation and upgradation of local breeds that are best adapted to extreme local conditions have direct relevance to managing climate risks and offer secure livestock based livelihoods. The Tharparkar breed of cattle in the hyper-arid Thar region and improving performance of goats in the Aravalli hill ranges using Sirohi breed are good examples of such measures. Under such agro-ecological conditions, strategy of food or income security takes precedence over simple profit maximizing motives.

Communities have developed several management practices for grazing, feeding and watering to deal with extreme conditions. Recognising their traditional knowledge and supporting communities with information and resources to fine tune such practices in response to climate signals is vital for adaptation of the vulnerable groups of the society.

Energy

The energy hypothesis of the V&A programme focused on improving the efficiency of devices that can reduce household drudgery and the stress on natural resources while also improving the household air quality. It is difficult to make extensive conclusions for the energy sector based on experience of the V&A programme and an additional case examined in this study. However, use of improved stoves at the household and industrial level in silk processing are good examples and convey the message that promotion and use of low carbon pathway technologies have important implications at all scales.

The cases examined in this study go beyond the above four themes of the V&A programme. Biodiversity conservation and drought proofing that have a direct relevance to climate risk management were additional themes covered by this study.

Biodiversity

In the case of forest-based livelihoods, a scientific approach through systematic resource assessment and ecological monitoring helps in understanding different levels of production and accordingly plan for production activities even during stress periods (i.e. low and erratic rainfall and temperature fluctuations). An example of this is the harvesting of honey in the Nilgiri bioreserve. Collective action to develop market linkages is vital as in the absence of a remunerative price, the resource is at the risk of being over-exploited.

The mangroves are traditionally considered as sacred and are revered by the local communities. The value of these resources became more pronounced after natural calamities (such as tsunami). When this respect for mangroves is complemented with modern restoration techniques, successful community based management systems and protection of these natural bio-shields, as seen in the MSSRF case, they help communities confront the impact of climate change and secure their livelihoods, thereby also reducing vulnerability.

Drought proofing

A paradigm shift from dependency on external relief measures during drought periods to self sufficiency by developing local resources is a step towards building response capacities of communities to manage climate risks. Investing in water harvesting structures, development of fodder banks and energy resources in an integrated manner improve the community's ability to cope with extreme conditions.

In the context of disaster preparedness and response, efficient information management (i.e. identifying local issues, needs and accordingly mobilizing support from meso level institutions for appropriate and timely action) through local networks contributes to efficient

and effective planning of programme interventions before they escalate into a disaster. The concept of setus and Abhiyan network as part of Sahajeevan case in Kutchh region, Gujarat is a good example of this. In other words skill development, networking and access to information help communities to confront the felt impacts of climate change.

The way forward

Climate change will pose new environmental risks and will differentially impact those whose livelihoods are directly dependent on natural resources. NRM interventions have impacted both the vulnerability context of households by risk reduction measures and contributed to strengthening the local livelihood base through increased physical and natural capitals. Improved access to capital and markets through self help and collectivisation have enhanced the financial capital of households, thereby enhancing their resilience to climate shocks and trends. However, only when these increments were complemented with increased human and social capital, post project sustainability was observed. It led to the community's ability to respond to external risks and opportunities and access additional information, services and support. This ability to adjust to changing conditions indicates enhanced adaptive capacities.

Grass root community institutions of the poor, or those that work with the poorer sections of the society, can be the building blocks of an adaptation strategy that seeks to target resources and information to people who are most vulnerable to climate change impacts. The Nine Square Mandala exercises revealed that a history of collective action to deal with adversity, interdependence among group members, homogeneity of interests and appropriate leadership are factors that contribute to the strength and cohesion of such local institutions. Local institutions can help improve people's resilience to climate hazards and can improve the outcome of adaptation interventions by linking people with external institutions and processes. To serve the needs of adaptation, such bodies need to be supported to establish wider institutional partnerships to access scientific, research, financial and advisory services. Local institutions (whether elected or otherwise) also need capacity building support to access and analyse information from the perspective of managing risks and designing appropriate protective measures. Adaptation strategies would be incomplete without attention to such institutional capacity development and linkage issues.

It would be appropriate to end this section on the note that conclusions shared above are in the form of suggestions, and readers are encouraged to draw additional insights from the detailed case studies, based on their areas of expertise and interest.

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8-2-351/r/8, Road No. 3,
Banjara Hills,
Hyderabad - 500 034, India
Telephone: +91 40 2335 5891
email: info@intercooperation.org.in