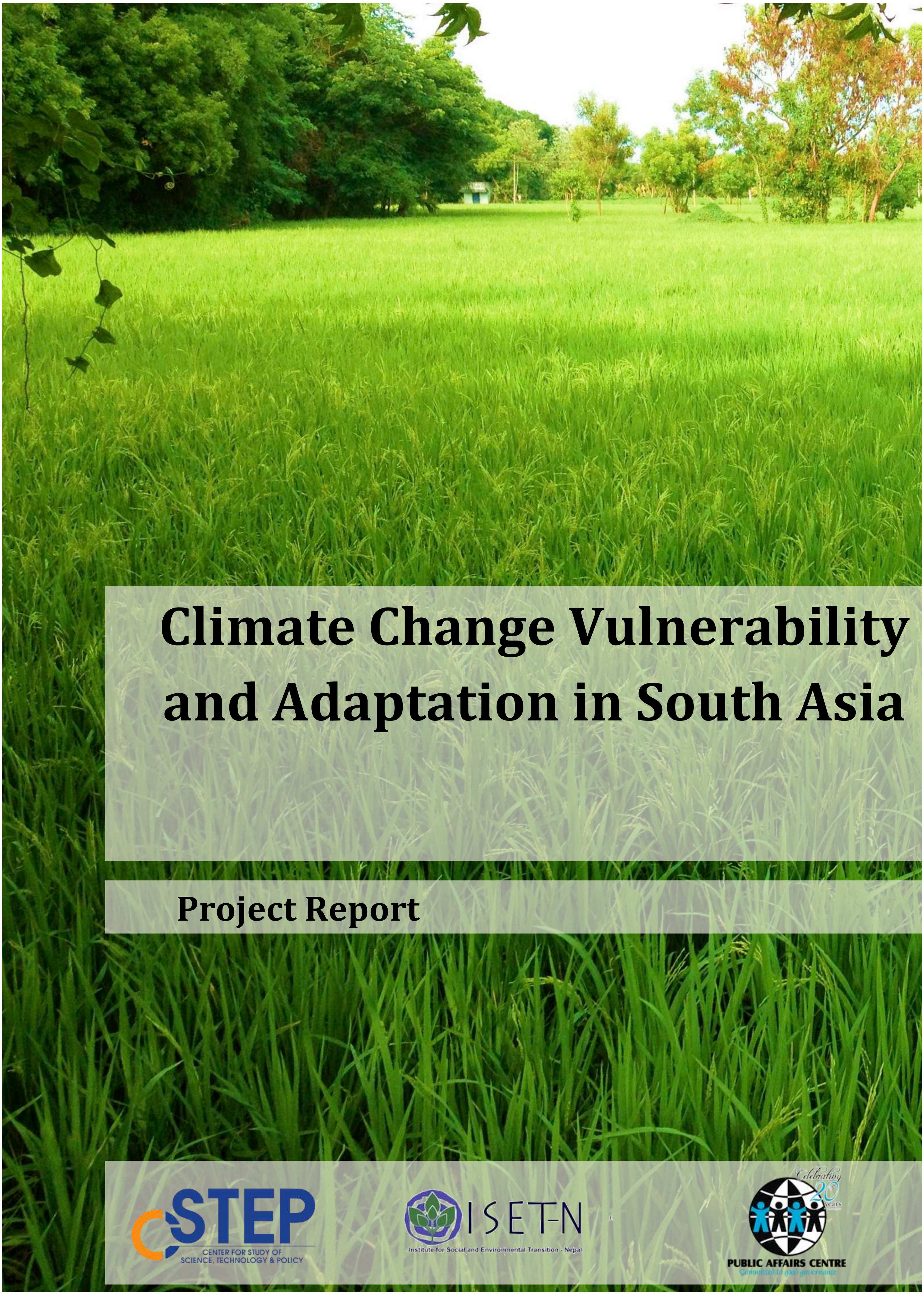

Climate Change Vulnerability and Adaptation in South Asia

Project Report

CSTEP
CENTER FOR STUDY OF SCIENCE, TECHNOLOGY & POLICY

ISET-N
Institute for Social and Environmental Transition - Nepal

Celebrating 20 years
PUBLIC AFFAIRS CENTRE
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Acknowledgement

We are grateful to the farmers, resource people, experts, and officials from all levels of government who generously gave their time and knowledge. We are deeply indebted to the International Development Research Centre (IDRC) for providing support to build the research capacity of the consortium partners and the communities we work with. We are also very thankful to our friends and colleagues for their immense support in the course of this project.

October 2014

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Abstract

This multifaceted project implemented by four consortium partners in South Asia aims to contribute to the study of vulnerability to climate change. The research was carried out at different scales, both top-down and at the local level, each using different methodologies. Areas selected for the study were two village development committees in Palpa and Kapilwastu districts of Nepal's Gandaki river basin and five villages in the Thanjavur district of Tamil Nadu, India. The overall goal of the study was to understand how vulnerability is experienced in these poor communities that rely on agriculture for their livelihoods and how this would change with increasing effects of global warming.

The research has led to the identification of local, institutional, development-related and climate-related factors that worsen vulnerability. The study found that multiple scales and types of vulnerability, including social vulnerabilities, poverty, development and stratification, tend to exist in actuality. Additionally, unequal development policies, poor institutions, politics, (meaning power relations and access to resources) and existing patterns of segregation increase vulnerability.

The study documents processes and mechanisms that could improve climate resilience at the district level and in local communities. The research also deepens thinking about how decision support tools could be deployed to organise and visualise knowledge from different arenas, thus integrating exogenous and endogenous vulnerabilities. The project has improved the organisational capacities of all the consortium partners and the groups that were engaged, thus building competence to undertake larger projects of this nature. It has also facilitated the building of partnerships with other experts in the field of vulnerability and adaptation to climate change.

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A. Background

Climate change is expected to have a range of impacts on the South Asian region, which is regarded as one of the areas of the world most vulnerable to the effects of global warming. Changes anticipated include heat waves, variability in the monsoons, droughts, melting Himalayan glaciers, flooding and sea level rise. An increase in extreme weather events such as cyclones, heavy rain and riparian and coastal flooding is also expected. These effects will lead to adverse effects on people's lives leading exacerbating environmental degradation, reducing livelihood options, increasing migration from affected areas and worsening health and well-being, especially for the poorest and most marginalised communities.

The majority of the people in South Asia rely on agriculture for their livelihoods, but with variability in the monsoons and water scarcity due to global warming, shortage of water for agriculture, people and livestock will be one of the biggest challenges for the region. This will be compounded by socioeconomic challenges and environmental degradation.

Assessing vulnerability to climate change and integrating this knowledge with low carbon development pathways in South Asian countries is critical.

Various methodologies to assess vulnerability along with approaches and strategies for adaptation are being developed. Assessments that are beginning to be used include different approaches, top-down methodologies that downscale climate change models and effects or use secondary levels of data and information, and bottom-up frameworks to understand why and how local people and natural systems are vulnerable to climate change. Such analyses are needed to understand the risks and to make appropriate policy decisions (Chapters 14 and 15 in the *IPCC AR5, Working Group II*).

There remain a number of knowledge gaps and challenges such as the development of suitable metrics, tracking adaptation outcomes, integrating lessons from development with vulnerability to climate change, integrating local and regional knowledge with local and regional policies, and further with national policies.

Vulnerability Assessments

Water is a natural resource that scientists believe will be seriously affected by global warming. Through floods, drought or salinization, these changes will threaten our lives, livelihoods and ecosystems. According to India's Second National Communication to the UNFCCC (2008), India is estimated to have close to 20 percent of the world's population but has only 4 percent of the world's water resources. Most of the water is received during the monsoons from June to September and more than three fourths annual supply is used for irrigation. Further, there is already significant land area that is drought or flood prone. With additional increase in the population and an increase in water use for agriculture, industry, and urban areas, the need to conserve water is critical.

Nepal, in its national communication to UNFCCC (Ministry of Population and Environment, Nepal, 2004), states that it has more than 6000 rivers and rivulets, which originate from a drainage area of 194,471 sq. km. Despite the availability of water, only 2 percent is withdrawn for various uses. Most parts of Nepal suffer water shortage problems during the dry seasons due to variation in precipitation. As reported by the national communication, Nepal's population growth rate is increasing by two percent each year, along with increasing standards of living and industrialisation. Water demand in Nepal is expected to increase several fold over the next two decades. The vast water resource potential of Nepal is of considerable importance, but the mismanagement of the resource has already given rise to water stress in various areas.

Vulnerability is defined as the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes" (IPCC's Fourth Assessment Report). It is regarded as a function of the sensitivity of a system to changes in climate and the ability to adapt to changes in climate. Under this framework, a highly vulnerable system would be one that is highly sensitive to modest changes in climate.

It can be represented as

Vulnerability = (Exposure + Sensitivity) – Adaptive Capacity.

Vulnerability is therefore a function of three parameters:

Exposure*:* This is defined as the degree of climate stress and may be represented as either long-term changes to climate, or by climate variability, including the magnitude and frequency of extreme events. Exposure thus consists of systems that can be affected by climate change (such as population, resources, property etc.) and changes in climate itself (such as rise in sea level, variations in precipitation and temperature and extreme events).

Sensitivity*:* Smith et al. (2001) define sensitivity as the degree to which a system will be affected by or remain responsive to climate stimuli. Sensitivity can be altered by socio-economic changes; for instance, drought resistant crops and flood shelters could reduce the degree of sensitivity in the applicable circumstances.

Adaptive Capacity*:* This refers to the potential or ability of a system to adjust to climate change, including climate variability and extremes, so as to moderate potential damages, to take advantage of opportunities, or to cope with consequences. In simple words, adaptive capacity is simply the capability of a system to adapt to the impacts of climate change. This typically reflects the condition of the available infrastructure and the socio-economic characteristics of the population living in a given region.

Goals and Approach of this Study

One of the main goals of this brief study was to gain a better understanding of climate change vulnerability and adaptation in selected sites in South India and Nepal. Consortium partners, depending on their expertise, used different top-down and bottom-up approaches to assess climate vulnerability in parts of South Asia.

The second goal was to improve organisational capacity in vulnerability assessments and adaptation studies within partner organisations in the consortium, so that we are able to build on this in future and make meaningful contributions.

The third was to interact with experts in this field, share preliminary findings, and learn from and with them in a conference, which we organised in August 2014. We decided to concentrate on water and agriculture, since these are the most important factors for vulnerability in the areas chosen.

Tamil Nadu lies in the Southern most part of India and has a total population of 67 million people. Public Affairs Centre (PAC), one of the partners in the consortium, conducted a study in the Kumbakonam Taluk of Thanjavur district, Tamil Nadu. PAC's methodology involved a bottom-up approach to derive a connection between livelihood, governance and climate variation.

The objective of the study by Center for Study of Science and Technology (CSTEP) was to understand the main drivers of climate change vulnerability in the districts of Tamil Nadu. CSTEP's study involved a top-down approach using secondary information to develop or analyse the vulnerability profile for the districts in Tamil Nadu and to identify the main drivers of vulnerability in these districts.

The specific objective of the Institute for Social and Environmental Transition (ISET), the consortium partner in Nepal, was to assess the vulnerability of selected communities and identify adaption options that could assist them to improve resilience. The study sites selected by ISET were Madanpokhara and Dubiya's, Village Development Committees (VDCs) in Palpa and Kapilwastu district located in Nepal's Gandaki river basin.

The consortium partner from The Indian Institute of Sciences, Bangalore, Dr. Rajiv Chaturvedi, undertook an integrated modelling of water supply and demand dynamics at a district level using Water Evaluation and Planning (WEAP), a tool developed by the Stockholm Environment Institute, Boston. This tool, recommended by the IPCC, is widely used and has been refined for specific parameters and local situations by various researchers in different parts of the world.

B. Methodology

1. Public Affairs Centre

Public Affairs Centre's approach to assessing the impact of climate change and formulating adaptation methods is founded upon the following strategic principles:

- ***Knowledge Creation:*** Knowledge is power; hence generation of people's knowledge through a Climate Change Score Card (CCSC) empowers communities to dialogue effectively with governance structures[1].
- ***Empowerment:*** Knowledge generated through CCSC and secondary sources of information will enable the community to monitor the impact of climate change on their lives. This will result in a more informed and empowered community. The local communities have the opportunity to learn about the science behind climate change and its impacts on their livelihoods and surrounding environment.
- ***Constructive and meaningful engagement for policy influence:*** Dialogue is a means of constructive engagement with governance structures at different levels. This is supported by the creation of action platforms that connect communities with informed and motivated government representatives.

Keeping the three strategies as a basis for communicating with policy makers and communities, PAC has developed a unique social accountability tool, 'Climate Change Score Cards'. The main objective of the CCSC is to empower community voices and bring together community and government officials on a single platform based on the 3Ds; Debate- Discuss-Decide. The platform helps address issues that impact the environment and identify options that are beneficial to policy makers as well as local communities. CCSC helps local communities gain knowledge through the process of knowledge creation. The science of climate change and its impacts are demystified while conducting a Participatory Rural Appraisal (PRA) exercise. This tool is designed to be amenable to interpretation and comprehensive use, by the often illiterate communities in climate change affected areas, yet elegant and rigorous enough, and useful to state authorities. Various governance strategies and changes in climate patterns impact livelihoods both in positive and negative ways. Hence, CCSC is a triangulation of Livelihoods – Governance – Climate Change (See Figure 1).

[1]Public Affairs Centre defines governance structures as service providers (constitutional and traditional) to the community.

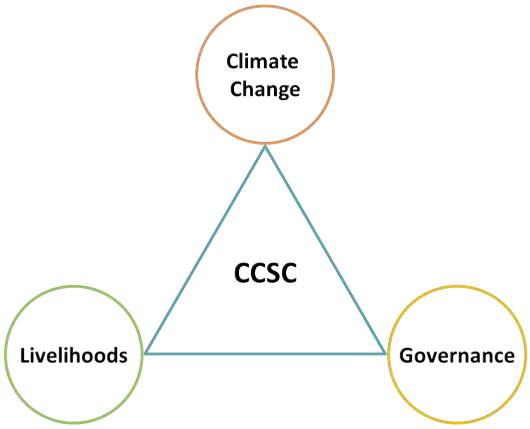


Figure 1: Framework for Climate Change Score Card

Modified Sustainable Livelihood Approach

As the study is focused around livelihood and its vulnerability to climate variations, the sustainable livelihood framework is derived from the Department of International Development (DFID). This is a holistic approach that tries to capture and provide means for understanding the fundamental causes and dimensions that affect livelihoods. The frame tries to draw out relationships between different aspects that affect livelihoods, allowing for more effective prioritisation of action at an operational level. The sustainable livelihood approach aims to achieve lasting livelihood improvements using asset-based indicators[2].

The livelihood capitals considered as shown in Figure 2 are the following:

- Natural: Land, Water, Forests, Environmental Services
- Physical: Infrastructure, Tools, Technology
- Financial: Credits, Savings, Wages
- Social: Formal and Informal groups, Social networks/cohesions, Collective representation
- Human: Skill, Capacity, Education, Health, Motivation

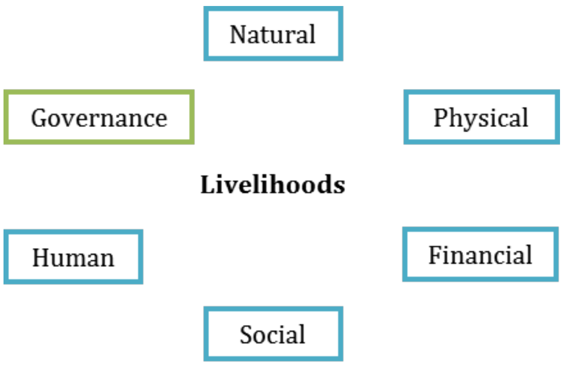


Figure 2: Modified DFID Framework for Sustainable Livelihoods

The proposed framework adds *Governance* (both constitutional and traditional) as an asset as governance structures play a pivotal role in supporting people and their livelihoods. Access and control over land and water, dispute resolution and modulation of the way of life are aspects

[2] Sustainable Livelihoods Support Office, 1999

that are usually controlled by traditional governance structures. Modern governance instruments in a democratic society are the use of rules and regulations, demarcation of territory of competing users and dispute resolutions of large issues. In addition, democratic governance processes also stream resources from other areas to those in need, and under stress from climate variability. The provision of incentives (such as subsidies) and punitive measures for misuse of resources (through judicial and executive means) also contributes to balance in the use of natural resources in times of stress or shortage.

The bottom-up climate change vulnerability assessment is part of a pilot study in five villages of Kumbakonam Taluk in Thanjavur district. The specific purpose of this study was to assess the vulnerability of agriculture-based livelihood to variations in climate in the context of various policies and schemes of the Government of Tamil Nadu.

The study built a vulnerability index and ranked the various villages in Kubakonam Taluk in terms of their performance on the index. The index captured a comprehensive scale of vulnerability by including many indicators that served as proxies. Specifically, the study looked at five different sources of vulnerability based on the capitals of the Sustainable Livelihood Framework, viz., the Natural Capital, Physical Capital, Financial Capital, Social Capital and Human Capital. The results from the index on the capitals were compared to capture the true nature of vulnerability of the people living in these villages.

In the literature, quantitative assessment of vulnerability is generally done by constructing a vulnerability index. This index is based on several sets of indicators that result in the vulnerability index of the village. This process produces a single number, which is used to compare different regions. Literature on index number construction specifies that there should be good internal correlation among the indicators (Refer to Table 1).

Table 1: A Typical Climate Change Score Card

Capitals	**Indicators**	**Parameters**			
		Cropping Pattern (Type of crops grown)	Crop Production	Crop Intensity (Number of Crops Grown in an Year)	Crop Infestation (Pests and Diseases)
Natural	Rainfall				
	Temperature				
	Soil Characteristics				
	Groundwater				
	River/Canal Water				
Physical	Irrigation System (Borewells)				
	Farm Machinery				
	Market Facilities				
Financial	Accessibility to Credit				
	Asset Base				

Scenario Planning

Scenario Planning is an exercise that identifies the current position of a village with respect to the livelihood capitals. Scenario planning aides the community representatives to identify the options/pathways to move to a 'Good-Good' scenario based on the current policies, schemes and program. The issues highlighted are prioritised by community representatives based on a consensus. Once the issues are prioritised the options to overcome these problems are highlighted relating to various Policies/Programs/Schemes of State and Central Governments. This process also requires a briefing of community representatives on government policies (Refer to Figure 3).

A Scenario Planning exercise is carried out using the coordinate system described in Figure 3 above. The governance systems are represented in the Y axis and the livelihood capital along the X-axis. The regulations analysis will help us identify the current scenario of the policies/schemes/programs that are applicable to the capital. The issues related to livelihood capital are identified through the PRA exercises and are prioritised by the community during the exercise. Scenario planning also helps in the identification of key institutions at the panchayat, district and state levels by the community representatives with the help of a facilitator.

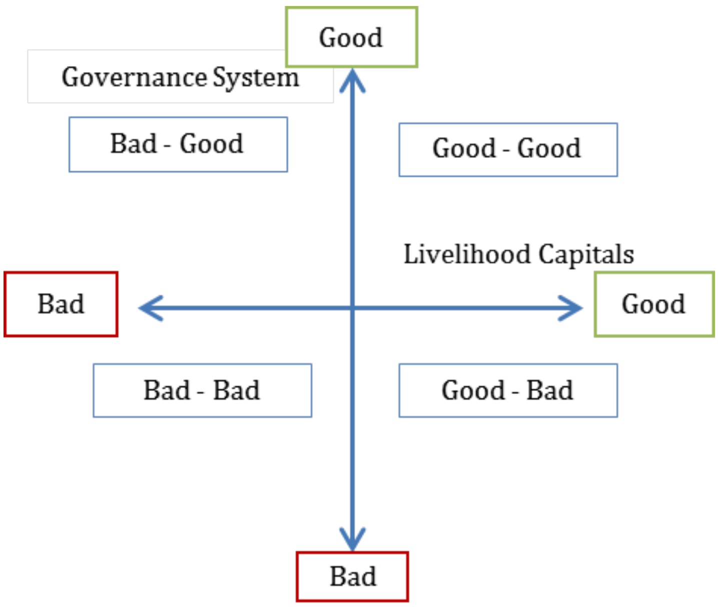


Figure 3: Coordinates for Scenario Planning

The PRA methods employed were the following:

i. Resource Plot – it was decided that Social mapping and Resource mapping would be clubbed to gather information related to identify vulnerable villages based on the resources and the social capital available. This exercise helped to identify issues related to:
    - Migration status
    - Land holding categories
    - Population density
    - Livelihood practices
    - Family and livelihoods
    - Infrastructure – water sources
    - Crops and cropping pattern
    - Natural Resources connected to agriculture – land, soil type/quality, canals, riverine systems, ponds, irrigation facilities such as borewells
    - Methods of water sharing
    - Vulnerable resources, zones
    - Geography and topography

ii. Services and Opportunity Map –This helped provide valuable visual information on services and opportunities available in the area. The discussions also helped in identifying the aspirations of the people and ways in which they can be realised.

- How adequate is the services for agriculture - Quality
- Institutions – transparency and accountability
- Access to technology
- Loan facilities for agriculturist
- Crisis management - compensation tools by Government
- Insurance - Insurance agency, what they insure and when

iii. Trend analysis linking with Seasonality Diagrams – to assess the changes that have occurred over a given time frame are:
- Cropping pattern, yield
- Rainfall
- Temperature
- Cultivation practices

iv. Force Field Analysis – was used to identify and analyse forces affecting situations and to bring in a positive change. It helped us understand the driving and restraining forces to agriculture as livelihood.

v. Livelihood Analysis – Helped examine and depict the livelihoods and focus on income, expenditure, and crisis

Resilient Thanjavur – A Think Tank

A Round Table discussion titled 'Resilient Thanjavur – A Think Tank' was held in Thanjavur in June 2014. The round table saw an assembly of various individuals from research institutes, agricultural universities, civil society organisations and agriculture community members. The discussion at the round table validated the findings of the PRA regarding the increase in temperature and increase in variations in precipitation in the Cauvery delta through a scientific analysis of Indian Meteorological Department data. The study process was explained to the participants and the indicators were shared. The indicators covered all six capitals of the modified sustainable livelihood framework viz., Natural, Physical, Financial, Human, Social, and Governance.

2. Conceptual Framework from ISET

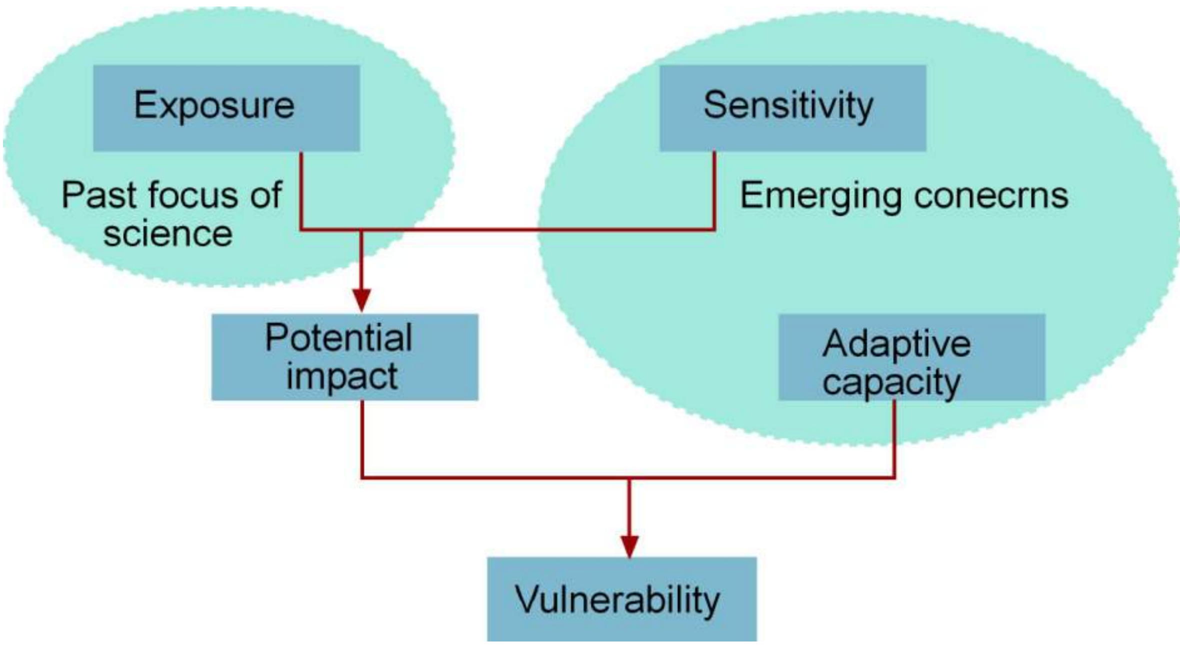


Figure 4: A Framework for Understanding Vulnerability (IPCC, 2007)

An earlier study has shown that the two VDCs are likely to face pressures on the community and its supporting infrastructure due to climate change as warmer temperatures, changes in precipitation pattern and extreme weather events pose a new risk to householders, community members and infrastructure (Dixit and Khadka, 2013). Effective adaptation to climate change depends on the availability of two important prerequisites: information on what to adapt to and how to adapt, and the resources to implement the adaptation measures. Answers to these questions are imperative for assessing vulnerability. This process can begin by identifying areas or resources at risk, and the threats posed by loss of such resources that threaten sustainable development due to increased vulnerability. The main purpose of vulnerability assessments is to identify the most vulnerable social groups and the underlying causes of their vulnerability, as well as to assess strategies and adaptation mechanisms that they take to past and current impacts of climate change. Such efforts will help explain feasibility of future adaptation initiatives to build adaptive capacity and resilience of vulnerable communities.

Various methods proposed for assessing vulnerability recognise that contexts and situations make vulnerability dynamic and that both climatic and non-climatic change—climatic, political, institutional, and socio-economic drivers--need to be considered. However, there is no universally accepted method available to assess vulnerability either (Fussel & Klein, 2006; Bohle *et al*., 2001; Blaikie *et al*., 1994; O'Brien, 2004). For the purpose of our understanding, we follow the IPCC definition of vulnerability, which characterises it as a function of exposure, sensitivity and adaptive capacity (Refer to Figure 4).

Vulnerability Assessment

Any vulnerability and impact assessment tool developed needs to be converted into an integrated, policy-driven tool to build resilience. This integration is achieved through Climate Resilience Framework (CRF), which considers impacts driven, by climate change as well as environmental, economic, social, demographic, technological, and political factors. The CRF brings together applied insights, and a theoretical foundation in order to examine interactions among climate exposure, ecosystems, infrastructures, institutions, and human behaviour. It promotes the integration of social and natural sciences, local and scientific knowledge, technical expertise and grounded, hands-on experience while providing opportunities for continuous learning. It helps decision-makers identify points of entry into existing policies, programs, and practices for implementing measures that help build resilience and adaptive capacity. It can be used as a tool to support decisions and overcome the limitations of linking specific or individual weather events to climate change. The CRF creates (refer to Figure 5) space for undertaking both top-down and bottom-up processes for assessing vulnerability. It has already been applied successfully in both urban and rural contexts and has the potential to be used across Nepal and in other nations to build resilience and adaptive capacity. The CRF has been used to build a case for Ecosystem based Adaptation (EbA) by placing ecosystems and people at the centre (refer to Figure 5).

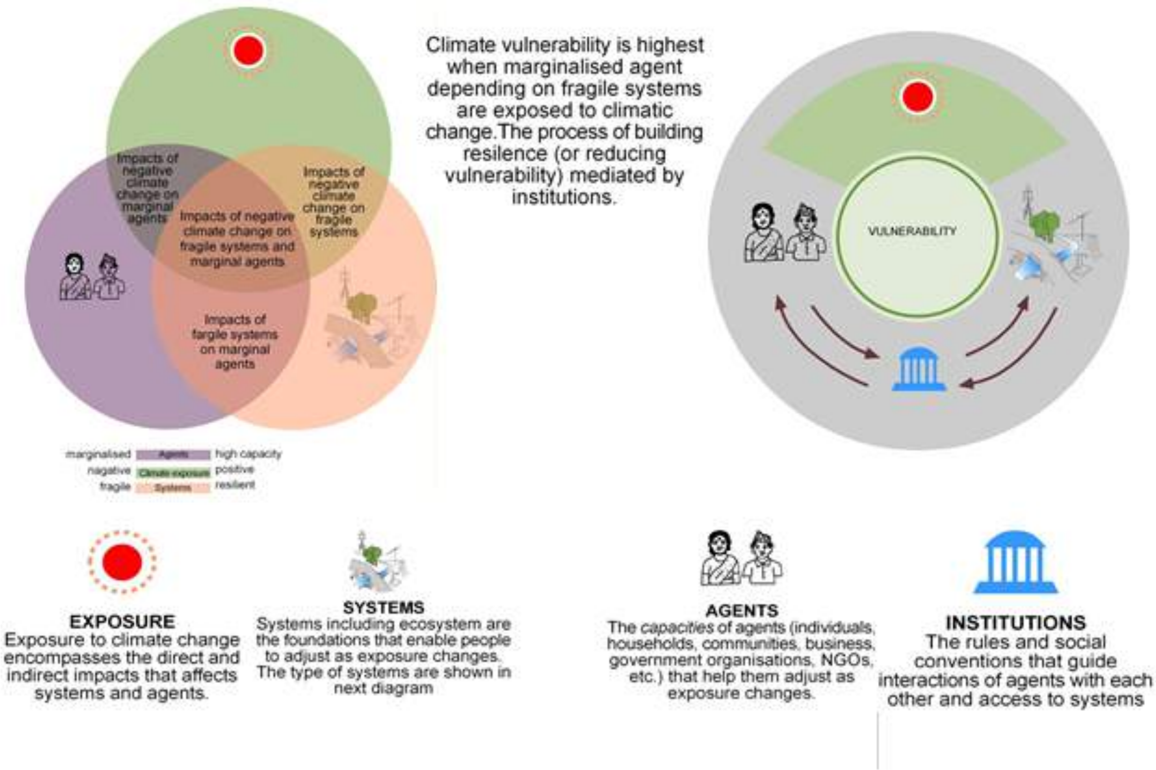


Figure 5: Climate Resilience Framework (CRF)

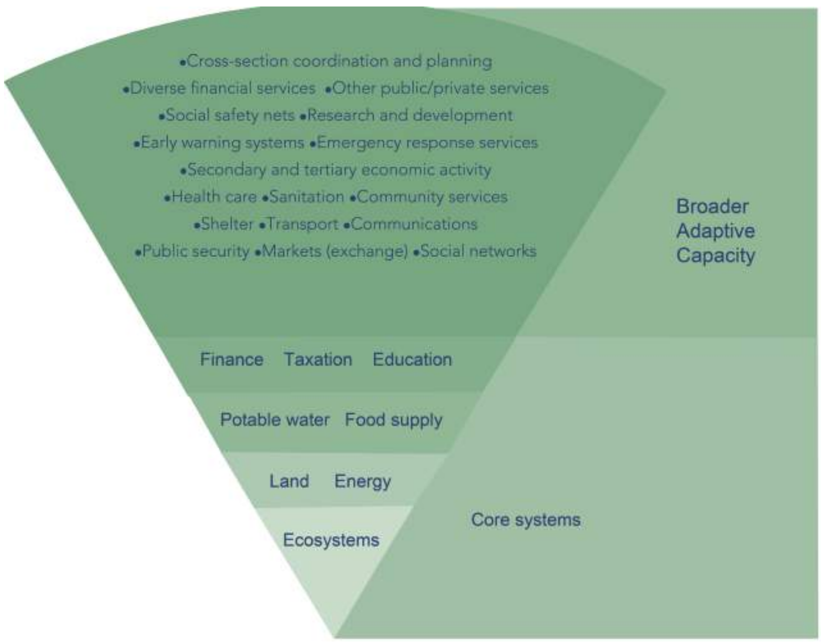


Figure 6: Conception of Core Systems and Broad Adaptive Capacity

But an important question emerges regarding the scale of assessment to capture the social context of vulnerability. Dixit and Khadka (2013) shed light on this concern by explaining the ways the CRF can be used to undertake assessment at the district, watershed, VDC and ward levels as a top-down exercise that must be backed with a bottom-up approach (Figure 7).

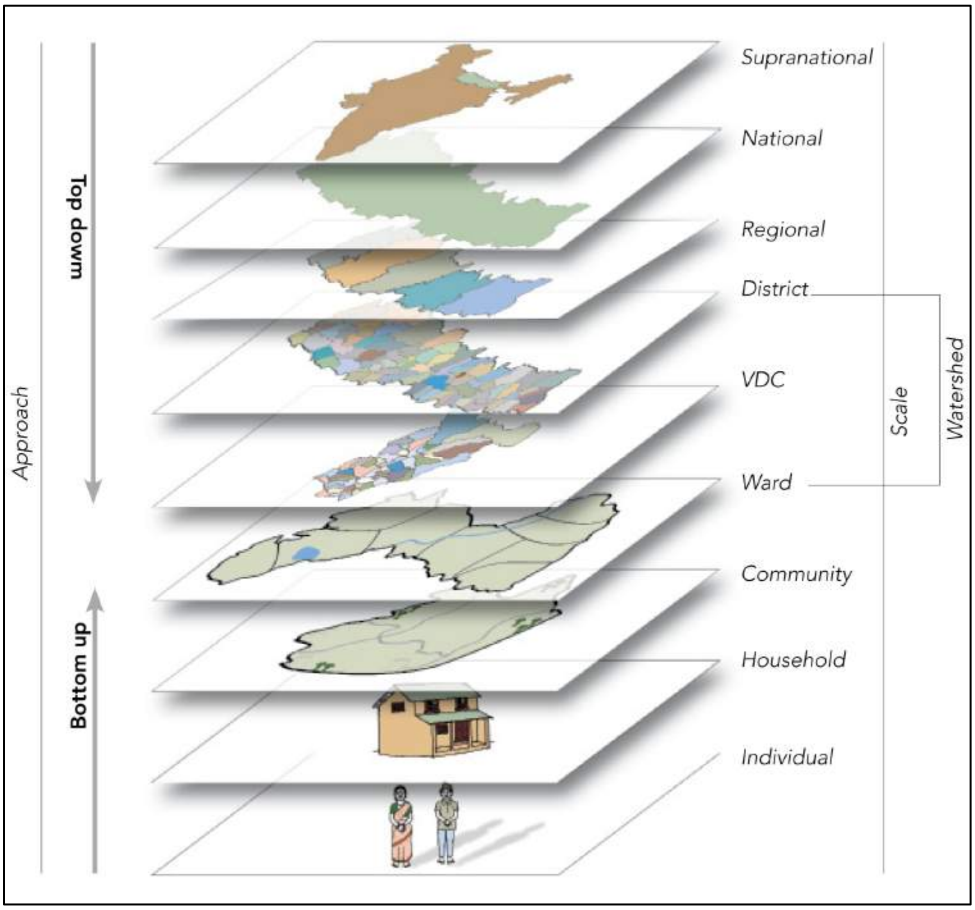


Figure 7: Layers of Vulnerability, Resilience and Adaptive Capacity (Dixit et al., 2014)

Thus both top-down and bottom-up approaches were used. In the top-down approach, the study team used reviews of literature on vulnerability assessment methodology at the VDC and ward level. The specific methods used for the assessment included indicator identification for vulnerability assessment through Participatory Rural Appraisal, vulnerability assessment through questionnaire survey, scenario planning and identification of adaptation options. Each method was participatory and aimed to derive indicators for assessing the vulnerability. The primary (field-level) and secondary (literature review and consultation-based data collected) data were screened, synthesised and analysed (see Figure 8).

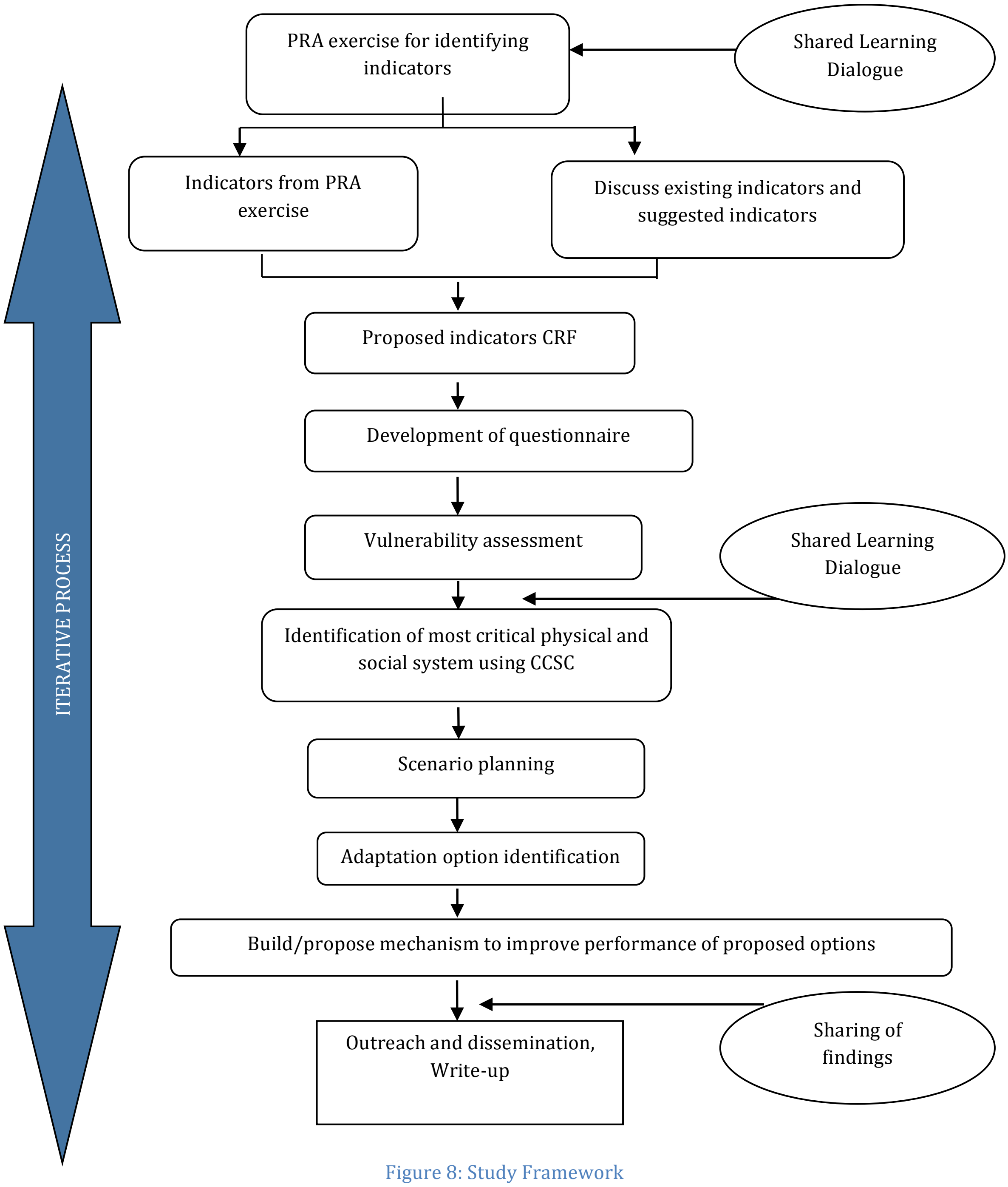


Figure 8: Study Framework

Scoping

This stage involved a literature review; meetings; sharing of thoughts and ideas with experts, study team members, and government officials; and preliminary field visits. It also involved discussions to clarify the conceptual framework and other matters.

Selection of Indicators

Participatory Rural Appraisal (PRA) was used to collect baseline information. PRA exercises are considered an important participatory planning tool that encourages a community to identify, plan, implement and evaluate activities. It uses a set of participatory techniques for assessing group and community resources, identifying and prioritising problems and appraising strategies for solving them. Participatory approaches are increasingly recognised as scientifically valid and valuable means to synthesise new knowledge (Canada Nepal Gender in Organizations Project, 2003). Thus the PRA was conducted in the selected VDCs to facilitate greater understanding on the concept of climate change, available resources, development problems and opportunities of the community with exploring impacts and adaptation options to climate change. Six PRA tools were implemented to collect the information for exposure, sensitivity and adaptive capacity (Table 2).

Table 2: Tools and Indicators used for Vulnerability Assessment

Component of Vulnerability	Tools used	Determinants Indicators
Analysis of exposure to climate change	1. Seasonal calendar 2. Trend analysis and historical timeline (For more details refer to Annex 1)	• Nature, magnitude and trend of climate variable (temperature, rainfall, snowfall, frost, fog etc.) • Nature, magnitude and trend of CC related hazards (cold wave, heat wave, flood, drought, hailstone, thunderstorm, landslides) • Changes in plant and animal behaviour • Changes in livelihoods activities (seed sowing, planting, harvesting etc.) • Physical information such as drying source of water, jungle etc.
Analysis of sensitivity	3. Resource and hazard mapping, 4. Hazard analysis matrix and pair-wise ranking,	• Nature, magnitude and trend of effects of climate change (CC related hazards, agriculture and food security, forest and biodiversity, human settlement and Infrastructures, water resources and energy, human health etc.) • Hazard prioritization
Analysis of adaptive capacity	5. Livelihood mapping and, 6. Stakeholder/ institutional analysis (Venn diagram)	• Livelihood assets such as (Physical: infrastructure, access to information/communication); (Natural: Forest and forest products, Land, water sources i.e. drinking water, irrigation etc.); (Human: population, education, skills etc.); (Financial: financial institutions, income source etc.) and (Social: formal & informal organizations, service providers etc.) • Community awareness/knowledge and information on climate change, Coping strategies, capacity to plan and affect changes

Resource and Hazard Mapping: Resource and hazard mapping were used to generate local knowledge and information regarding natural and physical features as well as climatic hazards on a map. The natural features to be identified on the map include rivers, wetlands, forests, barren land, valleys, cliffs and ridges and physical features include houses and other buildings such as schools, health centres and financial and economic support institutions, irrigation channels, storage tanks and cultivated land use types. Likewise, areas affected by climactic hazards such as flood, landslide, forest-fire, drought, cold, diseases and insects can also be located on the map.

Madanpokhara VDC

To learn about the types of natural and social settings of the VDCs a resource mapping process was carried out. The map below provides (see Figure 9) a picture of the VDC with areas where hazards have occurred and shows how they have affected local resources. The map also provides information on use of natural resources and provides ways to improve their use. The map shows the resource map of Madanpokhara VDC. Various natural resources like forest area, grassland, water sources, and agricultural land are shown on the map. Similarly, social resources like settlement schools, community places, and VDC office are also shown on the map. The map shows flood-affected areas of the VDC. The water sources are mainly confined to ward one two and three.

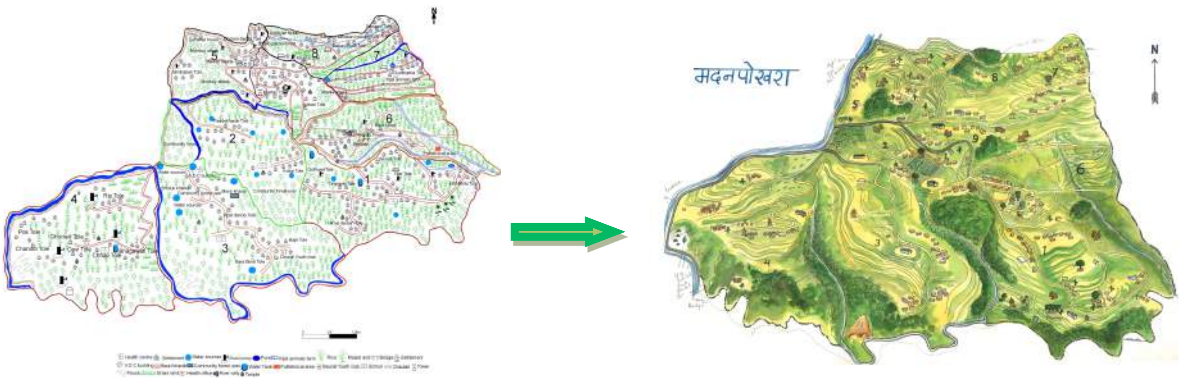


Figure 9: Resource Map of Madanpokhara VDC

The map below (Refer to Figure 10) shows the resource map of Dubiya VDC. Natural and social resources are shown in the map. Forests, agricultural land, ponds, lakes, grassland are the natural resources while, settlements, temples, health post, community house are social resources. Ward four consists of a high number of lakes. Ward 8 consists of most of the community forest.

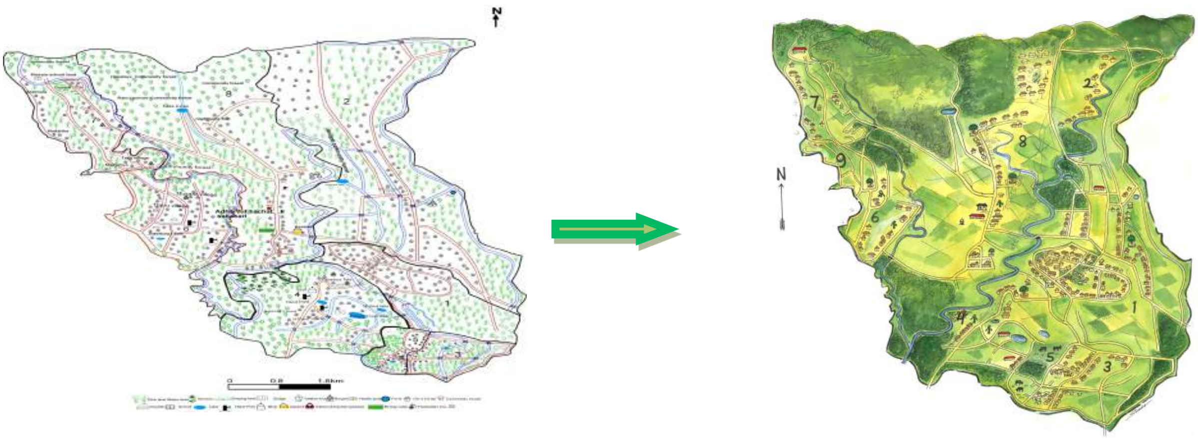


Figure 10: Resource Map of Dubiya VDC

Hazard Analysis and Pair-wise Ranking Matrix**:** This tool is used to assess risk and therefore the urgency of the need to respond. It assesses both the risk that a hazard will take place and the risk that the hazard will have an impact on various assets (Local Adaptation Plans of Action Manual). The tool is used to compare and prioritise the most critical climatic hazards identified. The hazards are analysed and ranked using pair-wise ranking matrix that helps the community to identify risks and prioritise them for community based adaptation planning. It helped us understand how communities perceive and evaluate local hazards.

3. Indian Institute of Science

Gosain *et al.* (2006), Gosain *et al.* (2011), Geethalaxmi *et al.* (2011) and Bhubaneswari *et al.* (2013) have explored the impact of climate change on water resources and agriculture systems in the Cauvery delta. These studies have generally used the Soil and Water Analysis Tool (SWAT) (Neitsch *et al.* 2002) for projecting the impacts of climate change on the hydrology of Cauvery delta. These studies primarily focus on water supply issues. However, the changing water demand dynamics is equally important in the larger context of the water security of the delta. In this study we took an integrated view by modelling both the water supply and demand dynamics at a district level. We carried out this study using the Water Evaluation and Planning [WEAP; SEI, 2001] tool. The model structure, function, inputs, parameterisation of supply and demand options, scenario description etc. are described in detail, in the Annexures. Key results from the Cauvery delta and Western Nepal study are presented in the Results section.

4. CSTEP

Vulnerability towards climate change has been defined and conceptualised in different ways. The Intergovernmental Panel on Climate Change defines vulnerability as “the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity” (McCarthy, Canziani, Leary, Dokken, & White, 2001). Exposure and sensitivity towards climate change for a system depend on the degree of exposure to hazards and effect of the hazard on natural systems. Adaptive capacity is the ability to recover or cope with these hazards.

For CSTEP’s study, vulnerability towards climate change was determined through an integrated vulnerability assessment process. It integrates profiles for climate change, demography, water use, socioeconomic conditions, access to basic amenities, infrastructure, finance, skill sets, and information by identifying and estimating indicators for each of them at the district level (MoEF-GIZ, 2014) (Mohan & Sinha, 2011). The indicators are grouped under exposure, sensitivity, or adaptive capacity. A total of twenty-four indicators were chosen for the analysis. Indicator choice and rationale are discussed in the next section. Figure 11 outlines the vulnerability assessment framework for this study.

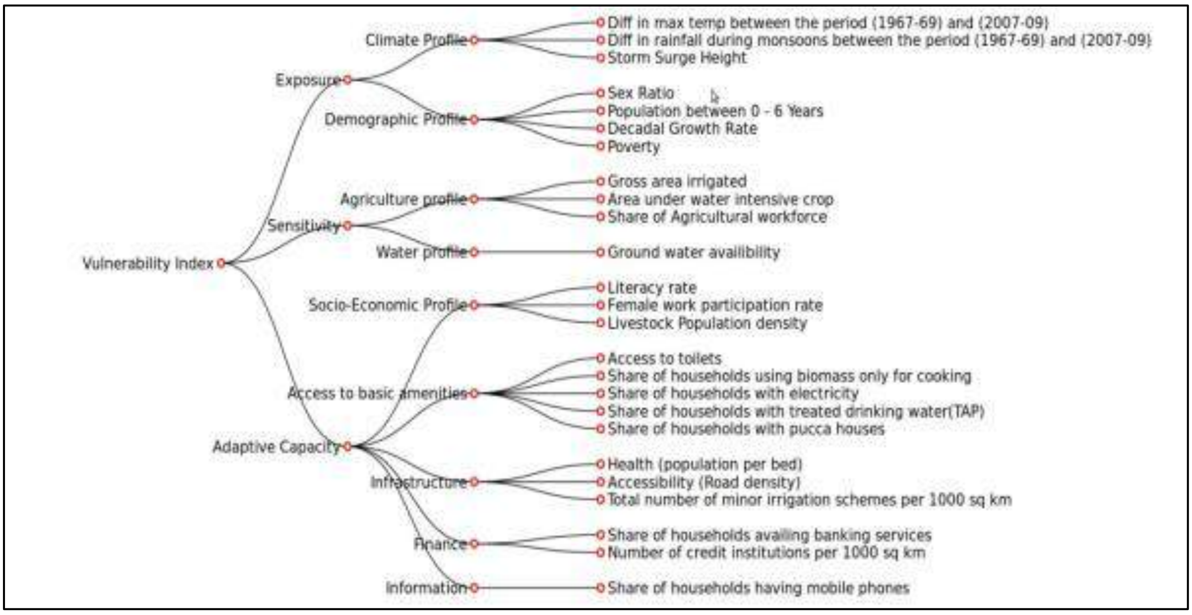


Figure 11: Vulnerability Assessment Framework

Limitations

It is important to keep in mind that identification and classification of the indicators is subjective. We would have liked to have used many more indicators more specifically related to agriculture within each district, but could not do so since the data was not available or verifiable, given the short duration of the project. Data constraints and methodological limitations are major barriers for a study of this kind.

- Data constraints
  - Sometimes these were not available from the same period for all indicators
  - Poverty and groundwater availability was assumed to be the same as the base year
  - On occasion data were not fully available for all time points for some districts. Indicator values for such districts were interpolated.
- Methodological barriers
  - Identification and classification of the indicators was subjective and the selection was done on the basis of the time series availability of data and significance of the data
  - Equal weights were assigned to all profile indicators.

Table 3: Framework

Vulnerability Index	Components	Profiles	Indicators
	Exposure	1. Climate profile 2. Demographic profile	Multiple Indicators
	Sensitivity	1. Agriculture profile 2. Water use profile	
	Adaptive capacity	1. Socio-economic profile 2. Infrastructure 3. Access to basic amenities 4. Finance 5. Information 6. Skill sets	

The initial process of vulnerability analysis was to select the indicators under the profiles mentioned above. The indicators were selected on the basis of literature research and the local context. The data for the indicators were normalised using the UNDP Human Development Index formula. The values for the indicators range from 0 to 1. Higher the value of the index, higher is the value of its component. The formula used for normalising:

$I_x = (I_d - I_{min})/(I_{max} - I_{\min})$, where I_x = Indicator Index, I_d = indicator value for district d, I_{min}= Minimum value of the indicator across all the districts, I_{max} = Maximum value of the indicator across all districts

After calculating the values for the indicators, the profile values were estimated by combining the values of the indicators that fall under it.

Profile = $(\sum_{i=1}^{y} Indicator\ index_i)/y$ where y = number of indicators in the profile.

A value was generated for each profile mentioned in the table above, which was then combined to get the value of the three broad components - exposure, sensitivity and adaptive capacity.

Components = $(\sum_{i=1}^{n} x_{pi} * p_i)/\sum_{i=1}^{n} x_{pi}$ Where x_{pi} = weight for each profile.

For the sake of simplicity, in this study equal weights were ascribed to all profile indicators. The values of the components were used to calculate the vulnerability index for the districts. $Vulnerability\ Index = Sensitivity\ (Exposure - Adaptive\ capacity)$ The values for the vulnerability index ranges from -1 to +1, the highest indicates the most vulnerable.

Indicators

The data sources for each of the selected indicators in this study are shown in Table 4.

Table 4: Components – Profiles - Indicators

Components	Profile	Indicators	Baseline Year	Data source
Exposure	Climate	Difference in maximum temperature between 1967-69 and 2007-09	1967-1969 & 2007-2009	Climate research Unit data sets. Maximum average temperature (1967,1968,1969, 2007, 2008 and 2009), Rainfall (1967, 1968, 1969, 2007, 2008, 2009)
		Difference in precipitation during monsoons between 1967-69 and 2007-09	1967-1969 & 2007-2009	
		Storm surge height	Historical data	Kalsi, S.R.N.Jayanthi, Y.E.A.Raj, and S.K.R.Bhoumik, (2007). "*Probable Maximum Storm Surge Heights for the Maritime Districts of India*". New Delhi: Indian Meteorological Department
	Demographic	Sex-ratio	2011	Census of India http://www.censusindia.gov.in/
		Decadal growth rate	2011	
		Population density between 0-6 years	2011	
		Poverty estimates	2007-08	Department of Economics and Statistics, Tamil Nadu http://www.tn.gov.in/deptst/ World Bank.
Sensitivity	[illegible]	Gross area irrigated	2011	Statistical Handbook 2011-2012,

				Tamil Nadu
		Area under water intensive crops	2011	Statistical Handbook 2011-2012, Tamil Nadu
		Share of agriculture workforce	2011	Census of India http://www.censusindia.gov.in/
	Water	Groundwater available	2008	Central Groundwater Board http://cgwb.gov.in/
Adaptive capacity	Socio-economic	Literacy rate	2011	Census of India http://www.censusindia.gov.in/
		Livestock population density	2011	Statistical Handbook 2011-2012, Tamil Nadu
		Female work participation rate	2011	Census of India http://www.censusindia.gov.in/
	Access to basic amenities	Access to toilets	2011	Census of India http://www.censusindia.gov.in/
		Share of households using biomass only for cooking	2011	
		Share of households with treated drinking water	2011	
		Share of households with electricity	2011	
		Share of households with concrete house	2011	
	Infrastructure	Health (Population per bed ratio)	2011	Statistical Handbook 2011-2012, Tamil Nadu
		Accessibility (Road density)	2011	Statistical Handbook 2011-2012, Tamil Nadu
		Number of minor irrigation schemes per 1000 sq. km	2011	Minor Irrigation Scheme 2006-2007 http://micensus.gov.in/CensusMISch.html
	Finance	Number of credit institutions per 1000 sq. Km	2011	District Statistical Handbook for Tamil Nadu, 2011-2012
		Share of households availing banking services	2011	Census of India http://www.censusindia.gov.in/
	Information	Share of HH having mobile phones	2011	Census of India http://www.censusindia.gov.in/

The IPCC defines 'Exposure' as "the nature and degree to which a system is exposed to significant climate variations. As mentioned earlier, 'Exposure' to climate change has been captured in this study under two broad categories; climate and demography, and indicators under each of these categories have been analysed.

***Climate**:* Climate variability increases the vulnerability of communities. The rationale for selecting certain indicators (climate profile) that reflect the levels of exposure to climate change is mentioned below:

1. Temperature: It indicates the variability in the maximum temperature of the region.
2. Precipitation: Climate change is expected to affect the intensity and frequency of rainfall. The study assumes that a decrease in rainfall will lead to adverse affects on agriculture and a decline in water availability in the region.
3. Storm Surge: Storm surge height is used as an indicator for gauging exposure to climate change in coastal districts.

***Demography**:* Skewed development processes increase the exposure of a population to the adverse effects of climate change (IPCC, 2012). Studying the changes in the demography of a region provides information on the quality of development that has taken place in that region. The rationale for the choice of the demographic indicators (demography profile) that reflect the exposure of the people living in the study area are mentioned below:

1. Sex Ratio: Sex ratio determines the gender distribution in the society. A skewed or a low sex ratio indicates gender discrimination. Socio-cultural structures place women in an inferior position to men, which leads to bias in the distribution of wealth and property, poor access to basic amenities and poor nutritional status. These in turn affect the "capabilities" of women. Poor adaptive capacity of women affects infants as well, making them more vulnerable to the impacts of climate change.
2. Decadal Growth Rate: A higher decadal growth rate would mean greater stress on natural resources, greater pressure to provide employment and other services, and overall greater pressure on all sectors of society. It is therefore selected as a proxy for increased exposure to climate change.
3. Population Density between 0-6 Years: Children are generally the most vulnerable to any kind of adverse change that affects a region. As the population density increases the effect of climate change is more pronounced in terms of susceptibility to diseases, availability of water, food and access to sanitation. Regions with high infant population density are more sensitive to the above effects, and are hence highly exposed.
4. Poverty: Persistent poverty has emerged as one of the main indicators of vulnerability to climate change in numerous studies (The IPCC's, Assessment Report Five). It reflects the inability to respond to adverse effects. The stress of climate change and climate related disasters are likely to worsen the conditions of people who are poor.
   Vibe

The relationship shared between the indicators mentioned above (under climate and demography profiles) and vulnerability is shown in Table 5.

Table 5: Relationship between Exposure Indicators and Vulnerability

Profile	Indicator	Relationship with Vulnerability
Climate	Temperature	Greater the difference in maximum temperature, higher the vulnerability to climate change
	Precipitation	Reduced rainfall leads to higher vulnerability to climate change
	Storm Surge	Higher the storm surge height, higher the vulnerability to climate change
Demography	Sex ratio	Lower sex ratio reflects higher vulnerability to climate change
	Decadal growth rate	The vulnerability to climate change increases for districts with high decadal growth rate

	Population density between 0-6 years	High population density below six years implies an increase in vulnerability to climate change
	Poverty	Increase in a poverty reflects an increase in vulnerability to climate change

'Sensitivity' to climate change is defined as "the degree to which a system is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea-level rise)". As mentioned earlier, 'Sensitivity' to climate change has been captured in this study under two broad categories; water and agriculture, and indicators under each of the categories have been analysed.

***Water**:* It is a very important resource serving a variety of purposes in the study area. Rise in temperature and variability in rainfall affect the water resources of a region. The rationale for the indicator chosen for analysing the effect of water on the sensitivity of the people in the study area to climate change is mentioned below:

1. Groundwater availability: Groundwater levels indicate the water resource strength of a region. It is also one of the primary sources for drinking water for many people in the region. Higher groundwater levels imply greater availability for future use and lower scarcity of water.

***Agriculture**:* It is a major source of livelihoods in the region and is highly sensitive toward the effects of climate change. The rationale for the choice of indicators (agriculture profile) that reflects the levels of sensitivity to climate change are mentioned below:

1. Gross Area Irrigated: The increase in gross area irrigated results in increased use of groundwater and greater dependence on rainfall. The greater the dependence of agriculture on irrigation – higher is the sensitivity towards the variability in precipitation due to climate change. A decrease in the amount of rainfall and continuous depletion of groundwater for irrigation use would make the region highly sensitive.
2. Area under Water-intensive Crops: A large area under water-intensive crops would mean increased demand for water resources.
3. Agriculture Workforce: This indicator is the ratio of the total agriculture workforce to the total workforce. Higher agriculture workforce implies that any adverse effect of climate change on agriculture would reduce the income generation for a large population.

The relationship shared among the indicators mentioned above (under water and Agriculture profiles) and vulnerability is shown in Table 6.

Table 6: Relationship between Sensitivity Indicators and Vulnerability

Profile	Indicators	Relationship with Vulnerability
Water	Groundwater availability	An increase in availability of groundwater implies a decrease in vulnerability to climate change
Agriculture	Gross area irrigated	Increase in irrigated area implies increase in vulnerability to climate change
	Area under water intensive crops	Large area under water intensive crops reflects higher vulnerability to climate change

	Agriculture workforce	Increase in the share of employment in agriculture implies an increase in vulnerability to climate change

According to the IPCC, adaptive capacity is "the ability or potential of a system to respond successfully to climate variability and change".

***Socio-economic Adaptive Capacity**:* It is the ability of the system to adjust to climate change and the associated hazards. The indicators under this category have been selected because they increase the coping ability of a system against an adverse situation, such as climate change. Mentioned below are the specific reasons for selecting each indicator:

1. Literacy rate: Literacy rate is used as a proxy to indicate the ability of a population to be better informed, to diversify their incomes, be better able to adapt in case of adverse situations such as climate change. Hence a higher literacy rate serves as a proxy for better adaptive capacity
2. Female work participation: Women are more vulnerable to the impact of climate change due to their social and cultural roles. Employment of women is an indicator of how resilient they and their families are. Higher female workforce therefore increases a family's resilience toward climate change.
3. Livestock population density: In this study livestock population is assumed to be an additional or an alternative source of income. Hence, higher the livestock population, higher is the adaptive capacity.

***Accesses to Basic Amenities**:* The indicators under this profile are fundamental requirements for development and daily life. These indicators are key aspects of good quality of life. They therefore serve as a proxy for adaptive capacity to climate change. The rationale for the indicators chosen under this category are mentioned below:

1. Share of households with access to toilets: This indicates the sanitation condition prevalent in the region. Access to proper sanitation leads to better hygienic conditions, reducing the spread of diseases and improving the health of people. Climate hazards will indirectly impact the sanitation conditions leading to adverse health impacts. Toilets also represent the infrastructure development of an area. Greater access would imply greater penetration of infrastructure development, which in turn increases adaptive capacity.
2. Share of households using only biomass for cooking: Biomass includes firewood, crop residue and cow dung. This indicates the reliance on natural resources for cooking, levels of internal pollution and its health impacts. Higher dependence on biomass would mean lower adaptive capacity.
3. Share of households with treated drinking water: Access to drinking water is one of the basic necessities for life. Climate change could lead to water stress, impacting the availability of drinking water. Hence, higher the share of households having access to safe drinking water, higher the adaptive capacity of the region.
4. Share of households with electricity: This indicates access to energy services and improved quality of life. Higher the share of households with electricity, higher is the adaptive capacity.
5. Share of households with concrete houses: Impacts of climate hazards such as cyclones, floods are hazardous to kuccha settlements. A concrete house has higher chances of withstanding the climate hazard than a temporary house. A larger number of concrete houses imply higher adaptive capacity.

***Infrastructure**:* The quality of infrastructure in an area indicates the extent of adaptability towards climate stresses. The rationale for the indicators chosen under infrastructure are mentioned below:

1. Health: The variable we examined under health is population per bed ratio. This suggests how easily a person can avail of hospital facilities for treatment. Good health facilities are a prerequisite for an area to cope up with climate hazards. Better infrastructural facilities suggest a higher adaptive capacity.

2. Accessibility: Road transport and good connectivity are necessities for any kind of development. Good road networks are required for smooth operation of market facilities, accessibility to economic centres and migration. Higher road density is linked with higher adaptive capacity.
3. Number of minor irrigation schemes per 1000 sq. Km: The effects of climate change on agriculture are expected to be quite severe in some parts of the country. Agriculture is a predominant source of income in Tamil Nadu. The number of minor irrigation schemes takes into account the number of ground and surface water schemes available for irrigation. The dependence on monsoons will reduce for areas having higher minor irrigation schemes, and would therefore have higher adaptive capacities.

***Finances**:* Availability of finance enables greater coping strategy against climate related losses due to the availability of insurance and credit, which in turn is linked to the overall adaptive capacity of a region. The rationale for the chosen indicators under this category are mentioned below:

1. Number of credit institutions per 1000 sq. km: Credit institutions include commercial banks, land development banks, cooperative banks and various other credit sources. Farmers rely on credit for agricultural inputs and productivity. In the absence of such financial assistance, their vulnerability to effects of climate change increases.
2. Share of households availing banking services: Higher share of households availing banking services indicates the presence of banking facilities and high usage of credit and insurance facilities. Thus as the proportion of households with banking services increases, their adaptive capacity also increases.

***Information**:* A good communication network reduces vulnerability by enabling early warning signals for disaster management. It can also serve as a medium for educating people and preparing them for a disaster. Hence the availability of information increases the adaptive capacity of the region.

1. Share of households having mobile phones: Mobile phones indicate the extent of development and give people the chance to receive and share information. They enhance their social connectivity, all of which are important for enhancing the ability to adapt to the effects of climate change.

Table 7 captures the relationship between various indicators under each category that affects adaptive capacity and vulnerability.

Table 7: Relationship between Adaptive Capacity Indicators and Vulnerability

Profile	Indicator	Relationship with Vulnerability
Socio-economic - Adaptive Capacity	Literacy rate	Higher literacy rate implies lower vulnerability to climate change
	Female work participation	Higher female work participation rate implies lower vulnerability to climate change
	Livestock population density	Higher livestock population density reflects lower vulnerability to climate change
Access to basic amenities	Share of households with access to toilets	Greater access to basic amenities implies lower vulnerability to climate change
	Share of households using only biomass for cooking	Higher dependence on biomass reflects a higher vulnerability to climate change
	Share of households with treated drinking water	Higher the share of households having access to safe drinking water lower the vulnerability to climate change

	Share of households with electricity	Higher the share of households with electricity lower the vulnerability to climate change
	Share of households with concrete houses	A higher number of concrete houses implies lower vulnerability to climate change
Infrastructure	Health	Higher the population per bed ratio higher the vulnerability to climate change
	Accessibility	Higher road density implies lower vulnerability to climate change
	Number of minor irrigation schemes per 1000 sq. km	Higher number of minor irrigation schemes implies lower vulnerability to climate change
Finance	Number of credit institutions per 1000 sq. km	Higher number of credit institutions implies lower vulnerability to climate change
	Share of households availing banking services	An increase in the share of households availing banking facilities implies a decrease in vulnerability to climate change
Information	Share of households having mobile phones	Increase in the share of households having mobile phones reflects a decrease in vulnerability to change

C. Results

1. Bottom-up Approach

Thanjavur

The river Cauvery is the fourth largest river in South India and flows from the North West to the South East. The Cauvery delta lies in the eastern part of Tamil Nadu between 10o N and 11o30 N latitude and between $78^{o}15$ E and$79^{o}45$ E longitudes. The Cauvery delta lies at the bottom of the Cauvery river basin. This delta zone covers four districts Nagappatinam, Thanjavur and Thiruvarur and parts of the districts of Tiruchy, Cuddalore and Puddukottai in Tamil Nadu and Karaikal district of Puducherry. The Cauvery delta zone has a total geographical area of 1.45 million Ha, which is equivalent to 11% of Tamil Nadu state (Cauvery Delta Sub Basin Tamil Nadu, National Water Mission, 2011).

The Cauvery delta forms complex water systems with issues of surface and groundwater, coastal instability and salinity intrusion. The normal annual rainfall is about 945 mm of which 48% is from the North East monsoon, and 32% from the South West monsoon. Since the delta is entirely dependent on rains for recharging its water resources, monsoon failures lead to acute water scarcity and severe drought (Nathan, 1995). Scientific analysis of climate change shows that there has been an increase in extreme events in the form of droughts for three consecutive years 2011-2013 (Rajendran, 2014) and floods (2010) and cyclones (untimely) in the past decade. The erratic behaviour of rainfall has led the agriculturists (primary livelihood of the delta) to depend on alternatives. The dependence on borewells has increased leading to increased salinity and migration to other places for better jobs.

A brief field survey was conducted in the Cauvery delta during a proposal development under the collaborative Adaptation Research Initiative in Asia and Africa (CARIAA), which highlighted issues related to variations in the climate and its impacts on livelihoods in the Cauvery delta. The field survey consisted of household surveys, focus group discussions and key informant interviews. The survey reinforced conceptions on the impacts of environmental variables on the lives and livelihoods of local communities. The survey helped articulate and better understand impacts that affect the main livelihoods of the delta.

The survey highlighted the reduction in the intensity and frequency of the South West monsoons (May to September). The North East monsoons (October to December) are delayed by 20 – 30 days, affecting the traditional cropping cycle. This increase in spatial and temporal variations in precipitation has rendered villages completely dependent on groundwater. Delta farmers who used to grow two crops a year are now cultivating three crops a year due to the availability of groundwater. This increase in the dependence on groundwater has created a positive feedback increasing salt-water intrusion and affecting the productivity of the soils in the coastal villages. Agricultural productivity has also reduced chronically due to these variations and anthropogenic activities such as sand mining and extensive use of chemical fertilisers to boost the yield. There has been a steady decline in the natural resources available to local communities and an increase in migration of agricultural labourers and practitioners to other places in search of better livelihood options. This initial understanding of the delta through the survey helped PAC to select five villages in Kumbakonam Taluk in Thanjavur district as the study area for this project.

Study Area

The district of Thanjavur in the Cauvery delta covers an area of 36.33 sq. km. with a population of 24, 06,957 (Census, 2011). The district can be classified into two main regions viz., deltaic and non-deltaic regions. The deltaic region covers the entire northern and eastern portions of the district where the river Cauvery with its wide network of branches irrigates more than half of the district. It comprises the whole of Kumbakonam Taluk and parts of Thanjavur and Papanasam Taluks. The rest of the southern and western areas of the district are non-deltaic or upland regions. A good portion of upland regions that were dry has now been brought under irrigation with the help of the Grand Anaicut canal, fed by the Cauvery-Mettur Project and by an extension of the Vadavar River. Non-deltaic region is also devoid of hills and slopes gradually towards the sea. Agriculture is the main livelihood of the region with paddy, cotton, blackgram, sugarcane, and coconut, being the major crops in the district.

As the study focused on agricultural livelihoods in the delta region, Kumbakonam block/Taluk was selected with a sample of five villages (refer to Table 8) in four gram panchayats and two river systems based on the following criteria:

- Location within Kumbakonam Taluk boundary
- Predominant livelihood being agriculture
- Location away from the state and national highway

Table 8: List of Study Villages/Panchayats/River System

Sl. No	Villages	Panchayat	River System
1	Oorudayanatham	Uthamadhani	Maniyar
2	Valapuram	Valapuram	
3	Sathangudi	Agarathur	
4	Nandhivanam	Marathanallur	Thirumalai Rajan
5	Karuvalarcheri		

Introduction to the Study Villages - Community Perception on Climate Change

- Oorudayanatham has about 220 households located on the banks of river Maniyar and is divided into two parts, one resided by Most Backward Caste (MBC) and the other part by Schedule Caste (SC). Both the castes have landowners, farmers and agricultural labourers (who work only on lands). Agriculture is the predominant livelihood with an average land holding of 0.33 acres per person in the village. Groundwater is the main source of water for drinking and agriculture. There have been changes in the pattern of cropping and in weather and climate parameters. The farmers follow a method of 'water sharing' with those who own and do not own borewells.
- Valapuram is located 2 km near river Maniyar. The village is home to about 200 households. One part of the village is occupied by the Palar community who are mostly agricultural labourers and the other part constitutes the majority of land owners from SCs. Groundwater is the main source of irrigation. The communities have observed a change in the weather and climate parameters over the past 30 years, which has led to a change in the cropping pattern. The village is also affected by migration of youth to nearby cities due to these changes.
- Sathangudi has about 250 households and is located at a distance of 5 km from the main road connecting the village to Thanjavur and is located along river Maniyar. Clay soil and its location at the downside of the river have left the village prone to floods. Agriculture is the predominant livelihood and is dependent mainly on groundwater.

- Nandhivanam is located along river Thirumalai Rajan and has 250 households. The land is mostly owned by few landowners and the rest in owned by agricultural labourers. There have been drastic changes in the weather pattern and cropping pattern followed in the village. There is evidence of migration by the youth in the village.
- Karuvalarcheri consists of 130 households and is located along river Thirumalai Rajan. Agriculture is the predominant livelihood with groundwater being the main source of water for irrigation and drinking.

Table 9: Overview of Study Villages

	Rainfall	Temperature	Fog
Oorudayanatham	**1984:** North East monsoon start in September *(Ippasi and Karthigai*) and is distributed in these two months. Cyclone and low pressure brings heavy rains during this period. **2004:** North East Monsoon starts from October to December. Summer showers increases due to this. **2014:** May and June (*vaikasi)* receives rain and there is three to four rainy days. Due to delay in North East monsoon it rains only 4 to 5 days in December. Cyclone and low pressure occurs unseasonal in January to May.	**1984:** Summer experienced from April to May and mid-June. **2004:** Summer experienced from April to June **2014:** Summer experienced from March –July. Groundwater reduces.	**1984:** December to February **2004:** January to mid-March **2014:** January to March
Valapuram	**1984:** Non-stop rain (*Adamalai)* from September to December. **2004:** Slight change in rain fall (October to November) **2014:** During cyclone or low pressure in the Bay of Bengal the rain reduces.	**1984:** *Panguni to Vaikasi*[3] is the summer period. Temperature reaches 90-95 degree F **2004:** Temperature reaches 90-95 degree F **2014:** Summer is experienced up to mid of *Adi*[4]. The highest temperature recorded is 102 to 105 degree F.	**1984:** January to March is winter. Fog and mist is experienced and is good for pulse crops and vegetable **2014:** "*Ippa kalammari pani peyuthu*". Evening and early morning mist in June is not good for crop. Heavy mist in January can damage crops (disease).
Sathangudi	**1984:** North east monsoon starts in September *(Ippasi and Karthigai*) and distribution of rains throughout these months. Cyclone and low pressure brings heavy rains. **2004:** Rain distribution highly changed **2014:** May and June receive rains. Delay in North East monsoon and no continuous rains. Due to delay in North East monsoon it rains only 4 to 5 days in December Cyclone and low pressure occurs unseasonal in January to May.	**1984:** Summer experienced from April 15 to June 15. **2004:** Summer extended from March to May. **2014:** Summer from March–June. Reduced groundwater leads to pest and diseases in cotton and other crops.	
Nandhivanam	**1984:** Northeast monsoon starts in September *(Ippasi and Karthigai*) and the distribution of continuous rains is throughout *(adaimalai*[5]*)* these months. Cyclone and low pressure brings heavy rains. **2004:** No continuous rain due to erratic distribution of rainfall in North East monsoon. **2014:** May and June (*vaikasi)* receives rain. Due to delay in North East monsoon it rains only 4 to 5 days in December. Cyclone and low pressure occurs unseasonal in January to May.	**1984:** Summer prevails during April to May. **2004:** Summer from March to June first week **2014:** Summer from mid-February to June. Reduced groundwater leads to influx of pests and diseases in cotton and other crops.	
Karuvalarcheri	**1984:** North East monsoon is experienced from September to October *(Ipasi and Karthigai*) and distribution of rains is throughout *(adaimalai)* the two months. Cyclone and low pressure brings heavy rains. **2004:** Delay in onset of monsoon. Rain received during low pressure or cyclone time **2014:** Delay in North East monsoon and no continuous rains. Four to five rains in a month up to December. Cyclone and low pressure occurring unseasonal - January to May increasing. Month of May and June (vaikasi) receives rain.	**1984:** Hot summer experienced during April and May. In June (Vaikasi) wind starts it reduces the effect of temperature. Summer is manageable with dress in field **2004:** Summer starts from March and ends in first week of June **2014:** Hot season from February to June. Reduced groundwater leads to influx of pests and diseases in cotton and other crops. Cotton requires every 12 to 15 days of irrigation. Paddy requires irrigation every day.	**1984:** December to February experienced mist. Highly useful for pulses cultivation **2014:** Heavy mist during December damages crop.

[3] Tamil Months of April to June
[4] Adi is Tamil for July
[5] Adaimadai means continuous rain in Tamil

Climate Change Score Cards: A Process

Climate Change Score Cards empower vulnerable people through the knowledge shared and generated from interacting with the community. CCSC helps understand both sides of the coin, and brings various stakeholders (communities, CSOs, Policy Makers, Government Officials and hence forth) on a single platform for a common cause – Improving the resilience of vulnerable communities.

The following steps were adopted in implementing the CCSC:

- **Input tracking**: Participatory Rural Appraisal (PRA), Regulation Analysis, Climate Data Analysis (modelling and forecast)
- **Selection of Indicators**: classified into livelihood capitals
- **Scoring of Vulnerability**: by communities and governance structures
- **Scenario Planning**: Governance V/s Livelihood capitals by the communities
- **Interface Meeting**: bringing together all stakeholders at the district level[6]
- **Policy Discourse**: at provincial and state levels

Input Tracking Exercises

The input tracking exercise involves three main components:

1. Analysis of Climate Data
2. Regulations analysis and
3. Understanding the community through Participatory Rural Appraisal methods

Regulation Analysis

One of the key components of the governance analysis is to understand the rules and regulations that govern the lives and livelihoods of people. In CCSC, one important premise of governance analysis is the expression of regulations and acts that affect the lives of people, through the design and implementation of schemes. Hence a macro analysis of the regulations was done to understand the policy environment and a detailed study of specific schemes of the government that have a direct bearing on the sector was also carried out. The analysis was based on policy design, target audience, feedback mechanisms, benefits envisaged for the target audience with a specific focus on improving the adaptation capacity of the vulnerable communities.

Participatory Rural Appraisal Methods

Participatory Rural Appraisal Methods were used to generate a basic understanding of the study villages. The highlights of the PRA exercises in the five study villages are shown in Table 10.

[6]As this was a short study, it focussed mainly on scenario planning and identification of pathways to reduce vulnerability

Table 10: Highlights of the PRA Exercises

PRA Exercise	Resource Management	Services and Opportunity Mapping	Force Field Analysis	Trend Analysis
Oorudeyanatham	There are 38 borewells owned by farmers for irrigation. Water is shared by those who have borewells with those who don't have borewells. Groundwater level is 35-40 feet. During rainy season water is drained, as there are no proper drainage facilities. Cauvery river water is not available, as the river canals do not function. People face water scarcity during summer.	There is a need for conducting field level research in the fields of farmers. There is no consultation with farmers to assess their needs and priorities. Visits from government agriculture extension or research personnel are irregular and inadequate.	Water sharing among farmers between those who own a borewell and those who do not own	There has been an increase in the number of sunny days from 75 days (March-May) in 1984 to 90 days.
Valapuram	There are 30 borewells with the depth varying from 25 to 220 feet. The river water reaches the village through the main canal.	The availability of farm machinery and regulated markets is an important reason for continued cultivation of paddy.	Availability of groundwater is at a depth of 25 feet. The soil is very rich in nutrients.	Reduction in the number of rainy days during the monsoons. Increase in the number of sunny days with an increase in temperature from 90°F to 102°F
Sathangudi	There are 30 borewells with a depth varying from 40 to 160 feet. The river water reaches the village through the main canal. Since the canals are silted they do not function.	There has been significant reduction in the extension services to farmers and the visit of government agriculture department officials to the villages, which has drastically reduced and hence farmers depend on private agro-service agencies.	Agriculture labourers are supportive and there is a mutual understanding and support to continue agriculture in the villages.	Erratic and unseasonal rainfall coupled with increasing temperatures leads to flooding and increase in pest attacks.

PRA Exercise	Resource Management	Services and Opportunity Mapping	Force Field Analysis	Trend Analysis
Nandhivanam	Of the 127 acres of agricultural land 110 acres is temple land and farmers own the remaining 17 acres. The village is connected to Thirumalai Rajan River, which has effective network of canals for irrigation of agriculture lands.	Agriculture programmes are marginal and small farmers reach a few better off farmers. Small, marginal farmers require on field extension service support from government agriculture departments staff by scheduling regular visit to the village.	The farmers and agriculture labourers in the villages have established mutual support mechanisms that enable timely agricultural operations.	Erratic rainfall and increase in the number of summer days has led to changes in cropping pattern and the intensity of crops.
Karuvalarcheri	Groundwater is available at a depth of 40 feet. The soil is very fertile and canals and sub-canals feed the village. Out of 161.50 acres, 38 borewells irrigate 111 acres. 68.73 % of area is irrigated by borewells during dry seasons.	Due to lack of adequate support from Government schemes and programs villagers are unable to get the benefits of seed subsidies, training programmes, godown facilities, land development techniques, etc.	Availability of groundwater and mechanisation is the motivating factor for agriculture.	There has been a shift in the cropping pattern from turmeric, and black gram to paddy and cotton crops.

In order to create a knowledge database on lives and livelihoods, people's activities were mapped and a primary database developed. The purpose of this database was to use the information as a basis for developing and scoring indicators to assess the vulnerability of the study villages.

Selection of Indicators

Indicators were developed for assessing the vulnerability of the local livelihoods to climate change (refer to Figure 12). These indicators would be developed based on the findings of the Participatory Rural Appraisal Methods, Regulation Analysis and Climate Data Analysis during the input exercises. These indicators were chosen in such a manner as to allow a comparison between the livelihood capitals (natural, physical and financial) and with other study villages.

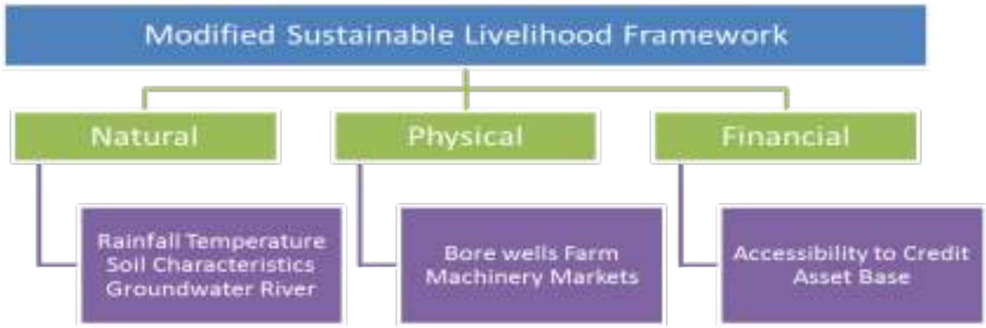


Figure 12: Classification of Indicators based on Livelihood Capitals

Scoring of Vulnerability

The process of scoring provides an opportunity for stakeholders (community members/researchers/government officials) to discuss various aspects of an indicator and then arrive at a common score. These discussions and debates promote critical thinking and reasoning, and usually ensure that some of the minor issues get clarified right at this stage. Further, it ensures that the members of a community are informed about all the issues on at same level. The importance of the exercise is not in the numbers but in the richness of the discussion that takes place before the scoring.

Scoring by Government Officials

The indicators were shared with the officials of the agriculture department, to get their perspective on vulnerability of agriculture in Kumbakonam Taluk of Thanjavur district. The deputy director of agriculture scored the indicators and the details of the scores are shown below in Table 11:

Table 11: Vulnerability Index Scored by Officials of Agriculture Department

Livelihood Capitals			**Vulnerability Index**
Natural	Physical	Financial	
0.64	0.69	0.60	0.67

One can see that the overall vulnerability of Kumbakonam Taluk based on the government's perspective is 0.67. Livelihood capitals are also highly vulnerable to climate change.

Scoring by Researchers and Civil Society Organisations

An exercise was conducted at the Round Table 'Resilient Thanjavur – A Think Tank'.

The participants in the Round Table were divided into four groups, Researchers, Civil Society Organisations and Farmers (both men and women). The participants scored the indicators in their respective groups. An analysis of the indicators showed that Natural Capital was the most influential capital for agriculture and thus the most vulnerable livelihood capital in Thanjavur delta (refer to Figure 13).

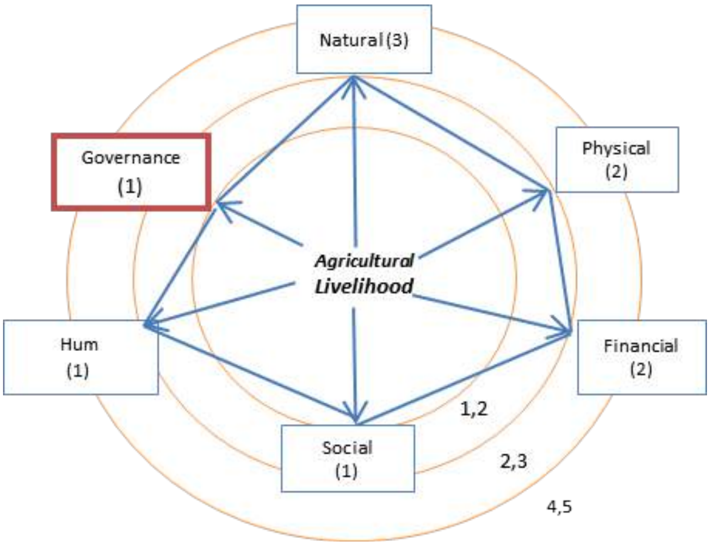


Figure 13: Analysis of Scores of Researchers, CSOs and Community Representatives

Another way of interpreting the scores is, the governance capital has the least influence for carrying out agriculture in the delta. This is a matter of concern as governance plays an important role in the lives and livelihoods of the people in terms of subsidies, policies, schemes and programmes, rendering the communities vulnerable to varying climate and weather patterns.

Scoring by Community Representatives

The score sheets were displayed in the villages and each indicator was explained to them. Then the scoring exercise began and the community representatives provided a reason for each score. Please refer to the Annexures for village-wise details of scores.

Once the scoring exercise was completed the vulnerability index for each capital was calculated giving equal weights to all indicators. The index is calculated using the Patnaik and Narain method of vulnerability index. One advantage of this method is that one can compute the indices based on individual capital and ranks can be allotted to each capital.

The vulnerability index of the villages studied is shown in Table 12. The Table also captures the vulnerability of individual livelihood capitals (Natural, Physical, and Financial). It can be seen from the Table that Natural capital is least influential in terms of allowing the farmers to choose the type of crop and the number of crops grown per year. This is a matter of great concern as most of the agriculture is dependent on groundwater. This situation is coupled with varying climatic patterns like erratic rainfall and an increase in average temperatures, which increases the vulnerability of farmers in the Cauvery delta. We know that groundwater levels have currently already increased in depth from 15 feet (1990) to nearly 120 feet.

Finance is another important capital for agriculture and is a highly influential indicator for assessing the vulnerability of communities. Farming communities, especially small and marginal farmers are highly dependent on money lenders as they find it difficult to link to formal institutions such as banks and cooperative societies. The communities are not fully aware and lack the will to apply for climate finance tools such as crop insurance as they have not faced any extreme conditions such as droughts and floods to date. In the case of droughts the farmers increase the use of groundwater and overcome the extreme conditions. This has resulted in a lack of will to shift to climate friendly finance tools such as crop insurances. The village of Valapuram is highly vulnerable to climate change, with a vulnerability index of 0.59. The village is vulnerable in every capital as agriculture in the village is highly influenced by groundwater and borewells are the only source of irrigation in the village.

Table 12: Vulnerability Index and Ranking of Study Villages

Study Villages	**Livelihood Capitals**			**Vulnerability Index**	**Vulnerability Ranking**
	Natural	Physical	Financial		
Oourodeyanatham	0.18	0.15	0.29	0.27	5
Valapuram	0.34	0.84	0.75	0.59	1
Sathangudi	0.41	0.83	0.75	0.53	2
Nandivanam	0.28	0.39	0.65	0.36	4
Karuvalarcheri	0.34	0.67	0.65	0.51	3

Nepal

Madanpokhara

The common types of hazards in the VDC are bank cutting, landslide, monkey problem, forest fire and drying of water sources (refer to Table 13). Among all the hazards appearance of monkeys are the major problem for the people of Madanpokhara. According to the villagers the monkeys started appearing in their VDC since 2003, creating havoc in their day-to-day life. People believe that the monkeys could have come from the nearby VDCs during the Maoist insurgency. During that time there was a bomb explosion in the forest of nearby VDCs. So these monkeys could have come to their VDC in search of habitat. Since then the life of the people of Madanpokhara VDC has been chaotic. The ward numbers one, nine, and two are mostly suffering from monkeys. Agricultural land has been destroyed. The monkeys eat the sowed seeds of maize that lead to decrease in productivity. Fed up by the monkeys some people have even stopped farming. Monkeys attack women and children and are a major nuisance. The incidences of landslide and bank cutting are creating a negative impact. People mentioned that the 2200-year-old temple is on the verge of sliding away due to landslide in ward number two.

Table 13: Types of Hazards in Madanpokhara VDC

Ward	**Incidences/Hazard**	**Consequences**
1	Monkey problem, dry landslide	9 households directly affected in Sirankot VDC
2	Bank cutting, landslide, monkey problem, water source drying	2 hhs affected, possibility of washing away 22 hundred old temple
3	Monkey problem, landslide	One of the big landslide of Palpa district called Khawa landslide (affected forest but no household affected)
4	Monkey problem, landslide, bank cutting of cultivable land	Due to landslide 20 -22 household affected
5	Forest fire, monkey problem	Sal forest affected

6	Monkey problem, destruction of cultivable land due to bank cutting	Bank cutting-12to13hhs affected Flood-15 hhs affected
7	Bank cutting by Aderi khola, monkey problem	Bank cutting affected 60 ropanies of land. One ropani is 5476 sq. ft.
8	Monkey problem, bank cutting	Possibility of flood entering into pragati tole.
9	Monkey problem, landslide	Due to monkey problem 5-6 hhs have stop doing agriculture

Dubiya

The pair wise ranking of Dubiya VDC shows drought as the major hazard. In addition to drought flood, bank cutting, cold wave, windstorm and hailstone, Army worm disease is also prevalent in the VDC (refer to Table 14). Almost every year occurrence of drought causes decrease in the productivity of land.

Table 14: Types of Hazards in Dubiya VDC

Incident / disaster	Drou-ght	Chol-era	Hail-stone	Army worm	Wind-storm	Flood	Mala-ria	Bank cutting	Cold wave	Rema-rks
Drought		**Drou-ght**	**Drou-ght**	**Drou-ght**	**Drought**	**Drou-ght**	**Drou-ght**	**Drou-ght**	**Drou-ght**	Drought =16
Cholera	Drought		Hail-stone	Army worm	Wind-storm	Flood	Cholera	Bank cutting	Cold wave	Chol-era=2
Hailstone	Drought	Hail-stone		Hail-stone	Wind-storm	Flood	Hail-stone	Bank cutting	Cold wave	Hailstone =6
Army worm	Drought	Army worm	Hail-stone		Wind-storm	Flood	Army worm	Bank cutting	Cold wave	Army worm=4
Wind-storm	Drought	Wind-storm	Windst orm	Wind-storm		Flood	Wind-storm	Wind-storm	Cold wave	Wind-storm= 10
Flood	Drought	Flood	Flood	Flood	Flood		Flood	Flood	Flood/ cold wave	Flood= 13
Malaria	Drought	Chol-era	Hail-stone	Army worm	Wind-storm	Flood		Bank cutting	Cold wave	Malaria= 0
Bank cutting	Drought	Bank cutting	Bank cutting	Bank cutting	Wind-storm	Flood	Bank cutting		Bank cutting/ Cold wave	Bank cut-ing=10
Cold wave	Drought	Cold wave	Cold wave	Cold wave	Cold wave	Flood/ cold wave	Cold wave	Bank cutting/ cold wave		Cold wave=14

Livelihood Mapping: It is a tool used to identify the five capitals of sustainable livelihoods used by the community. This tool identifies and categories local livelihood assets and resources that are available within the community. From this exercise one can measure the ability of a system or a community to adjust to climate change effects, to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. The livelihoods mapping exercise was conducted for each ward of Madanpokhara and Dubiya VDC. This tool identified and categorised local livelihood assets and resources available within the community. Based on this exercise, the people discussed how able a system or the community should be to adjust to climate change effects, to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. The findings of the exercise are listed below:

Madanpokhara

VDC building, schools, village roads, rest stops, community buildings, vegetable collection centre, communication facilities, and cooperative buildings are some of the important and almost common physical resources in each ward of the VDC. Water sources, productive land, community forests, rivers are some natural resources in each ward. According to the locals there are more than 65 and 15 water sources in the ward no. 8 and 6 respectively. There are a number of degree holders, doctors, nurses, engineers, charter accountants, government professionals and other skilled human resources in the VDC. There are 21 doctors in wards no. 5 and 9. A total 13 Dhaka production cottage industries are located in ward no. 1, 3, 4 and 6 (5, 4, 3, 1 nos. industry respectively.)

It was found that the status of livelihood assets and resources that are available within the VDC are very good. Among the livelihood assets, human resources and natural resources are very strong.

Madanpokhara VDC's systems are able to adjust to climate change effects or to cope with the consequences.

Dubiya

Local people have identified a series of options for livelihood. Those options have been divided into five different groups. These are physical, natural, human, social, economic and socio-political. Based on the exercise, people in the community discussed the ability of the system or the community to build adaptive capacity to the effects of climate change.

Diverse livelihood options increase the ability to cope with extreme situations. A service-oriented person such as a teacher, technician, security personnel (policy and army), doctor, engineer, nurse, health assistant, traditional healer, carpenter, artist, helps in the livelihood of each household. In addition, small business houses like mills, cutting and tailoring, general shops, medical shops, and cable suppliers add value to livelihoods. Local entrepreneurs as saving groups, fish faring groups, poultry farm and commercial vegetable farming groups also make contributions to local livelihood.

There was a decrease in cow and buffalo rearing by 95 percent but increase in goat, pig, rabbit and poultry farming (Dixit and Khadka, 2013). That indicates the intervention of commercial livestock farming in VDC. Besides these social institutions like awareness centre, children club, vegetable and agricultural group, diwal location, mother groups, youth club, CBO, political parties, farmer group, community forestry user group, other user groups also added value to have better livelihood condition in VDC.

Remittance is a major option for incomes in the VDC. At least one person (especially youth) from each household has migrated abroad to Malaysia, Qatar, Saudi Arabia, Kuwait or India for work. Migrants have created a foreign employment group such as ChitijPravasi saving group, which provided financial support to buy some assets to Adharbhut cooperative at Rangain, Dubiya.

Individual households attempt to achieve livelihood options better by engaging themselves in both farm activities like producing marketable vegetables and off-farm activities like seasonal and long-term migration, small business, skilled work and service in government and private sectors. While the emigration of economically and socially privileged groups has created some wage employment opportunities for landless and marginalised households, it has also created labour shortage (Dixit and Khadka, 2013).

Changes in different systems such as roads, education, telecommunications, health services, civil society, banks, CBOs, and political parties have affected livelihoods and many other socio-economic structures that influence the understanding and way of thinking of local people in Dubiya.

Stakeholders/Institutional Analysis (Venn Diagram): In order to analyse concerned stakeholders or institutions that exist within or work with the community, a tool comprising of Venn diagrams were used to investigate linkages, relationships and interactions between differing groups of households, institutions or community groups. This has enabled the project to identify potential partners in specific areas such as adaptation options of climate change. Then, the institutions are prioritized on the basis of the services rendered to the community and linkages created based on who works directly with whom and why. This exercise provided information that is described below.

Madanpokahara

During the exercise on institutional analysis (refer to Figure 14), the community identified a number of institutions that work with their community. Out of those institutions people recognized five institutions as being the most important in terms of services and facilities available to the community and the possibility of collaboration with them.

Figure 14: Institutional Analysis in Madanpokhara VDC

Table 15 shows a glimpse of those institutions selected in Madanpokhara VDC. These are listed in the order of priority.

Table 15: Most Important Institutions preferred by the Community

VDC	Name of Institutions (in priority order)	Other institutions
Madanpokhara	i. Ward Citizen Forum/ward committee ii. VDC and DDC iii. Schools/colleges iv. Radio Madanpokhara (the first community radio of south Asia) v. Community forestry user groups and District Drinking Water Office	• FECOFUN, • Saving and credit cooperative • Cooperatives (agriculture, bee keeping, coffee, milk and vegetable) • Women groups • Coffee production groups • Women welfare association • DFO/Range Post • DADO/ASC • District veterinary office/veterinary service centres • Association of District Coffee Entrepreneurs • Red Cross Society • Banks, • District soil conservation office • DDWO • Local youth clubs • District public health office • District Hospital, Lumbini Medical College, Mission Hospital, Health Post, Family Planning Clinics • District Education Office, Campuses, Madanpokhara Polity-Technical Institute, • Development partners

Dubiya

The community has identified a number of institutions that are interlinked. Among the identified institutions, local people recognised five as the most significant in terms of availability of services and facilities to the community and opportunity of relationship with them. The picture shows arrangement of those institutions selected in Dubiya VDC. These are listed in order of priority in Table 16.

Table 16: Most Important Institutions preferred by the Community

VDC	Name of Institutions (in priority order)	Other institutions	Remarks
Dubiya	1. VDC office 2. Adharbhut Gramin Bikas Sewa a leading NGO in VDC 3. Adharbhut Gramin Bikas Sewa Cooperative 4. Sub-health post 5. Community forestry user groups and government schools	• Farmer help centre • Children club • Women groups • Self help groups • Farmer network • Differently able network • Saving and credit cooperative • Women welfare association • NGO/INGO • Political parties • District Public Health Office • District Administrative Office • District Development Office • Local youth clubs • Awareness centre • Private schools • District Red Cross Office • District Agriculture Development Office • District Livestock Services Office • District Drinking Water and Sanitation Divisional Office • District Postal Office • Nepal Telecom • District veterinary office/veterinary service centres • District forest office • District Hospital, Family Planning Clinics • Department of Water Induced Disaster Prevention	

Using the above-mentioned tool a set of indicators (Table 17) was developed for assessing vulnerabilities of the VDCs, and based on these a questionnaire was developed for vulnerability assessment. A sample questionnaire is attached in the Annexure.

Table 17: Indicators for Assessing Vulnerability

Categories	Indicators	Rationale
Exposure	Percentage of disaster affected households	Indicates households in higher exposure
	Number of drinking water sources affected by disaster	Indicates households in higher exposure
	Irrigation sources affected by disaster	Affected irrigation source have more exposure and thus can decrease agriculture production
	Percentage of disaster affected land	Affected land exposes people to vulnerability and limits agricultural production
	Disaster affected crop	Affected crop exposes people to vulnerability and decrease production
Sensitivity	Percentage of pest and disease affected households	Climate change could make pests more common and affect households
	Percentage of land plotting area	Increase in plotting reduces arable agriculture land
	Percentage of area affected by invasive species	Increasing number of invasive species destroys crops and useful plants

	Percentage of landless households	Landless households have low adaptive capacity, as they are dependent on natural resources for their livelihood
	Percentage of households using non engineered system of water for drinking	Dependency on non-engineered system of drinking water increase pressure on water use
	Percentage of households using non engineered irrigation facilities	Non reliable and unstable irrigation system limits food production from arable land
	Percentage of households using traditional sources of energy for cooking and lighting	Traditional energy for cooking and lighting increase pressure in agriculture, lighting, communications, manufacturing transport and other systems
	Percentage of household dependent upon remittance	Remittance will increase decency of people, reduce diversified livelihood activities
	Percentage households with nature based livelihood	Households with less livelihood diversification likely to be more vulnerable to climate stress
	Percentage of households having very less food sufficiency	Food deficiency indicates individual household are vulnerable to climate stress
	Number of water source affected by road construction	Indicates haphazard road construction harm existing resources
Adaptive Capacity	Road density	Road networks help people move from place of living to workplace and access to services
	Number of concrete bridge	Concrete bridge helps people move from one to another place
	Distance to nearby market	Nearby market enables access food as well as sell local produces
	Number of mobile phone using household	Can increase response capacity by sharing information
	Percentage of forest area	Will help buffer services to local community by minimising erosion and maintaining available natural resources
	Percentage of households having pakka house	Pakka households may survive hazard and also is an indication of well being
	Percentage of households using clean energy for lighting	Clean energy will allows different systems to be run and helps individuals and household to adapt
	Percentage of households using engineered system of water for drinking	Access to piped water system is likely to improve adaptive capacity during extreme situation
	Number of financial institution	Availability of loan (with and without collateral) can increase adaptive capacity during extreme conditions
	Number of health institution	These build adaptive capacity of the individuals and families during extreme conditions
	Sanitation facility	These build adaptive capacity of the individuals and families during extreme condition
	Number of educational facility	Presence builds adaptive capacity of the individuals and families
	Social networks	Presence builds adaptive capacity of the individuals and families during the time of stress
	Number of small industries	Presence builds adaptive capacity of the individuals and families
	Government agencies	Provide key services to adapt to people and help in adaptation.
	Number of non-governmental agencies	Can get support in emergency disaster and stressful times

Vulnerability Assessment

The method proposed by IPCC to capture vulnerability as a function of exposure, sensitivity and adaptive capacity was used in this study. In recent studies on urban resilience done by ISET-International, the notion of climate change is considered to be an outcome of interaction of exposure, performance of systems, the characteristic of the population particularly the question of whether they are marginalised or mainstreamed and the institutions. The fragility of the systems on which people rely to switch strategy, the exposure of those systems and populations as well as their activities to specific climate hazards collectively determines vulnerability. Thus, in ISET's analysis vulnerability is a function of exposure, fragile systems, marginalised and low capacity population and constraining institutions.

Vulnerability was assumed to be directly proportional to exposure and sensitivity and inversely proportional to adaptive capacity. Thus, if a system is exposed to hazards and sensitive to climate change, it is likely to be vulnerable, but if it has considerable adaptive capacity, its vulnerability will decrease. This relationship is shown in Figure 15 and expressed as follows.

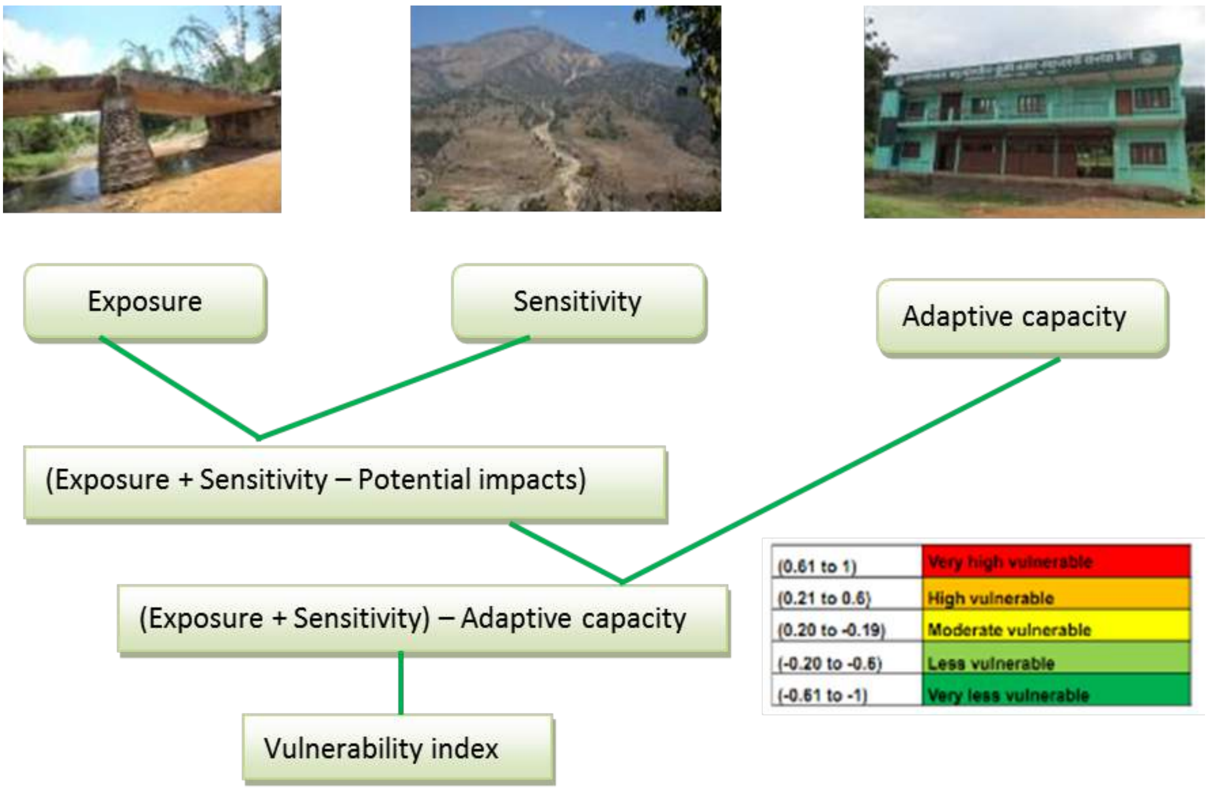


Figure 15: Relationship between Exposure, Sensitivity and Adaptive Capacity

The vulnerability of the wards in both VDCs was ranked using an aggregate figure for the status of various systems. The quality and relative robustness or fragility of each of these systems is one determinant of the ability of local populations to shift strategies. The ranking of each ward is shown in Figures 16 and 17.

Ranking on the basis of the availability and accessibility and its systems revealed that in case of Madanpokhara ward number one and three are the most vulnerable ward whereas six is the least vulnerable ward. Similarly, in Dubiya ward number one is the most vulnerable whereas ward number 8 and 9 are the least vulnerable.

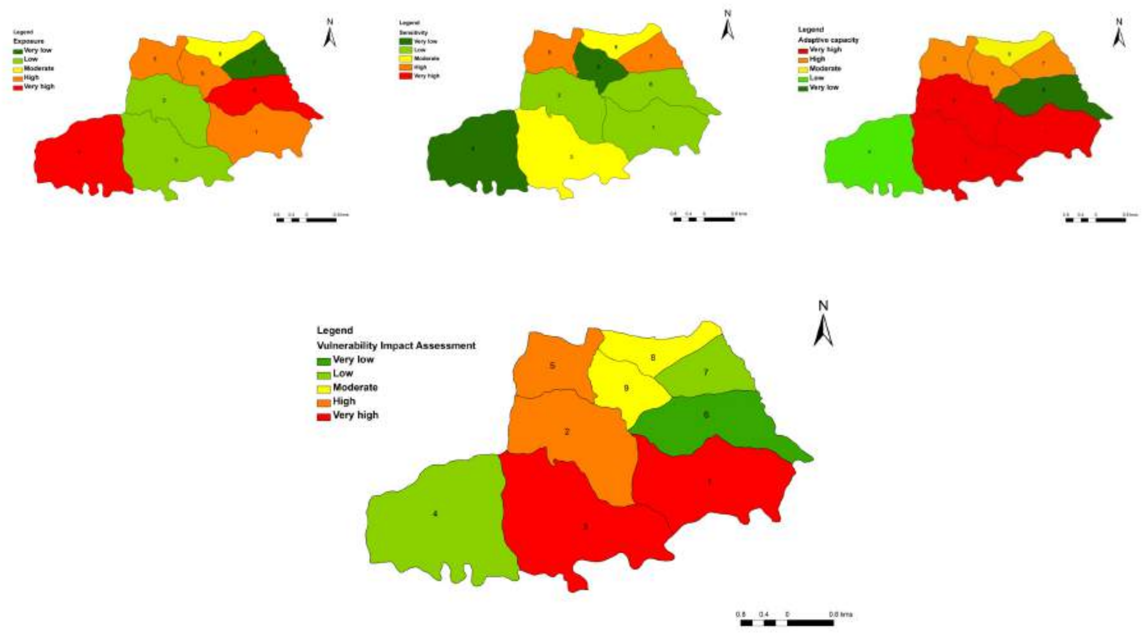


Figure 16: Vulnerability Ranking of Madanpokhara VDC

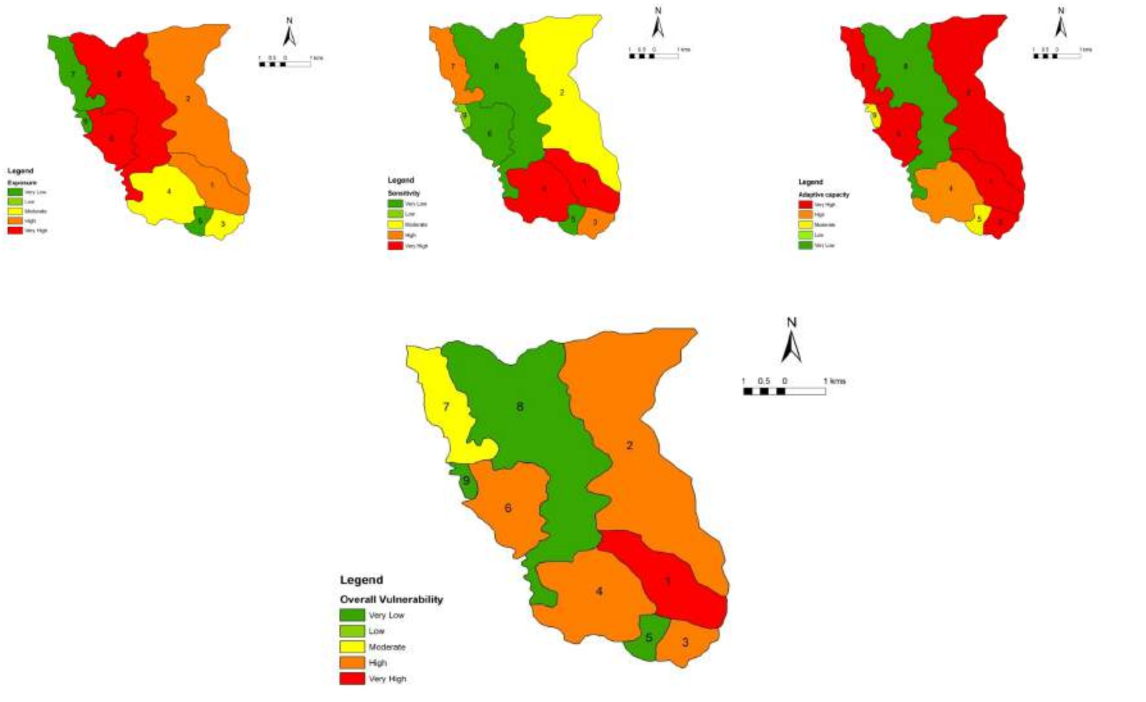


Figure 17: Vulnerability Ranking of Dubiya VDC

Local Resilience Planning

With the identification of vulnerable wards and vulnerable local populations within both VDCs, the next stage was to use a climate change lens to develop local climate scenarios of the future in order to explore future hazards, exposure and changes in vulnerability. The process of visioning scenarios for the future allows people to understand the levels of uncertainty in climate change and they also take the local context into consideration in this process. This assists the community in identifying options to strengthen resilience and adaptive capacity.

Understanding systems as gateways to services helps in learning about complex social dimensions and are a useful lens through which to perceive local life and its complexities. The visioning of the future with its climate uncertainties and identifying and analysing adaptation options within a community require a familiarity with the local living conditions within a community.

Scenarios are a vital part of vulnerability assessment and adaptation planning as they help to characterise future climatic and non-climate conditions that are critical vulnerability assessments and policy making. They provide insights on the scope, focus and timeline for adaptation interventions to address possible climate change impacts and vulnerability (Figure 18). Scenario planning creates possible futures to inform present decision making and provides a systematic approach for the development and testing of plans, strategies and policies in an uncertain environment through the creation of possible futures (O'Brien, undated). But it is imperative to take note that scenario planning is based on the generation of descriptions of possible futures involving a high degree of uncertainty and are not predictions of a particular future.

In ISET's project the future climate scenarios were obtained from a 2009 study that used various global circulation models (NCVST, 2009). The scenarios presented help to enhance the participant's imagination of plausible, coherent pictures, descriptions of possible futures and the identification of options to combat the adverse effects brought by changes in climate.

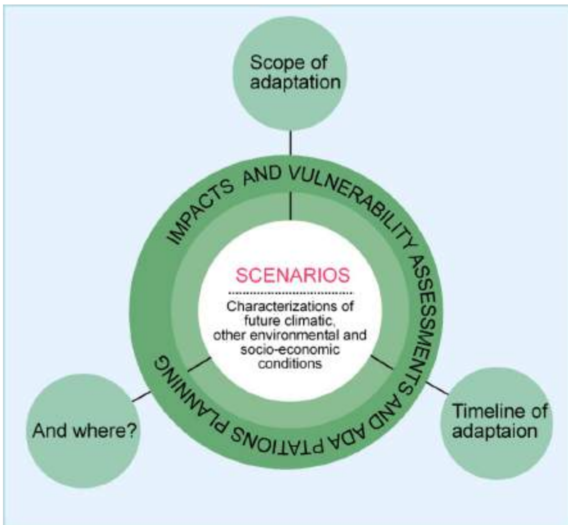


Figure 18: Scenarios as Essential Inputs to Impact and Vulnerability Assessments and Adaptation Planning

Step-wise activities carried out to prepare local resilience planning framework were as follows:

Identification of most critical physical and social system: Both the environment and our social systems can play a role in building resilience to climate impacts and reducing vulnerability of our communities and economies. Therefore the participants were asked to identify social and physical systems most at risk that need immediate attention to improve resilience. For this the Climate Change Score Card (CCSC) method was used. CCSC has been developed by Public Affair Centre (PAC) India based on a pilot study in the Gulf of Mannar, Tamil Nadu, India, which empowers the community with relevant knowledge and provides opportunity for dialogue with governance structures at different levels. CCSC empowers the community by building local capacity in engaging with government in elevating local strategies of adaptation and survival into the framework of governance (Figure 19).

CCSC is an adaptation of the Community Score Cards (CSC), a well-known community-level monitoring tool, where community members and service providers come together to provide feedback on service delivery (Community Score Card Manual, undated). It is a hybrid of the techniques of social auditing, community monitoring and citizen report cards aimed at giving feedback to service providers. It is based on the experience of service users. It allows service providers and the community to interface with each other and enables social and public accountability and responsiveness from service providers.

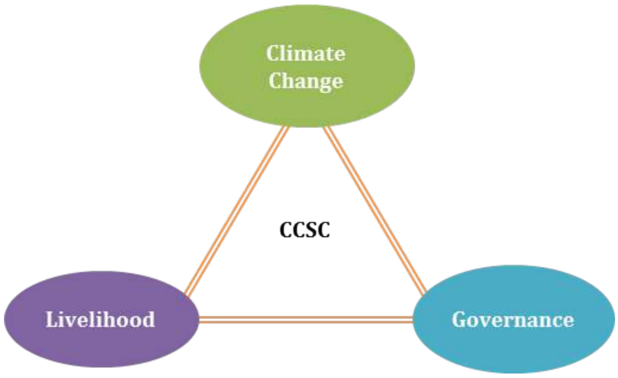


Figure 19: Climate Change Score Card

Using the CCSC the participants from Madanpokhara as well as Dubiya scored the important systems identified from questionnaire survey against the efficiency of government services (Tables 18 and 19). This exercise helped to identify the most critical systems in the VDC that need immediate action so as to mitigate the effects of a changing climate.

Madanpokhara

Table 18: Scoring Against Various Government Schemes

Indicators	Schemes/Benefits	Subsidy	Technical support	Relief	Average score
Natural disaster	1 to -1	2	2	1	6
Drinking water and sanitation	4	4	4	4	16
Monkey threats	0	0	0	0	0
Irrigation	3.5	3	3	0	9.5
Agriculture	3	1.5	2	0	6.5
Forest	5	3	4	NA	9
Roads	4	1	3	1	9
Communication	4	1	1	0.5	6.5
Health	4	3	3	1	11
Education	4	3	3.5	1	11.5
Energy	3	2	3	0.5	8.5
Livelihood	4	1	1	0.5	6.5

options					
Loan/credits	4	3	1	2	10

Dubiya

Table 19: Scoring Against Various Government Schemes

Indicators	Schemes/Benefits	Subsidy	Technical support	Relief	Average score
Natural disaster	1	0	0	0	1
Drinking water	2	1	0	0	3
Sanitation	4	3	3	2	12
Irrigation	3	3	2	1	9
Agriculture	2	2	1	0	5
Roads	3	2	1	1	7
Health	2	2	2	1	7
Education	2	2	3	3	10
Energy	1	1	0	1	3
Livelihood options	1	1	0	0	2
Loan/credits	0	1	0	0	1

This exercise helped to identify the most critical social and natural systems in the VDCs that needed immediate attention to improve the resilience of the community.

Scenario Planning

Identifying critical physical and social systems helps to envision a range of scenarios and uncertainties in the future. The quadrant method was used to develop possible scenarios. The upper right quadrant shows a progressive future that will have sound social harmony while the lower left quadrant suggests that the VDC will be on the brink. The upper left quadrant suggests that the VDC will be tolerable to live in but will not always be healthy. As a result, people will need to work hard. The lower right quadrant presents a picture of the VDC with opportunities that are not captured (refer to Figure 20).

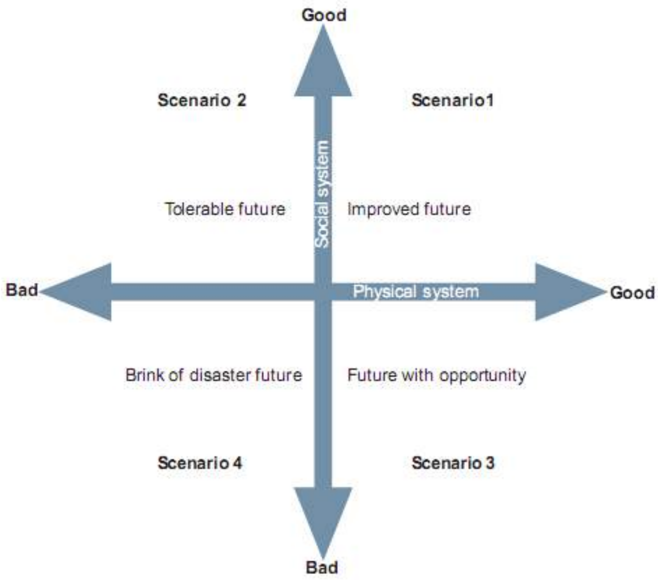


Figure 20: Uncertainty Analysis Quadrant

Madanpokhara

The information below captures Scenario Planning in Madanpokhara VDC.

When agriculture does not help

- Increase in poverty
- Change in occupation
- Foreign employment
- Suicidal tendencies increase among farmers
- No guarantee over seed source
- Cultivable land turns fallow
- Proliferation of "Michahajhaar"
- Conditions for migration emerge

Disaster

When both aspects are ideal

- Increase in income
- Improvement in education and health sector
- Livelihood augmentation along with social wellbeing
- Increase in job opportunities
- Decrease in floods, landslides and erosion
- Clean and healthy environment
- Decrease in migration to foreign countries
- Natural and ecological balance if sustained
- Establishment of a healthy society

Agriculture

When both aspects oppose each other

- Low production may result in famine and new diseases in crops
- Increase in the incidence of clashes, disputes and social insecurity
- Increase in use of the pesticides and insecticides in crops, loss in soil fertility
- Disappearance of locally useful seed varieties and dependence on hybrid seed
- Reduced economic activities, financial crisis and youth migration
- Increase in natural disasters as floods, landslides and damage to physical infrastructure
- Depletion of water sources, use of dirty water and chance of spreading communicable diseases

When nature does not help

- Reduced productivity (famine)
- Economic burden to farmers
- Frustration among farmers
- Search for alternative employment
- Energetic youth population migrating to foreign countries.

Dubiya

The information below captures Scenario Planning in Dubiya VDC.

Tolerable

- New ideas for entrepreneurship
- Search for wage-labour in other places
- Foreign employment attractive to youth
- Search for alternative food sources
- Drawn towards rearing cattle
- Exploring new non-traditional agricultural occupations for one's income (fishing, mushroom farming etc.)
- Food prices increase

Disaster

Progressive

- Increase in productivity
- Increase in self-employment
- Improvement in health sector
- Decrease in expenses
- Increase in job opportunities
- Decrease in foreign employment
- Improvement in quality of life

Livelihood

Subsistence

- Decease in production (legume and oil seed crops) reduced income due to pest and disease in agriculture
- Health impact and untimely death
- Youth migration
- Risk in social security
- Deterioration in quality of education
- Increase in new diseases and invasive species and food insecurity condition
- Continuous river bank cutting leads to a decrease in agriculture production

Unable to utilise the opportunity

- Declining productivity due to natural calamities
- Decrease in income
- Inability to capitalise on the sources of irrigation
- Increase in expenses
- Untimely death

Identification of adaptation options and the role of agents

The scenario of society on the brink was used as the basis for planning resilience and identifying options. The issues under the most critical scenario were analysed thoroughly. Participants of each VDC were presented with resilience options for Dubiya and Madanpokhara. The results of this exercise are summarised in Tables 20 and 21 respectively. The participants also explored linkages to other systems and the possible agents who would implement them in Tables 20 and 21 respectively. The participants suggested possible options for implementing resilience. They felt that improving the performance of existing agriculture systems would improve productivity and improve economic condition. Local people believe that the national political situation and migration of youth continue to undermine the creation of local opportunities in both VDCs. Participants from both VDCs recommended that the priority must be to enhance new technology in agriculture, better service from government sector, development of new entrepreneurs and management of drinking and irrigation water within the VDC.

Table 20: Resilience Strategies Madanpokhara

Issues	Future vulnerabilities		Resilience strategies	Relation with other systems
	Erratic precipitation	Increasing temperature		
Low production may result in famine and new diseases in crops	Increase in intense rainfall or no rainfall condition will affect production	Drought will increase and may cause high food insecurity	Forest and water source conservations, control of plotting in productive land, search for new food and technology, change in cropping pattern	Health, livelihood and security
Increase in the incidence of clashes, disputes and social insecurity	More disputes in future due to flood, damage of property and infrastructure	Increase in insecurity due to increasing drought	Proper implementation of law and policies, generation of self-employment activities	Local and government organisations
Increase in use of pesticide and insecticide in crops, loss in soil fertility	Too much water can sweep away fertile soil	Increasing temperature favours new diseases, increase in use of pesticides will reduce soil fertility	Use of compost fertiliser in farm, promotion of organic pesticides and use of Integrated Pest Management (IPM) technology	Agriculture, irrigation, Health, Government office, NGOs
Disappearance of local seed varieties and dependency on hybrid seeds	Too much and too little water will be reason for decrease in production and extinction of local seed varieties	In severe drought condition farmers will use hybrid seed and chemical fertilisers	Develop drought and flood tolerant local improved seed varieties, nursery management in VDC	Health, local organisation
Reduced economic activities, financial crisis and youth migration	Increase in migration rates due to lower production and economic activities	High temperature is not favourable to younger people in the VDC and thus increase in migration rate	Maintain balanced peripheral ecosystems, and conduct income generation and self-employment activities	Financial Institutions
Increase in natural disasters as flood, landslide and damage of physical infrastructure	Erratic precipitation will increase disaster	More drought condition and rise of new diseases will have negative impact on health	Plantation and soil conservation, control of landslide, management of drainage, construction of gabion and retaining walls	Agriculture, forest
Depletion of water sources, use of dirty water and chances of spreading communicable disease	Rise in spread of communicable diseases because of increase in flood	Rise of new diseases that affect humans, livestock and agriculture, extinction of livestock and birds	Better management of drinking water, use of medicine to purify drinking water, and initiation for conservation of biodiversity	Health, water, agriculture, forest

Table 21: Resilience Strategies Dubiya, Kapilbastu

Issues	Future vulnerabilities		Resilience strategies	Relation with other systems
	Erratic precipitation	Increasing temperature		
Decrease in production (legume and oil seed crops) less income due to pest and disease in agriculture	Windstorm and rainfall cause harm to crops, will decrease production	Loss of crop and decrease in production, infestation with new crop diseases	Construction of ponds, installation of tube wells and conservation of the forest	Agriculture, irrigation
Health impacts and untimely death	Increased chance mortality due to erratic precipitation	Transfers of diseases through air and heat waves	Focus on maintaining clean and healthy environment; building a health institution in each ward of VDC	Health, water
Youth migration	Increasing disaster events will result in famine that will urge the youth to migrate	Dry conditions are one of the reasons for low production that will force the younger generation to migrate	Increase in employment programme and commercial farming such as fruit, non-seasonal vegetable farming and livestock farming	Agriculture, industry and relation with entrepreneurs, Government agencies, NGOs
Risk in social security	Greater security risk due to frequent flood event	Lower security due to increasing drought	Formation of social security team in the community and undertaking patrolling in the evenings	Financial institution
Deterioration in quality of education	Difficult in having access to quality education due to flood, landslide, and damage to roads and bridges	Students will suffer from new diseases and this will increase the frequency of absence in schools	Conduct plantation programmes in schools and improve sanitation	Health and economic condition
Increase in new diseases and invasive species and food insecurity	New diseases will spread in rainy season because of more frequent flood	High chances of spreading disease through air. Increase in temperature will favour growth of invasive species	More awareness programmes on sanitation and health, organizing free health check-up camps	Soil condition government agencies, NGOs
Continuous river bank cutting leads to a decrease in land and agricultural production	Continuous rainfall will increase the incidence of river bank cutting	Continuous heat can cause arable agriculture land to become more dry	Conduction of plantation programmes in open land in coordination with district forest office, construction of gabion walls	Water, soil condition

Agents

The options thus identified can strengthen local resilience and also enhance development. The list of options may assist in building capacity of the community to respond to the likely impacts of climate change. The possible agents at local, regional and national level, who could help in undertaking the options, were identified followed by the contributions of the organisations at each level (refer to Table 22).

Table 22: Agents in Madanpokhara

Resilience Strategy	Presence of Agents			What type of help			Selection
	Local	Regional	National	Local	Regional	National	
Forest conservation, plantation, control of plotting in productive land, search of new food varieties	Local user committee	DFO, Regional Forest Directorate (RFD)	Department of Forest (DOF), NGO/INGO	Plantation of tress	To make plant available to VDC	Technical and financial support	Local user groups
Proper implementation of law and policies	VDC	DDC	MOFALD	Implement law and policies at local level	Mentoring and evaluation	Revise the land use polices	MOFALD
Adoption of commercial livestock farming activities and increase in awareness, Use of IPM technology, search of new food and technology, change in cropping pattern	VDC and local user groups	DDC, DLSO, DADO	Department of Agriculture (DOA), NGO/INGO, MOFALD, MOAD, Nepal Agriculture Research Council (NARC)	Training, awareness campaign for organic farming	Training and technical support	Financial support	VDC, DADO MOAD
Development of drought and flood tolerant verities and increase in production	Local cooperative and use groups		MOAD	Formation of cooperatives and mother groups	Financial and technical	Revision in current policy	DADO, DLSO
Conduction of income generation and self-employment activities, running of small industries	User groups and VDC, local cooperative	DDC, DCSSIO	MOFALD, MOI, NGO/INGO	Training	Financial and technical support	Financial and technical support	DDC, MOFALD
Soil conservation, landslide control with gabion and retaining wall construction, drainage management, avoid use of bull dozer in construction of roads	User groups, VDC	DDC, DADO, DIRO, DSCO, Divisional Water Induced Disaster Prevention Office(DWIDPO)	DOA, Department of Water Induced Disaster Prevention (DWIDP)	Adoption of organic farming	Financial and technical support	Financial and technical support	VDC, DDC
Management for better drinking water supply and use of medicine to purify drinking water	VDC, sub-health post	DDC, Zone hospital, District Public Health Office (DPHO)	Department of Water Supply and Sewerage (DOWSS), MOHP	Awareness, technical support	Financial and technical support	Financial support	Sub-heath post, DPHO

2. Top-down Approach

Indian Institute of Science

Water supply and demand modelling for Thanjavur district in Tamil Nadu, India, and a micro-catchment in western Nepal

In this study the aim was to better understand water supply and demand in two study areas (western Nepal and the Cauvery delta in India) by assessing the following:

1. Current water supply and demand scenario at a micro-catchment scale in western Nepal and at district scale in Thanjavur district of Cauvery delta, and extend this REFERENCE scenario over the period 2010 to 2035.
2. Impact of repeated monsoon failure (droughts) scenario on water supply and demand balance in the Cauvery delta from 2010 to2035.
3. Impact of projected climate change on water supply and demand balance at a micro-catchment scale in western Nepal from 2010 to2035.
4. Impact of demand side interventions such as 'crop-switching' and proliferation of 'SRI practice' on water supply and demand balance for the Thanjavur district in the Cauvery delta from 2010 to 2035.

Study Area

Two villages (Dubiya and Madanpokhara) in western Nepal were selected for field-work and out of these Madanpokhara and its larger micro-catchment was selected for detailed water supply and demand modelling (Figure 21).

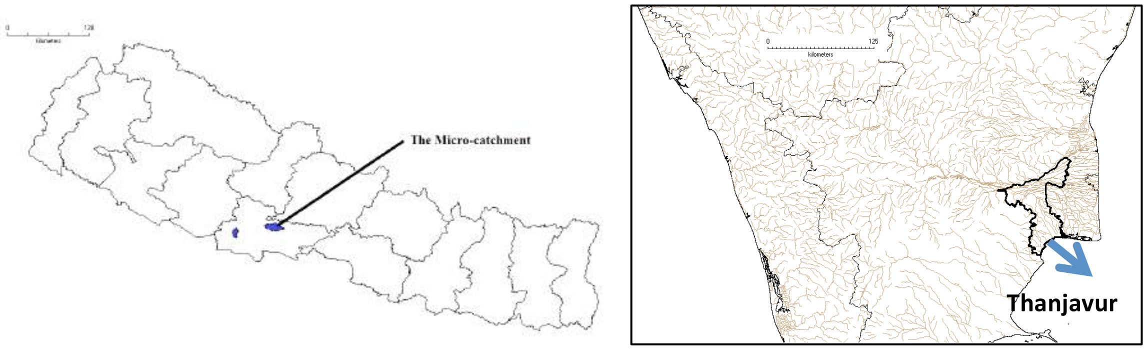


Figure 21: Study area a) Madanpokhara micro-catchment in western Nepal, and b) Thanjavur district in Cauvery Delta

In the Cauvery delta, in the absence of a relevant micro-catchment boundary, water supply and demand dynamics are modelled for the Thanjavur district, which lies between Grand Anaicut and Lower Anaicut reservoirs on the Cauvery/Coleroon river (Figure 21).

WEAP Results for Thanjavur District

We investigated the impact of multiple monsoon failures (drought years) over the water supply and demand dynamics of the Thanjavur district. We also investigated if adaptation strategies such as 'crop-switching' and the 'SRI method of rice cultivation' could mitigate adverse impacts of the drought.

Thanjavur district is generally, richly endowed with water resources as much of the upstream areas of the Cauvery catchment receive rain during the South West monsoon, and the district itself receives a bulk of its rainfall during the North East monsoon season. Hence, barring the months from January to June it receives plenty of water throughout the year.

According to our estimates currently the district requires about 3.5 billion m^3 of water supply per annum, which will increase by about 15% over the period from 2010 to 2035, due to increasing water intensity of agriculture and increasing water demand from increasing population and industries. However, as more and more rice area (transplanted rice cultivation) is brought under the SRI method (System of Rice Intensification) of cultivation (Refer to the Annex for details) annual water demand decreases. Crop-switching provides additional water saving benefits.

In terms of water shortages in the district, the months from February to May face water scarcity even under the reference scenario, however under the drought scenarios the scarcity extends to other months of the year as well. Our modelling based investigation suggests that SRI and crop-switching scenarios effectively mitigate this scarcity (Figure 22).

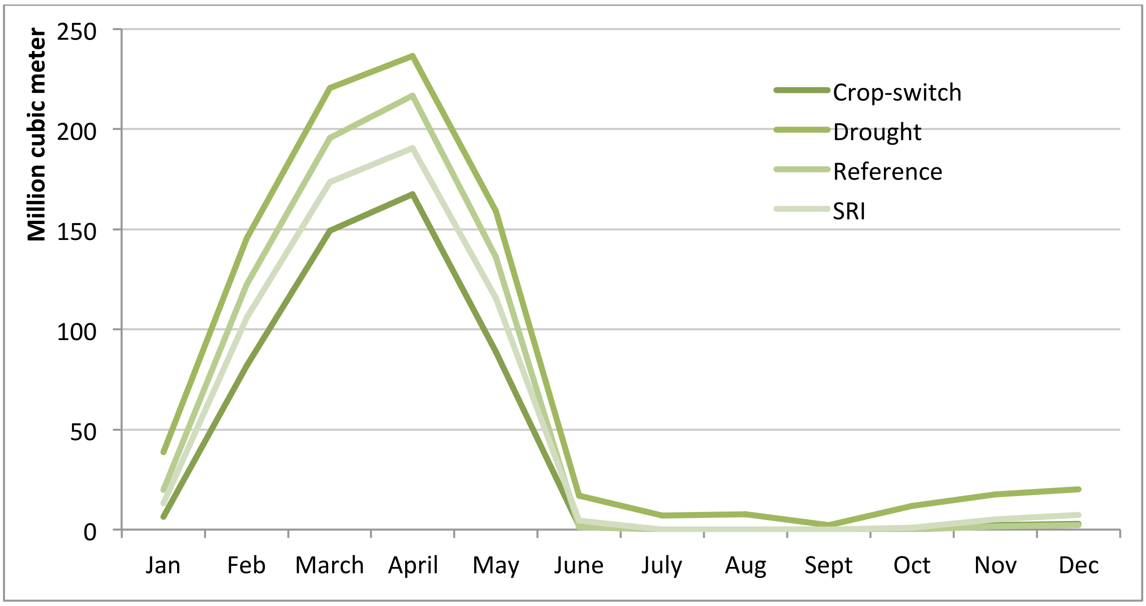


Figure 22: Monthly Average Supply Demand Imbalance or Unmet Demand in Thanjavur District

Figure 23 shows that the supply-demand imbalance rises steadily under the reference scenario, and increases abruptly in the drought years. However, under the 'SRI' and 'crop-switch scenarios' the supply-demand imbalance decreases steadily, so much so, that even in the drought years towards the 2030s, the unmet water demand under these two scenarios will remain less than that of the reference scenario. Thus, a combination of these two strategies has the potential to completely mitigate the adverse impacts of a drought year.

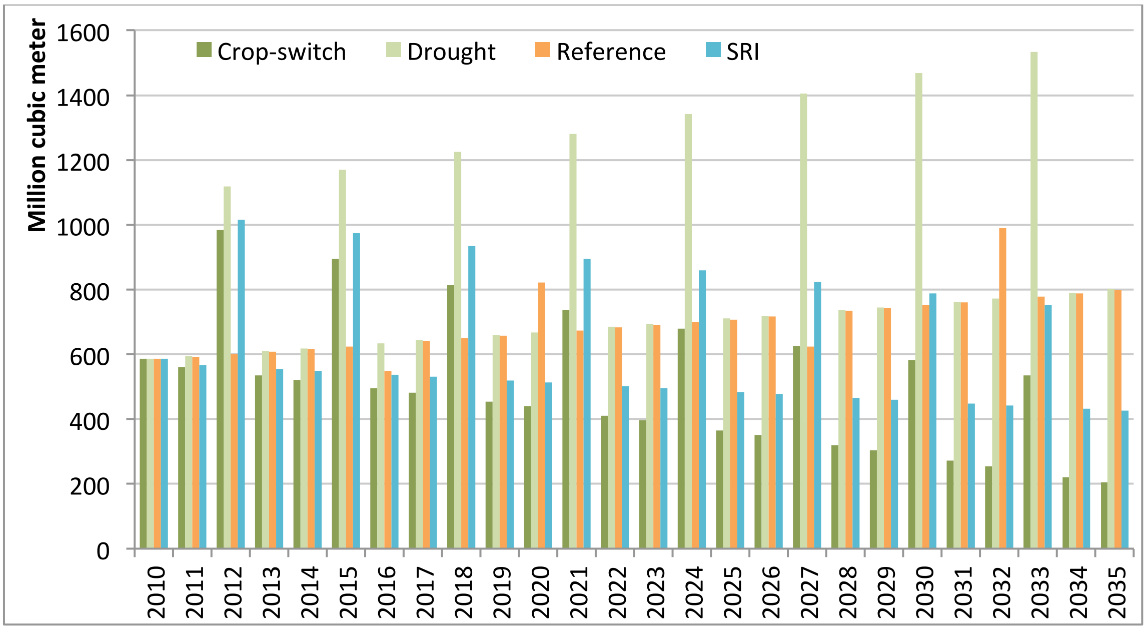


Figure 23: Annual Supply Demand Imbalance or Unmet Demand in Thanjavur District

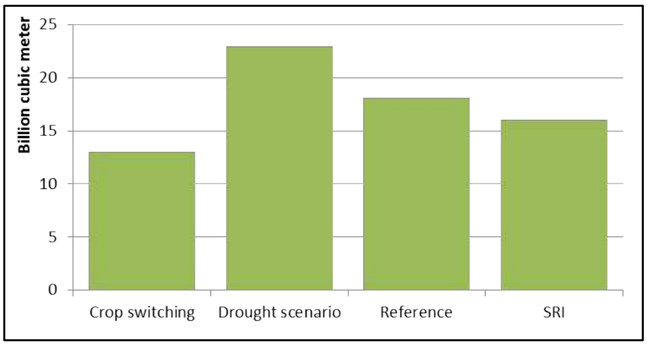


Figure 24: Unmet Water Demand (over 2010-2035) under Different Scenarios

Figure 24 shows that on a long-term basis 'crop-switch' and 'SRI' scenarios face lower water shortages than the reference scenario. This is a remarkable finding given the fact that both the scenarios: crop-switch and SRI face multiple drought years (over the period of investigation) whereas Reference scenario enjoys normal years all throughout.

WEAP Results for Western Nepal

Madanpokhara micro-catchment in western Nepal is modelled to investigate the impact of climate change on the supply and demand balance of water for this micro-catchment from 2010 to 2035. Climate change scenario is created based on coordinated regional downscaling experiment's output from the Rossby Centre and the Swedish Meteorological and Hydrological Institute's (SMHI) regionally downscaled model for the South Asia region.

[this can be found at http://cccr.tropmet.res.in/cordex/files/downloads.jsp]. For more details on the climate data and its processing, model parameterisation, model validation, assumptions, and methodology, please refer to Annexures from this study. Figure 25 presents some of the key results from this analysis.

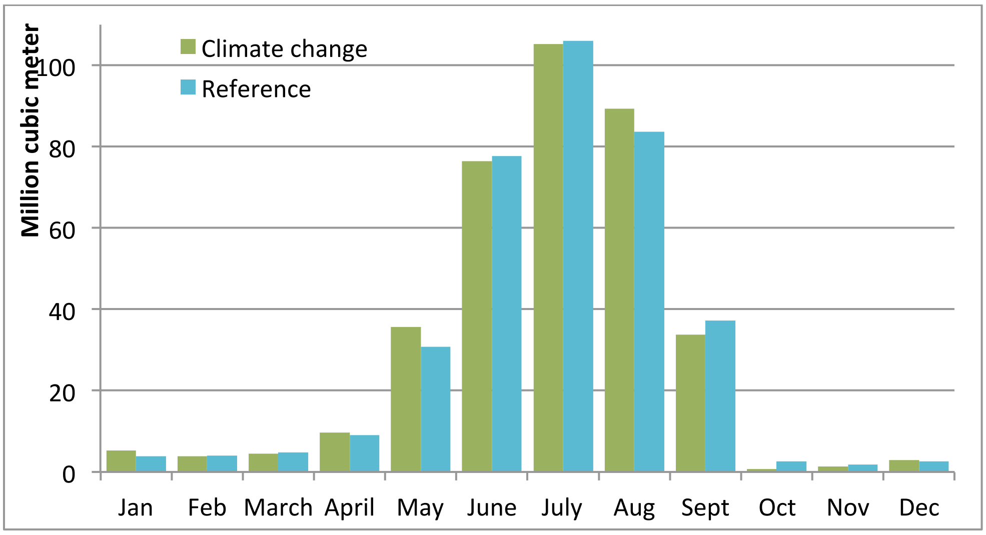


Figure 25: Monthly Average Water Supply (Surface and Groundwater) to Madanpokhara Catchment under the Reference and Climate Change Scenarios (2010-2035)

The catchment receives much of its water supply during the South West monsoon season. Under the climate change scenario a slightly larger quantity of rainfall is received during the monsoon season, but post-monsoon rainfall decreases slightly leading to reduction in water supply during these months.

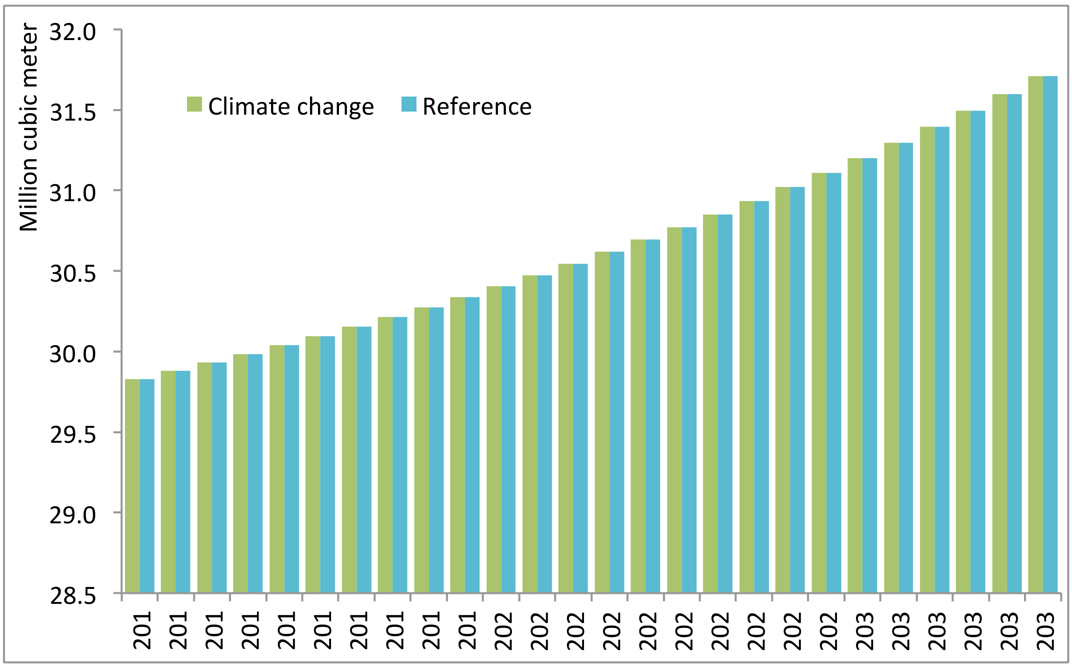


Figure 26: Water Demand in Madanpokhara Catchment under the Reference and Climate Change Scenarios

Water demand in the catchment increases mainly in response to population growth.

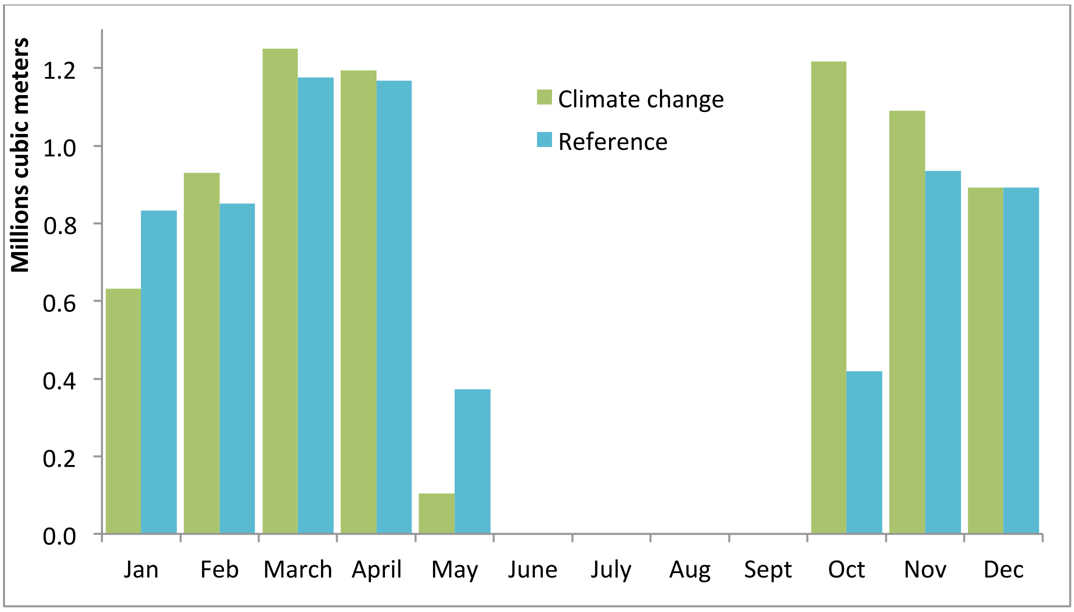


Figure 27: Supply Demand Imbalance or Unmet Demand

Generally the months from February to May face water scarcity in this catchment; however under the climate change scenario the water scarcity is projected to increase during the post-monsoon months (refer to Figure 27).

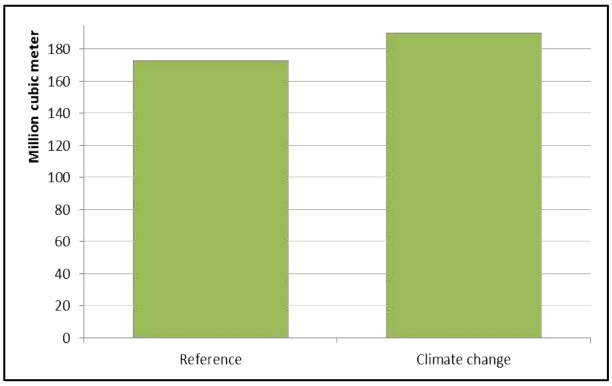


Figure 28: Unmet Water Demand over Long-term (2010-2035)

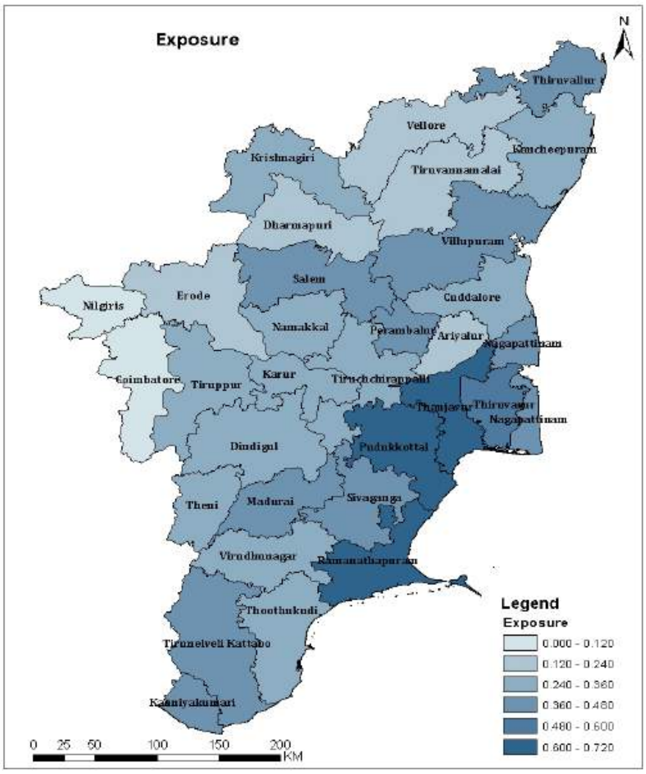
Climate data analysis for this catchment suggests that under the RCP4.5 scenario this particular catchment experiences an average annual temperature rise of 0.74°C (over 1980-2009 to 2006-2035), and the rainfall increases slightly (about 1%). In spite of a slight increase in the rainfall, over the long-term the catchment faces increased water scarcity under the climate change scenario due to increased temperatures and also due to the fact that the rainfall increases during the rainy season and actually decreases during the crucial post-monsoon months (refer to Figure 28). Apart from increasing water scarcity, climate change scenario could also lead to more flash floods and landslides in this mountainous system during the rainy season.

CSTEP

Using Secondary Information to Develop a Vulnerability Profile for Tamil Nadu

The vulnerability assessment was carried out for all districts of Tamil Nadu. The analysis for each of the components is given below:

Exposure: The exposure component comprises of the demographic and the climate profile. The climate profile indicates the climate variability in the region while the demographic profile provides a picture of development in an area. Exposure reflects the magnitude of change due to climate in combination with development factors such as poverty and decadal growth rate. The normalised exposure values for Tamil Nadu indicate that the coastal districts are far more exposed to the effects of climate change in comparison with inland districts. Districts such as Thanjavur, Pudukottai and Ramanathapuram are highly exposed. Please see Figure 29 in which the darker shading shows districts with higher exposure values.



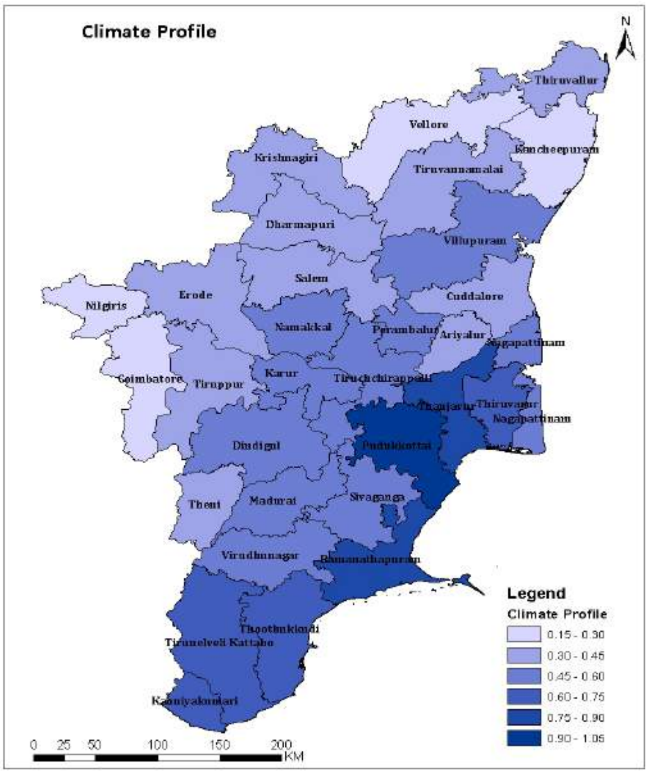


Figure 29: Climate Profile and Exposure Levels for Tamil Nadu Districts

The climate profile map also indicates that the coastal districts, especially Thanjavur, Pudukottai and Ramanathapuram are more exposed in terms of climate variability. Sixty percent of the districts in Tamil Nadu have experienced close to 0.8 degree rise in temperature, while the coastal districts have experienced a higher rise in temperature. The coastal districts also have high storm surge heights. Thiruvarur, Vilipuram, Cuddalore and Ramanathapuram have elevated values for demographic profile. The inland districts such as Salem, Krishnagiri, and Perambalur have higher exposure values for the demographic profile, which serves as a driver for higher exposure values when compared to other districts. For instance, Perambalur has the highest poverty level and combined with its high decadal growth rate and climate variability, it ranks as a high exposure district when compared with others. Districts that are less exposed to climate change are Coimbatore, the Nilgiris, Vellore, and Kancheepuram. Higher sex ratio, relatively lower poverty rate and decadal growth are factors that reduce values for exposure in these districts in comparison to other districts of Tamil Nadu. However, this does not necessarily imply that these districts have a lower vulnerability to climate change, since the study is examining relative levels across all districts of the state.

Sensitivity: Sensitivity is the degree to which a system is affected due to climate change. In this study, the sensitivity component examines agriculture and water profile – sensitivity of natural resources to climate change. Figure 30 shows that more than half the districts are sensitive to the impacts of climate change. The coastal districts, especially Vilipuram, Thiruvarur, Thanjavur and Nagapattinam are more sensitive to the effects of climate change compared to the others. This is due to the low availability of groundwater compared to other districts combined with a greater dependence on agriculture. Darker shades indicate districts with higher values for sensitivity.

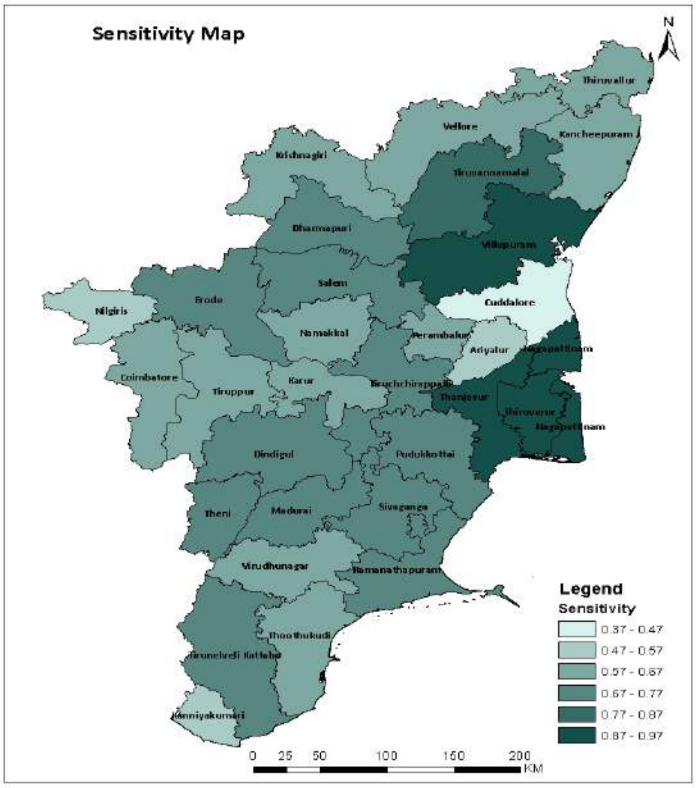


Figure 30: Sensitivity Values for Tamil Nadu Districts

The least sensitive district appears to be Cuddalore, but we consider this to be an anomaly. Even though the groundwater availability in Cuddalore is the highest compared to the entire district, we think that this is from salt-water intrusion since much of the district's water is reported to be saline. Districts such as the Nilgiris, Coimbatore, and Tiruppur appear to have a relatively lower sensitivity to climate change. Factors such as rainfed agriculture and forest cover have not been considered for sensitivity in this study. Inclusion of these indicators would have provided a more detailed and perhaps a more nuanced study.

Figure 31 shows the agricultural profile of the state. The indicators for the agricultural profile are gross area irrigated, area under water intensive crops and share of agricultural workforce. Dependence on agriculture for the following districts is very high -Vilipuram, Thanjavur, Thiruvarur. Close to half the workforce depends on agriculture in Thanjavur and Nagapattinam. The darker shade represents districts that have higher values of sensitivity in the agricultural profile.

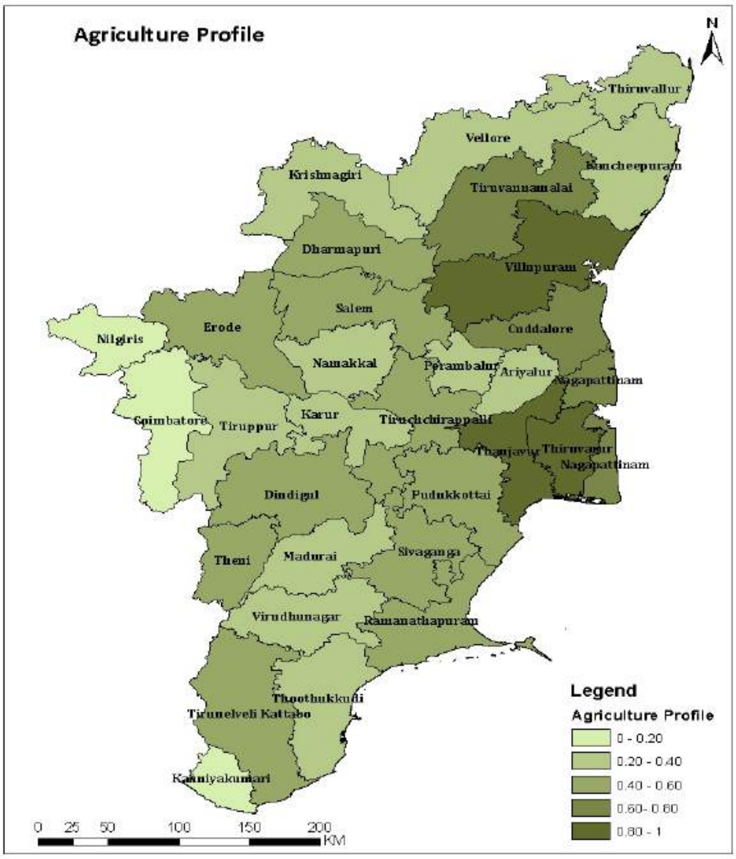


Figure 31: Agriculture Profile of Tamil Nadu

Adaptive capacity: Adaptive capacity is the ability to recover or adjust to change. In the context of climate change, it refers to the ability to adjust to the effects of global warming. In this study the indicators chosen for adaptive capacity are a combination of specific and generic adaptive capability factors. Specific indicators for adaptive capacity to climate change include variables that indicate the access to information, finance, infrastructure development and skill sets. For instance, health, accessibility, banking and credit facilities, the number of mobile phones indicates infrastructural development and access to information. The rationale for these indicators is provided in the methodology section. Generic indicators include socio-economic and development indicators. Access to basic amenities such as sanitation, drinking water and electricity indicates access to basic services for a given population. Literacy rates and female workforce participation indicate the extent of socioeconomic development in the region (see the methodology section for further discussion on these). The combination of all these indicators represents the adaptive capacity of the region. The coastal districts towards the southeast of Tamil Nadu and the northern districts have low adaptive capacities relative to other districts. Low infrastructure development, poor access to basic amenities and financial resources are seen to be the main drivers for a low adaptive capacity. Districts with low adaptive capacity are represented with darker shading in Figure 32.

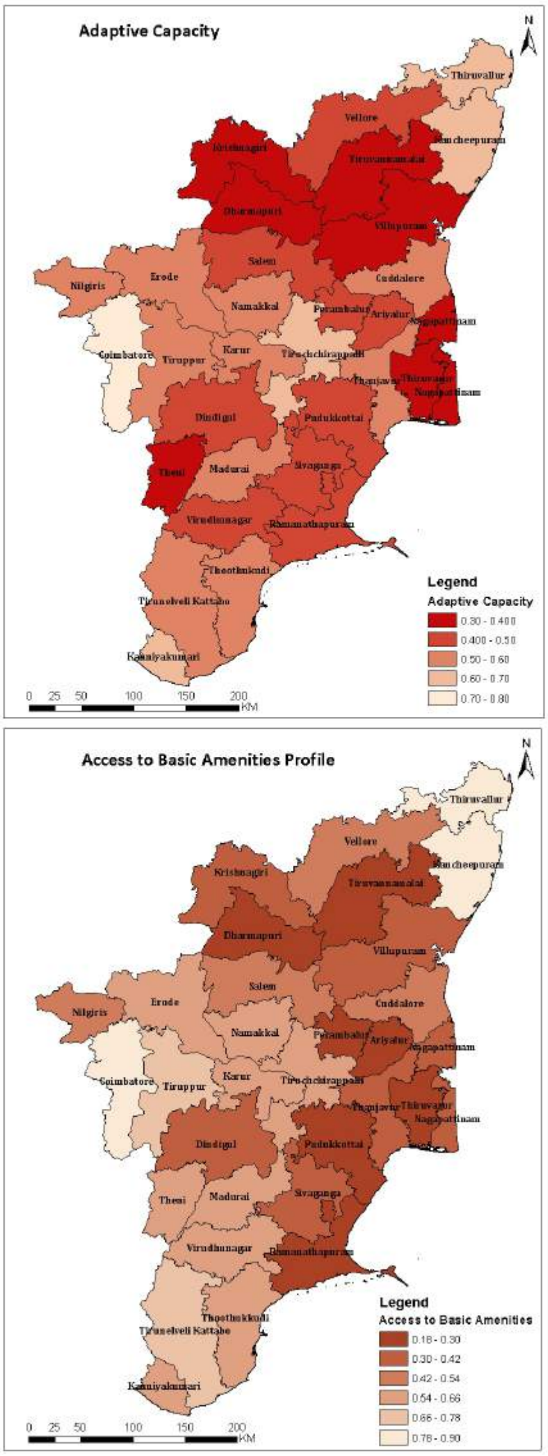


Figure 32: Adaptive Capacity and Access to Basic Amenities

Inland districts - Dharmapuri, Thiruvannamalai, Krishnagiri and coastal districts – Pudukottai, Thiruvarur, and Ramanathapuram have poor access to basic amenities, which affects the adaptive capacity of the districts when compared with other districts. Dharmapuri, Vilipuram, and Krishnagiri rank low compared to other districts in infrastructure development such as road network, health facilities and minor irrigation schemes. Thanjavur, Namakkal, Erode and Coimbatore have better infrastructure development than the other districts. A darker shade in Figure 33 indicates lower values for infrastructure profile, which implies a lower adaptive capacity

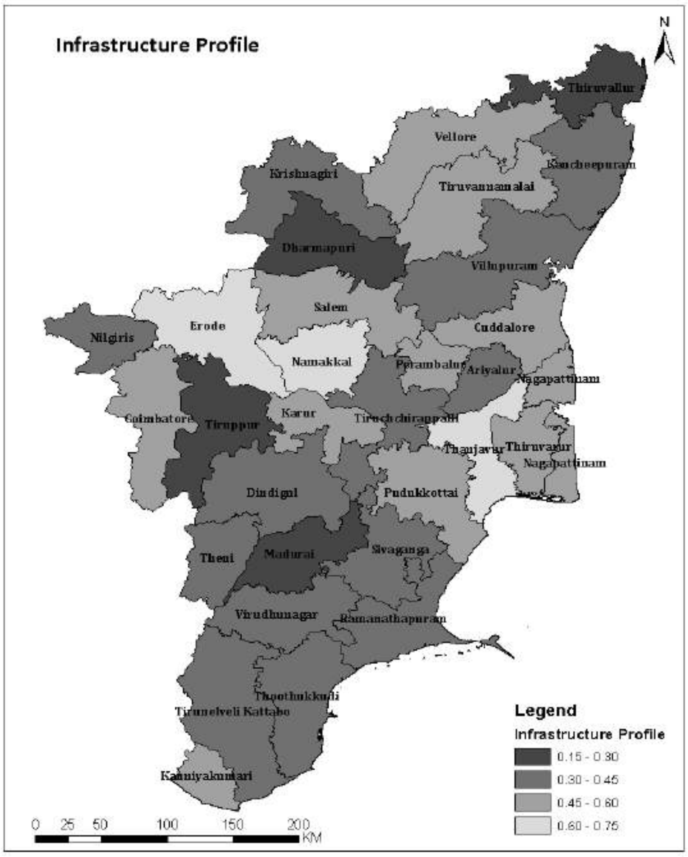


Figure 33: Infrastructure Profile for Tamil Nadu

The literacy rate values are low for districts such as Dharmapuri, Krishnagiri, Salem and Vilipuram. Figure 34 shows the normalised value for literacy among the districts. The values range from 0 to 1 indicating low to high literacy rates among the districts. The districts coloured blue have the lowest literacy rates relative to other districts.

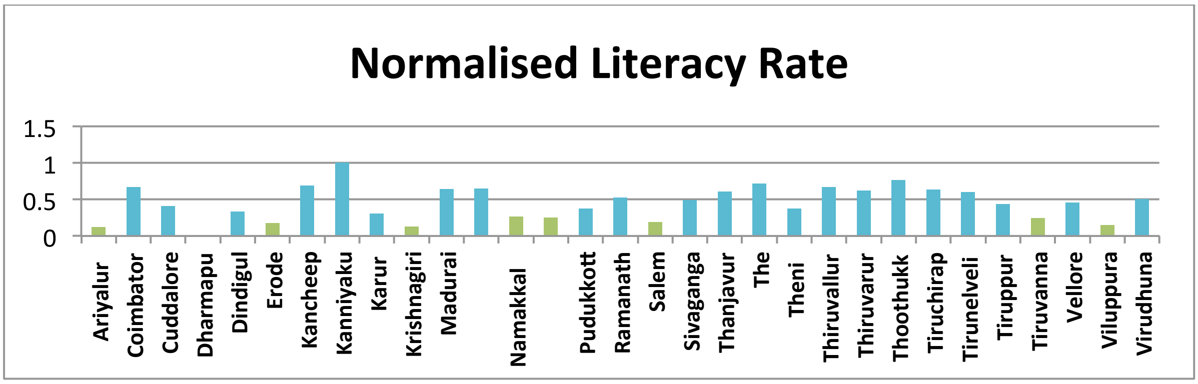


Figure 34: Normalised Literacy Rate

Vulnerability Index: The vulnerability index is calculated as a combination of exposure, sensitivity and adaptive capacity. The index value ranges from -1 to +1 indicating low to high vulnerability. Highly vulnerable districts are shown with darker shading in Figure 35.

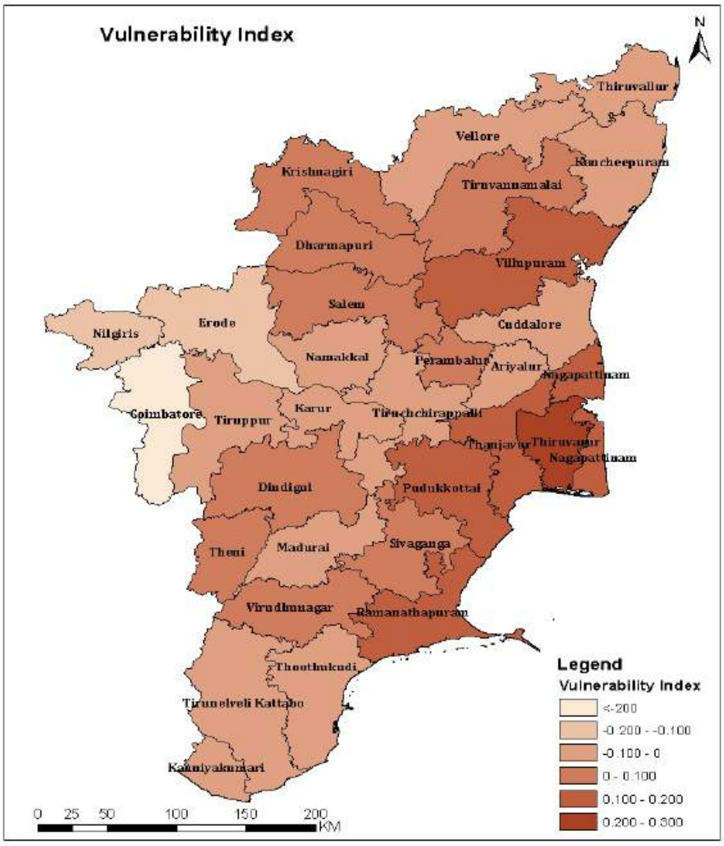


Figure 35: Vulnerability Index for Tamil Nadu

The Northern and Southeastern districts of Tamil Nadu have the highest vulnerability rankings when compared to the rest of the state. The northern Tamil Nadu districts such as Dharmapuri, Vilipuram and Krishnagiri are ranked high in the index due to low adaptive capacity. While the coastal districts have high exposure component combined with low adaptive capacity values. Coastal districts such as Ramanathapuram, Pudukottai, Thiruvarur and Thanjavur have high exposure in the climate profile. High storm surge heights serve as the main driver for the elevated values of exposure for these districts. All the districts have experienced close to a 1-degree rise in maximum temperature and almost all of them have experienced an increase in precipitation during monsoons. Table 23 lists the most vulnerable and least vulnerable districts and the main drivers of vulnerability from our limited study:

Table 23: Vulnerable Districts and Drivers of Vulnerability

Districts with high vulnerability	**Districts with lower vulnerability**
Ramanathapuram, Thiruvarur, Vilipuram, Krishnagiri, Nagapattinam, Pudukottai, Thanjavur and Tiruvannamalai	*Tiruchirapalli, Coimbatore, Erode, Vellore*
~ 1 degree rise in maximum temperature. Coastal districts have a higher rise in temperature than inland districts. High storm surge height for the coastal districts	~ 1 degree rise in temperature
Agriculture dependence is high, but the number of minor irrigation schemes is less compared to other districts	Dependence on agriculture is low
High poverty rates combined with higher decadal growth rates, low sex ratio, poor access to basic amenities financial resources	Low poverty rates, low decadal growth rate, good sanitation condition, low dependence on biomass for cooking, higher number of concrete houses, better availability of financial resources

D. Lessons Learned and Discussion

1. PAC

The study by PAC highlighted issues related to different forms of livelihood capital. It appears that Natural Capital does not influence the pattern and the intensity of agriculture followed in the Thanjavur villages that PAC studied. It is a matter of concern that agricultural livelihoods are heavily dependent on groundwater, which is becoming a depleting resource. Second, the influence the Governance Systems have on agricultural livelihoods is a matter of concern, as governance needs to play an important role in the lives and livelihoods of the people with regard to subsidies, policies, schemes and programmes. Even though the delta has a unique and an ancient system of canals, the water does not reach many of the villages, as the canals are almost defunct. This is due to encroachment, siltation and clogging from waste and the rampant mining of sand. Furthermore, erratic rainfall and increases in temperature have left the agricultural communities vulnerable to the changing climate.

During the roundtable, we learned that there is scope for building a think tank involving various stakeholders to integrate the concerns of vulnerable communities through knowledge building and an action platform to inform and educate policy makers at various levels. Integrating the concerns of communities in an organic fashion through 'Community Centred Governance' is the best way to address many of the issues of climate change. We believe that local communities have a vast repository of knowledge and practical solutions, but what is required is an instrument that allows them to consolidate their knowledge, connect it with the large number of regulations and laws that apply to their lives, and empower them to engage with the governance structure in a constructive and result-oriented manner.

The overall learning of Public Affairs Centre is on how to go about generating systematic data and knowledge for developing a framework for assessing climate adaptation and resilience in river deltas focussing on agricultural livelihoods. In this project, PAC refined the CCSC tool by applying and adding additional dimension (Vulnerability Index and Scenario Planning) to make it more comprehensive. Capacity development of the Public Affairs Centre team has taken place through participation in the field exercises, scenario planning and shared learning dialogue methods with the support of ISET. The team has modified and incorporated this in the CCSC process.

Through the study we interacted with experienced farmers and their groups and learned that traditional paddy varieties were found to be resilient to drought and floods in the delta region. We also learned about the benefits of traditional crop varieties and organic farming to both the environment and the sustainability of the livelihoods.

The study had a number of limitations. PAC used the most vulnerable capital to plan the scenario for the villages to move to a 'good – good' scenario. All the livelihood capitals are to be considered for the overall development of the village. Community representatives tend to work with political parties and this hampered the study. The social structures in few villages also hampered our work, as two of the communities did not want to sit on the same platform. Due to constraints of time and resources the pilot study had to identify the most vulnerable livelihood capital based on the vulnerability index. Only current, not future, vulnerability is assessed in the study.

2. ISET

The study in Nepal revealed that climate vulnerability varies widely across the country and its impacts are primarily experienced locally. Thus, local responses and solutions will also be required as part of adaptation planning. The study generated a number of lessons.

The Climate Resilient Framework provides a holistic perspective to assess impact and vulnerability and provides an opportunity for iteration, which is the basis of assessing vulnerability within the policy-making domain. It can therefore serve as a useful tool to support decision-making. The approaches to vulnerability assessment described in this study are multidisciplinary, considering both a hazard-based and a social perspective.

It is essential to consider the changing social values and aspirations, which are crucial for vulnerability assessment and adaptation planning. These factors will be important determinants in designing strategies for building resilience and adaptive capacity because the role of agents and institutions is changing as their responsiveness, resourcefulness and capacity to learn increase.

The study showed that in Madanpokhara District the most vulnerable wards are 1 and 3, and the least vulnerable ward is 6. Similarly in Dubiya, the most vulnerable ward is 1 and the least vulnerable wards are 8 and 9. Although the nature of selection of indicators to assess vulnerabilities were different, this results aligns with the research output of ISET-Nepal's previous study on Cross-scale implications of forest and water management for adaptation.

3. CSTEP

This study attempts to construct a vulnerability profile by focusing on indicators, developed mostly by using secondary information collected by the government and others, that measure exposure, sensitivity and adaptive capacity to climate change. It involves a macro level profile for the entire state of Tamil Nadu. The assessment provides a gateway for further detailed analysis of vulnerability in the region. As the assessment has been based on secondary data it could be complemented with community-level studies in a few areas, hot spots in the state.

Vulnerability varies across different areas in the state, across districts and communities. We find that the least vulnerable districts are those with good infrastructure and demographic profiles and development, while the most vulnerable districts exhibit poor infrastructure development and high poverty combined with high growth rate of population. A major proportion of vulnerability and its components depend on the location of an area or district.

India has about 300 million people living in poverty, roughly the size of the United States. The challenges they face are poor access to energy services, little or no education, marginal livelihoods heavily dependent on ecosystems, and poor sanitation, health and drinking water. Added to this is the heavy cultural and social burden of India being a deeply segregated society across caste and class lines. Dalits, tribals, the very poor and women and children usually suffer the most in most communities across the country. If climate change impacts are layered on top of this existing burdensome situation, the most vulnerable will be even more vulnerable to the effects of warming.

The results that found in Tamil Nadu seem to strengthen this understanding. The highly vulnerable districts have poor socioeconomic conditions, higher poverty and poor infrastructure, but the effect of storm surges along the coast due to climate change is expected to be quite severe, making coastal districts vulnerable as well. Multiple scales of vulnerability tend to exist in actuality and these need to be recognised and understood. The climate vulnerability community is only now beginning to recognise social vulnerabilities including poverty, development and stratification. We find, in fact, that unequal development policies and institutions, politics (meaning power relations and access to resources) and existing patterns of segregation are increasing vulnerability. We need studies that layer climate change vulnerability over already existing forms of endogenous and exogenous vulnerability. Understanding social stratification and development indicators in relation to vulnerability is therefore a critical knowledge gap.

The conference on climate change vulnerability assessments and adaptation highlighted the fact that this field is very much a dynamic one, where conversations on how to measure, what to measure and what is meaningful are still being hotly debated. We would add that there is however enough information available for policy makers at all levels to begin incorporating our understanding of climate change effects and vulnerability into policies. Improve education, health, and literacy, empower women, provide jobs and improve food security. All these would contribute to improving climate resilience.

4. Limitations and Directions for Future Research

There were several limitations in the implementation of this project. The duration of the project was quite short (7 months) and therefore the iterative learning process that such research entails was cut short, as there was not enough time for the research and interaction with others that could have been carried out.

Two of the consortium partners studied local communities and were better able to collaborate and learn from each other. CSTEP and IISc adopted a top-down approach and worked closely together.

One of CSTEP's objectives was to apply DARPAN, a decision support tool developed in-house, in such a project. It was not possible to accomplish this exactly as envisaged since our consortium partners needed the full duration of the project time to complete their field-work and analysis; thus DARPAN work could not begin until the last month of the project.

CSTEP used the time to learn about the role and limitations of using secondary information in such research and the importance of using knowledge gained from the field of development in climate vulnerability analysis.

Another objective for CSTEP was to coordinate the project, but the coordinator was identified only after the project began and thus a plan for drawing up and strictly following rules of coordination was not specifically developed and agreed upon by consortium members.

The research however, brought the team closer to the larger community of civil society groups and researchers who work on vulnerability and adaptation, bringing new ideas and potential partners for collaborative future research. CSTEP has also learned how it could use DARPAN in future research to visualise the layering and integration of information from several areas of knowledge (development, poverty studies, environment and climate) to understand their combined effects on a community when thinking of how climate change would impact them.

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F. Annexures

Annex 1: Trend Analysis and Historical Timelines in Nepal

Trend analysis and historical timeline exercises were conducted to highlight trends and key points in the history of the community that households considered had an impact on their livelihoods –either climatic or non-climatic that might either be positive or negative. This tool is used to gain an insight into past climatic hazards and identify trends (frequency) in their nature, intensity and impacts. A trend analysis and timeline is a chronological listing of key events in the community's history over a period of time. It is visually powerful, offers the opportunity for a large group of people to participate, and introduces fundamental concepts of hazard, impact, change, coping, and institutional support.

In Madanpokaharaand Dubiya VDCs the participants were divided into different groups for in depth discussion. Group discussions of the timeline provided an opportunity to ask the elders about past climatic and non-climatic scenarios and their traditional responses to them. The exercise revealed the following:

Madanpokahara

Hailstone: In November 1997, hailstone fell as a result, paddy, mustard and vegetables were severely destroyed. In November 1998, hailstones fell again but there was no destruction at Madanpokhara VDC.

Epidemic of diseases: An epidemic of Sindhure diseases spread in 1959 at Madanpokhara VDC, which caused zero production of paddy and maize crops. Apparent impact of this epidemic was the non-use of seeds for local paddy; instead, Madhesi-verity of paddy was used. Approximately nine million rupees in Maadi and one million rupees in Madanpokhara were lost due to the incident.

Outbreak of insects: In 1961, a group insect named Salaha appeared suddenly in Madanpokhara VDC that destroyed all the crops especially maize. It led to an estimated loss of around 4-5 million rupees. As a result, scarcity of grain seeds occurred and there was famine in the village.

Flood and landslide: The floods in 1933 affected Ward no. 7 (in Arkhale of Madiphaant) and eroded more than three hectares of cultivated land. The paddy fields, which were ready for harvesting were destroyed. In the same year, a hill at Gabde Chaur, Ward no. 1 was swept away destroying paddy crops in Madi valley. On September 29, 1981 due to heavy rainfall and flood there was soil erosion and inundation in Ward no. 6 and 7. In 1970, a person was buried under a collapsed house in Ward no. 9 due to flash flood and landslide, while 2 persons were rescued.

Huge earthquake: A huge earthquake occurred on January 15th, 1876 in Madanpokhara VDC, and as a result the Mandavhrishi temple collapsed and a number of houses collapsed.

Fire Rampage: In 1990, an incident of caught fire was occurred in the community forest in Shikhardanda in Ward no. 5, Due to efforts of community people, no casualties occurred.

From this exercise, it was learned that flash flood and landslides have been occurring frequently in Madanpokhara VDC. However locals say the frequency has reduced due to forest conservation.

Dubiya

Flood: The inhabitants of VDC experienced three huge floods in 1961, 1985 and 2012, which affected the whole of VDC. Huge amounts of assets were damaged.

Malaria disease: VDC suffered from malaria spreading from 1949 to 1951. There was another outbreak in 1986 and as a result, the inhabitants of Ward no. 5 were affected.

Cholera: In 1948 there was an outbreak of cholera where the entire village along with neighbouring villages were affected. Again in 1983 cholera struck and it affected Ward No. 1, 2 and 8.

Hailstorm: In 1991, hailstorm affected the entire village as a result of which a lot financial damage occurred. Subsequently, in 1992 hailstorms again affected the entire village and huge monetary losses occurred.

Wind: In 1998, huge windstorms affected around NRs 1.5-2 million worth property.

Forest fire: In May 1937 forest fire occurred and destroyed crops and assets. In 1947 there was another forest fire, which destructed massive property.

Drought: In 1972 drought affected the village destroying crop production. Most of the people affected were either marginalised or under-privileged.

Thunderstorm/lighting: A powerful thunderstorm struck the village killing one person in 1969.

Army insect: A sudden outbreak of army insect (name given by locals) occurred in 2011 affecting the wheat crops throughout the village. Subsequently, in 2012, there was another attack.

Seasonal Calendar: Seasonal calendars can be used in a different ways. For adaptation planning they were used to compare seasonal variation over a year, and also to compare past seasonal data with present data (GoN, 2011). In this PRA, the seasonal calendar was used to analyse exposures to climate change effects such as temperature, rainfall, snowfall, vegetation, important patterns of hazards (such as flood, drought, landslide, hailstone, forest fire etc.) throughout a calendar year. The calendar shows community based activities, patterns of human and livestock health, important social activities livestock production, cropping and cultivation, weather and climatic conditions, problems and opportunities for the village according to season.

For this purpose, the participants were divided into different groups in both VDCs to encourage the rigorous discussion. This exercise revealed the following facts and findings:

Madanpokhara

- Early sprouting, flowering and fruiting in many plants like peach, plum etc. by one month approximately.
- According to locals, the numbers of cool days has extended by about 15 days.
- Some birds' varieties such as Titro, Hutityau, Saras, Kuthurluk, vulture, dove, sparrows, and wild life animals, for example, leopards, bear have decreased. Some birds like water-ducks, Bhyakur, KaloNihure have disappeared. Likewise, Goman, Karet, and monkeys have appeared in the area. Jackals, *lampuchhre* birds have increased. Some plant species such as Damarai, Belauti, Nilotutho, Seto, Phulne, Ganaune and Bhalukuri have disappeared.

- The amount of rainfall has decreased compared to 20-30 years ago. Monsoon also starts late and lasts until the end of August. Thus, the monsoon has shifted by about 15 days. Winter rainfall would occur from Apr 16th to May 15th and May 16th to June 15thafter which maize would be dispersed. But, now, those months are going to be dry due to decreasing rainfall.
- At the lower belt of Madanpokhara VDC, mist has become more frequent and more long lasting from December 16th to February January 15th, Jan 16 to Feb 15 and Apr 16th to May 15th, lasting more than a week and sometimes even a month at a time. The mist began forming from 1994/1995. The area never experienced mist before. Likewise, frost at the upper belt has decreased in comparison to previous decades. The decrease in the number of cool days and the increase in the number of warm days are clearly evident in the VDC.
- Mosquitoes have appeared in these areas, while it was not found earlier i.e. about 20 years ago.

The compiled seasonal calendar of Madanpokhara VDC is shown in table 24. Here, the dark shading indicates typically high degree and the light shading signifies low degree of the event.

Table 24: A Seasonal Calendar of Madanpokhara VDC (compiled)

SN	Element of Season	Seasonal Diversity	Time	Apr 16-May 15	May 16-June 15	June 16-Jul 15	Jul 16-Aug 15	Aug 16-Sept 15	Sept 16-Oct 15	Oct 16-Nov 15	Nov 16-Dec 15	Dec 16-Jan 15	Jan 16-Feb 15	Feb 16-Mar 15	Mar 16-Apr 15
1	Temperature	Hot Period	before												
			now												
		Cold Period	before												
			now												
2	Precipitation	Monsoon rainfall	before												
			now												
		Winter rainfall	before												
			now												
3	Plant and animal behavior	Flowering	before												
			now												
		Fruiting	before												
			now												
		Appearance & Disappearance (plant)	before												
			now												
		Appearance & Disappearance (Animal)	before												
			now												
4	Hazard characteristic	Landslide	before												
			now												
		Flood	before												
			now												
		Droughts	before												
			now												
		Mist (lower belt)	before												
			now												
		Hailstone	before												
			now												
		Frosts (upper belt)	before												
			now												
5	Livelihood activities	Seed sowing (maize, paddy)	before												
			now												
		Harvesting	before												
			now												
6	Physical information	Deviation on water & water sources, forest	before												
			now												

Dubiya

- Oct 16th to Nov 15th and Feb 16th to Mar 15th are the most moderate months.
- Windstorm in Apr 16th to May 15th and May 16th to June 15th.
- Hailstorm and lightning are frequent in Apr 16th to May 15th and May 16th to June 15th resulting in loss of lives and properties.
- People these days go to hills to avoid scorching sun.
- Some years we had face total drought with no rain at all.
- Local mangoes sprout during the last week of Margh and fully ripen by Apr 16th to May 15th.

- Simal (Red silk) and Palash (ButeaFrondesa)used to flower during late Margh whereas these days they flower during Mar 16th to Apr 15th
- Makhmali (Globe Amaranth) and Thunge flower used to blossom in Kartik whereas now it can be seen in May 16th to June 15th as well.
- Local breeds of flowers are vanishing whereas hybrid flowers are replacing them. Among extinct or endangered species: Local mangoes, banana, chiuri (Diploknemabutyracea), Bair (Ziziphusmauritiana), Bael (Aeglemarmelos, Mahua (Madhucalongifolia) etc.
- Domestic animals such as cow, buffalo, sheep, goat, pig, fowls were found in each and every household however, people have stopped raising animals. The number of cows and pigs is dwindling heavily every year.
- Wild animals such as tiger, leopard, raate, deer, thaar, white monkey, antelope are on the verge of extinction. Vulture, Demoiselle crane, crow, sparrow, kalij pheasant, cuckoo, parrot, hill myna, priniaetcwere found but are gradually reducing in numbers.
- Awareness has increased, personal hygiene/sanitation is looked after and the availability of medical treatment is causing the communicable diseases to fail and fall.
- AIDS, diabetes, gout, menigitis, galgantho, are seen in humans and faujikira, caterpillar, khapatekira, paterokira etc. damage vegetation.
- Seasonal vegetable farming was common back then but now entire 12 months are credited to vegetable planting and harvesting in a professional manner.

The compiled seasonal calendar of Dubiya VDC is shown in table 25.

Table 25: Seasonal calendar of Dubiya VDC

SN	Season-al Compo-nent	Season-al Divers-ity	Time	Apr 16-May 15	May 16-June 15	June 16-Jul 15	Jul 16-Aug 15	Aug 16-Sept 15	Sept 16-Oct 15	Oct 16- Nov 15	Nov 16- Dec 15	Dec 16-Jan 15	Jan 16-Feb 15	Feb 16-Mar 15	Mar 16-Apr 15	Remark
1	Temperature	Hot days	Now													The average seasonal duration of summer has increased.
			Then													
		Cold days	Now													Kartik and Falgun are equally cold. Mangsir is colder. Poush and Margh are the coldest months.
			Then													
2	Rainfall	Monsoon Rain	Now													Earlier it used to rain for a long time. Now, either it rains heavily in sudden bursts or it does not rain at all.
			Then													
		Winter Rainfall	Now													
			Then													
3	Disaster	Flood, Landslides	Now													
			Then													
		Drought	Now													
			Then													

		Hailstorm	Now													
			Then													
		Frost/Cold wave	Now													Frost was minimal before whereas it has increased a lot these days.
			Then													
		Forest fire	Now													Forest fire has gone down due to emergence of community forests.
			Then													
		Lightening	Now													Lightning strikes have so far increased.
			Then													
4	Flora	Flowering time	Now													A drastic change has not been observed in flowering time however the amount of flowers that blossom every year has decreased compared to previous years.
			Then													
		Fruition time	Now													Less fruits compared to previous harvests.
			Then													
5	Wildlife	Occurrence	Now													Broiler, high quality fish-breeds
			Then													
		Extinct or Endangered	Now													Cows, tigers, bears, other wild animals, porcupines, deer, *Dhedua* monkey
			Then													
6	Diseases	Humans/ Animals	Now													Diabetes, cancer, bird flu gone up, diarrhoea gone down, smallpox gone down, tuberculosis gone down
			Then													
		Plants	Now													Infections in plants are seen more compared to the past. *Khaira, Dadhua* etc.
			Then													
7	Water source	Drinking Water	Now													Hand pump, well, river, *kunta*
			Then													
8	Vegetation	Annual agriculture	Now													
			Then													
		Winter agriculture	Now													Vegetable farming was only possible in the winters however it's now done throughout the year. There is a

																substantial growth in vegetable farming.

Annex 2: Questionnaire for Vulnerability Analysis at Ward level (from ISET)

Development Region:

District:

VDC:

Ward number:

Village/Tole:

Total Population:

Number of households:

Number of Male:

Number of Female:

Name of Interview facilitator:

Date:

A. Exposure Indicator

Table 26: Disaster and Households

SN	Type of Disaster	Affected Households
1.	Flood	
2.	Landslide	
3.	Drought (decrease in production/no production)	
4.	Cold wave	
5.	Thunderstorm	
6.	Hailstorm	
7.	Fire	
8.	Communicable/water borne disease	
9.	River bank cutting	
10.	Others (specify)	

Table 27: Disaster Effect in Different System

SN	Disaster type	Affected areas (sector)							
		Road (km)	No. of drinking water source	No. of irrigation source	No. of bridge	No. of mobile tower	No. of school	No. of financial institution	No. of government organisation
1.	Flood								
2.	Landslide								
3.	Drought								
4.	Fire								
5.	River Bank Cutting								
6.	Others								

Table 28: Comparative analysis of climate change in the last ten-fifteen years (at local level)

SN	Season	Temperature			Precipitation			Hailstorm			Dew			Fog			Lightning			Thunder storm			Fire		
		I	D	S	I	D	S	I	D	S	I	D	S	I	D	S	I	D	S	I	D	S	I	D	S
1.	**Before Monsoon**																								
2.	**Monsoon**																								
3.	**After Monsoon**																								
4.	**Winter**																								
5.	**Yearly**																								
6.	**Daily**																								

Note: 1. Before monsoon- Chaitra, Baisakh and Jestha, 2. Monsoon- Ashad,Shrawan, Bhadra and Ashwin, 3. After Monsoon- Kartik and Mansir, 4. Winter- Paush, Magh and Falgun

I= Increase, D= Decrease, S= Same

Table 29: Land use and Disaster

SN	Type of land	Area (Ha)	Flood Landslide (Ha)	Drought (Ha)	Bank Cutting (Ha)	(Ha)	Remarks
1.	Bari / Pakha						
2.	Khet Land						
	Total arable land						
3.	Forest area						

4.	Khoriya/ Kharbari						
5.	Pastureland						
6.	Settlement						
7.	Others (specify)						

Table 30: Crop Production and Disaster

SN	Type of Disaster	Affected Households	Major Type of Crops (Cereal, Vegetable, Fruits)	Amount of production loss (kg)	Cost of production loss (NRs.)
1.	Flood				
2.	Landslide				
3.	Drought				
4.	Cold Wave				
5.	Thunderstorm				
6.	Hailstorm				
7.	Bank Cutting				

Sensitivity Indicator

Table 31: Impact of pest and diseases

SN	Type of disease	Affected household (No.)	Production loss area (Ha)	Cost of production loss (NRs.)
1.	Army worm			
2.	*Daduwa*			
3.	*Patero*			
4.	*Sindure/Rate*			
5.	Others (specify)			

Table 32: Invasive species and threat of animals

SN	Name	Expansion area (Ha)	Area of production loss (Ha)
1.	*EupatorimAdenophorum*		
2.	*Micarantha species*		
3.	Weeds (with smell)		
4.	Monkey		

5.	Others (specify)		

1. *Land and Roads*

Table 33: Present condition of land plotting (fragmentation)

SN	Type of Land	Condition of land plotting**	Area (Ha)
1.	Arable land		
2.	Fallow		
3.	Destruction of hills/improved ditches		
4.	Others (specify)		

*** a. Finalised mapping, b. Land & road prepared, c. Houses under construction, d. House construction completed*

Table 34: Impact of road construction

SN	Road type	Total (km)	Impact in water source (No.)	Remarks
1.	Conduction of new road			
2.	Improving existing road			
3.	Others (specify)			

Table 35: Land holding pattern

SN	Types of holding	No. of Family
1.	Hold own land by themselves	
2.	Land rented out to others	
3.	Holding own land and rented others land	
4.	Landless/ only having own house	
5.	Others (specify)	

2. *Water resource*

Table 36: Water availability

SN	Type of water resource	Number	Availability		Remarks
			Seasonal	Year round	
1.	River				
2.	Rivulets				
3.	Pond / ditches				
4.	Spring/ tap water				
5.	Groundwater				
6.	Wetland				

*** Specify if any water sources dried up*

Table 37: Drinking water

SN	Type	Benefite d HHs	Present condition*	No. (now)	No. (before 10 years)	Water quality	
						Now*	Before*
1.	Piped water						
2.	Public tap						
3.	River/ rivulets						
4.	Well						
5.	Tube well						
6.	Pond						
7.	Rainwater harvesting						
8.	Others (specify)						

**a. better, b. good and c. worse; ** specify if there is arsenic or iron contamination in available water source*

Table 38: Water use

SN	Major use	Source					
		River	Rivulets	Pond / diches	Spring/ tap water	Groundwater	Wetland
1.	Drinking						
2.	Irrigation						

3. Irrigation (Source of irrigation used at ward level)

Table 39: Irrigation (Source of irrigation used at ward level)

SN	Name of source	Type		Irrigated area (Ha)	Benefitted HHs No.	Sufficiency (Yes/No)
		Seasonal	Year round			
1.	Tube well/ deep borewell					
2.	Spring					
3.	Plastic lined pond					
4.	Sprinkler					
5.	Pond/lake					
6.	Canal (river/rivulet)					

4. Food

Table 40: Food Sufficiency

SN	Food sufficiency condition	Number of HHs	Remarks
1.	Less than three month from own production		
2.	Three to six month from own production		
3.	Six to nine month from own production		
4.	Nine to twelve month from own production		
5.	Year round sufficiency with stock from own production		
6.	Having no own production**		

***Specify the option for food management if any households have no own production*

Table 41: Cropping patter and crop cycle

Time	Cropping pattern in Khet land	Crop Cycle in Khet land	Cropping pattern in Pakha land	Crop Cycle in Pakha land
Before (10 years)				
At present				

Table 42: Use of hybrid seed and pesticides

SN	Major Reason (√)		Remarks
1.	Regular production not sufficient to feed		
2.	To increase production in short time (commercial)		
3.	Less production from local verities		
4.	Others		

5. Youth Migration

Table 43: Youth Migration

SN	Major Reason (√)		Migrated location*	Remarks
1.	Less employment opportunities			
2.	Unable to sustain livelihood from agriculture			
3.	Less interest in farming			
4.	Trend of earning high amount of money in short time			
5.	Further study/higher education			

**a. within Nepal, b. India, c. Gulf countries, d. other countries*

B. Adaptive Capacity Indicator

6. Road and market

Table 44: Condition of road and distance (within ward)

SN	Road type	Distance to road from centre of ward (km.)	Distance to bus stop from centre of ward(km.)
1.	Highway		
2.	District road		
3.	Hulaki road		
4.	Feeder road		

Table 45: Details of road

SN	Road type	Length (km)
1.	Black topped	
2.	Gravel	
3.	Fair weather	
4.	Others (specify)	

Table 46: Details of different type of bridge

SN	Type of bridge	Number	Remarks
1.	Concrete		
2.	Culvert		
3.	Foot bridge		
4.	Wooden bridge		

Table 47: Market

SN	Title	Name/location	Distance (km)	Means of transportation*
1.	Market within of nearby village			
2.	Market at headquarter			
3.	Main market at farthest distance			
4.	Haatbazzar			

* a. walk, b. bicycle, c. motorbike, d. bus/ car/ jeep/truck

7. Communication

Table 48: Means of communication (ward level)

SN	System	Effectiveness*	Number	Benefitted HHs	Remarks
1.	Landline phone				
2.	Mobile				
3.	PCO/ cyber café				
4.	Household with internet				
5.	Television				
6.	Radio				
7.	Others (specify)				

**a. better, b. good, c. worse*

Table 49: Distance to mobile towers (ward level)

Location of tower	Number	Distance from centre of ward (km)	Remarks

Table 50: Forest resource

SN	Types of forest	Number	Area (Ha)	Benefitted HHs(firewood)	Benefitted HHs(timber)	Benefitted HHs(fodder)
1.	Government					
2.	Private					
3.	Community					
4.	Religious					
	Total Area					

8. Energy use

Table 51: Energy use

Category of use	Number of households (user)							
	Electricity	Solar	Biogas	LPG	Firewood	Kerosene	Dung cake	Briquette
Lighting								
Cooking								
Room heating								
Cooling								
Others								

9. *House type*

Table 52: House type

SN	House type	No. of HHs	Remarks
1.	Concrete roof with brick wall and cement mortar		
2.	Zinc roof with stone/ brick wall		
3.	Zinc roof with stone wall and clay mortar		
4.	Straw roof with clayey wall		
5.	Thatched /Zinc roof with wooden wall		
6.	Others (specify)		

10. *Livelihood*

Table 53: Livelihood

SN	Major livelihood options	Dependent HHs	Remarks
1.	Agriculture		
2.	Service/ pension		
3.	Business		
4.	Local industry(small/ medium)		
5.	Remittance		
6.	Daily wage labour		
7.	Others(specify)		

11. *Financial intuitions*

Table 54: Financial intuitions

SN	Name	Number	Access to loan taken		Remarks
			Easy (√)	Hard (√)	
1.	Cooperative				
2.	Micro-credit				
3.	Income generation group				
4.	Relatives/neighbours				
5.	Local money lenders				

12. Health and sanitation

Table 55: Health services

SN	Type	Number	Benefited HHs	Remarks
1.	Traditional healer			
2.	Local healer (*Baidhya*)			
3.	Primary sub-health post			
4.	Primary health post			
5.	Hospital			
6.	Private clinic			
7.	Health assistant			

Table 56: Types of toilet and use

SN	Types	No of HHs using/ not using toilet
1.	Pit latrine	
2.	Pan latrine	
3.	Without toilet	
	Total	

13. Educational institutions

Table 57: Educational institutions

SN	Types	Number	Number of teacher			Number of Student		
			Male	Female	Total	Male	Female	Total
1.	Primary							
2.	Lower secondary							
3.	Secondary							
4.	Higher secondary (+2)							
5.	College (above +2)							
6.	Informal learning centre							
7.	Training centre							
8.	Others (specify)							

14. Social network (groups and sub-groups)

Table 58: Social network (groups and sub-groups)

SN	Types	Number	Number of Member	
			Male	Female
1.	Mother group			
2.	Saving group			
3.	Vegetable farming group			
4.	Livestock farming group			
5.	Forest user group			
6.	Irrigation user group			
7.	Drinking water/sanitation group			
8.	Biodiversity conservation group			
9.	Federation			
10.	Others (specify)			

15. Off-farm activities

Table 59: Off-farm activities

SN	Types of industries	Number	No. of Involved person	
			Male	Female
1.	Bamboo			
2.	Carpentry			
3.	Clay/ceramics			
4.	Textile			
5.	Dhaka cap			
6.	Carpet (*radhi, pakhi*)			
7.	Cutting and tailoring			
8.	NTFP			
9.	Others (specify)			

16. Government agencies/ organisations

Table 60: Government agencies/ organisation

SN	Name	Number
1.	Agriculture service centre/ sub-centre	
2.	Livestock service centre	
3.	VDC office	
4.	Post office	
5.	Others (specify)	

17. Non-governmental organisations

Table 61: Non-governmental organisations

SN	Name /Type	Number	Major working areas	Remarks
1.	NGO			
2.	CBO			
3.	Club			
4.	Civil Society			
5.	Others (specify)			

Annex 3: WEAP Model

The WEAP (Water Evaluation and planning) model was developed by the SEI to enable evaluation of planning and management issues linked with water resources in a given area/catchment. The WEAP model can address a wide range of issues including sectoral demand analyses, water conservation, water rights and allocation priorities, stream flow simulation, reservoir operation, ecosystem requirements and project cost-benefit analyses (SEI 2001). WEAP model has two primary capabilities:

1) Simulation of hydrological processes such as evapotranspiration, runoff and infiltration to enable assessment of the availability of water within a catchment.

2) Simulation of anthropogenic activities superimposed on the natural system to influence water resources and their allocation (i.e., consumptive and non-consumptive water demands).

The system is represented in terms of its various water sources (e.g., surface water, groundwater, and water reuse elements), withdrawal, transmission, reservoirs, and water demands (user-defined sectors). The data structure and level of detail can be customized (e.g., by combining demand sites) to correspond to the requirements of a particular analysis. A graphical interface facilitates visualization of the physical features of the system and their layout within the catchment. The WEAP model basically performs a mass balance of flow sequentially down a river system, making allowance for withdrawals and inflows. To simulate the system, the river is divided into reaches. The reach boundaries are determined by points in the river where there is a change in flow as a consequence of the confluence with a tributary, or a withdrawal or return flow, or where there is a dam or a flow gauging structure. Typically, the WEAP model is applied by configuring the system to simulate "baseline" year, for which the water availability and demands can be confidently determined. The model is then used to simulate alternative scenarios (i.e., plausible futures based on "what if" propositions) to assess the impact of different development and management options. The model optimizes water use in the catchment using an iterative Linear Programming algorithm.

1. Annex for water supply and demand modelling for the Thanjavur district in the Cauvery delta

Key hydrological features of the study area are shown in the figure 36.

Figure 36: Key hydrological features of the study area (source: WRIS, NRSC)

Two major streams i.e. Coleroon and Cauvery are identified for detailed modelling (Figure 37)

Figure 37: Major rivers in the area

The following figure shows the parameterisation of the study area in the WEAP model

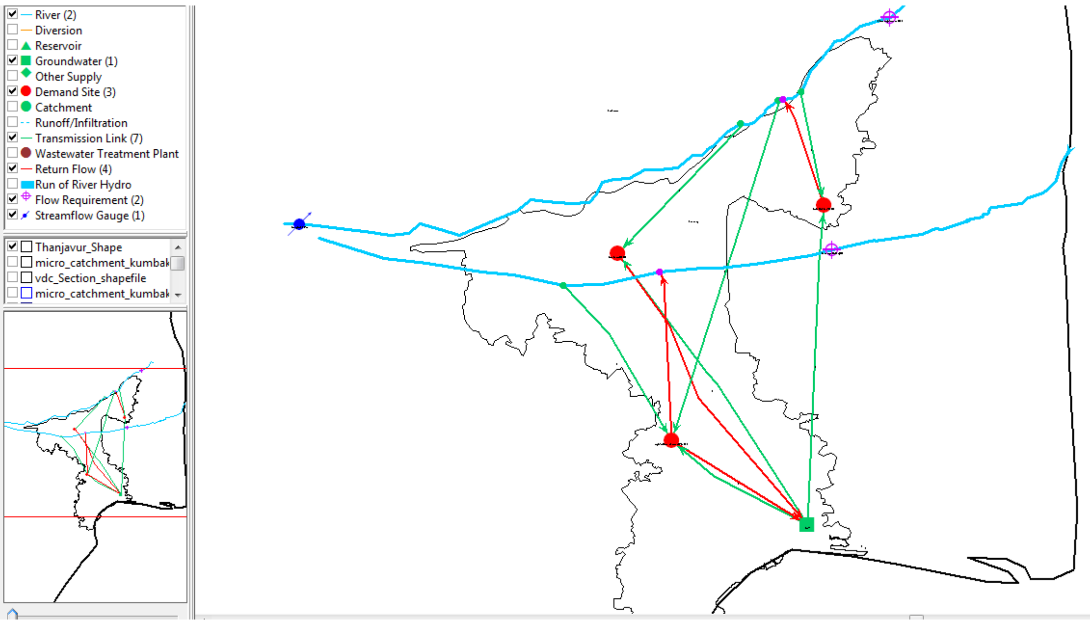

Figure 38: WEAP model parameterisation for the Thanjavur district

Stream-flow data from the Grand anaicut and lower anaicut is obtained from (Bhubaneswari et al. 2013 and Cauvery delta sub-basin report for NAPCC, prepared by ADB (http://www.cwc.gov.in/main/downloads/Sub-basin%20study%20under%20NWM%20-Appendix%204%20Cauvery%20Delta%20Sub%20Basin.pdf)

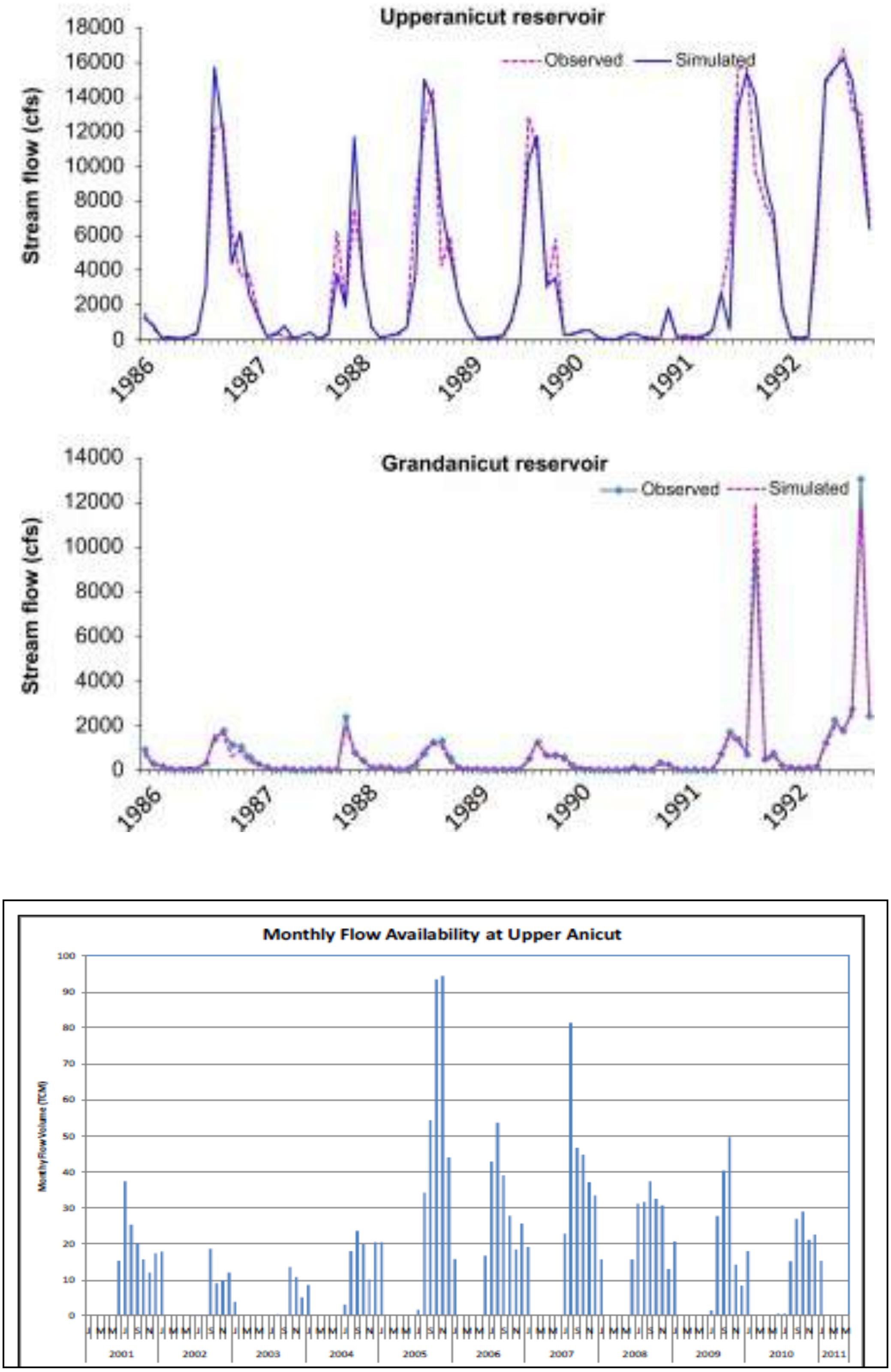

Figure 39: (a,b,c) Stream-flow information at upper anaicut and lower anaicut reservoirs

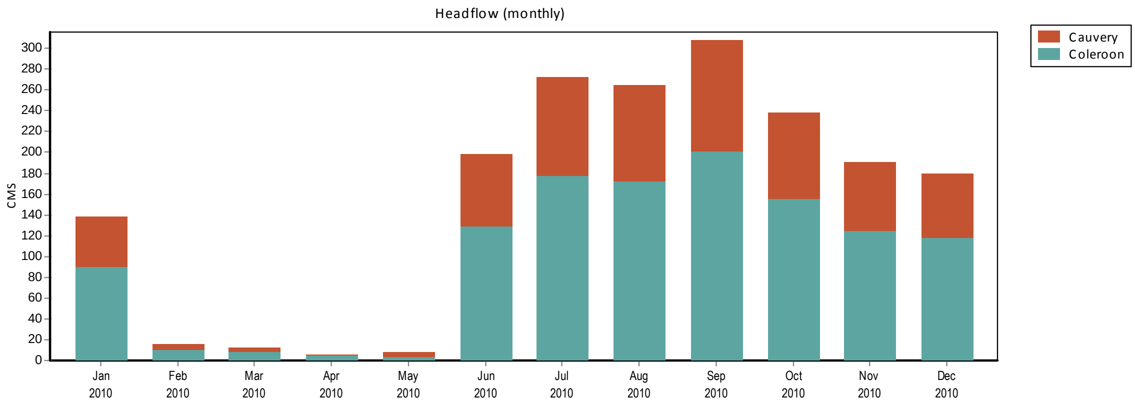

Figure 40: River head-flow as provided in the model

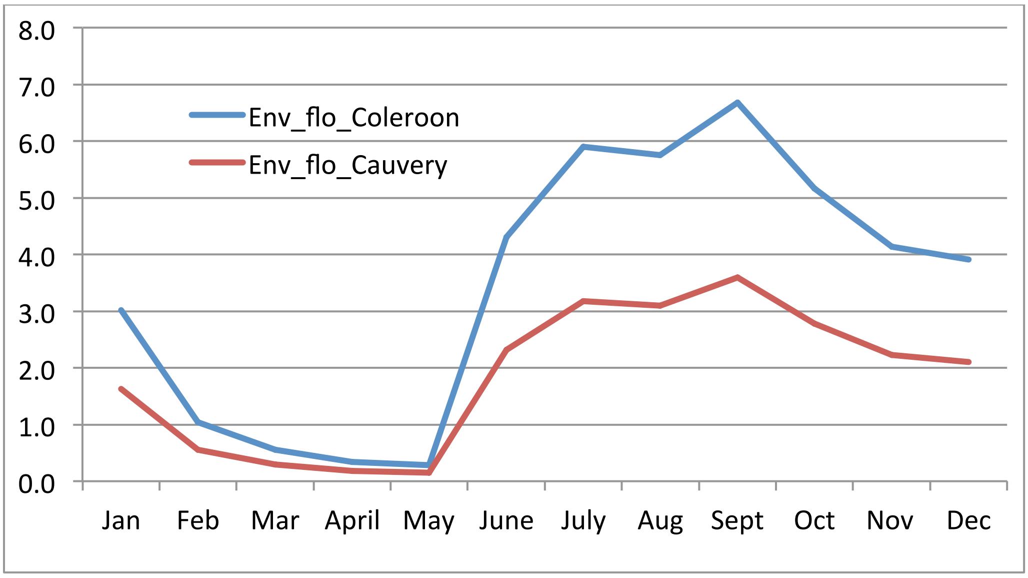

Figure 41: Minimum environmental flow as prescribed in the model (cms)

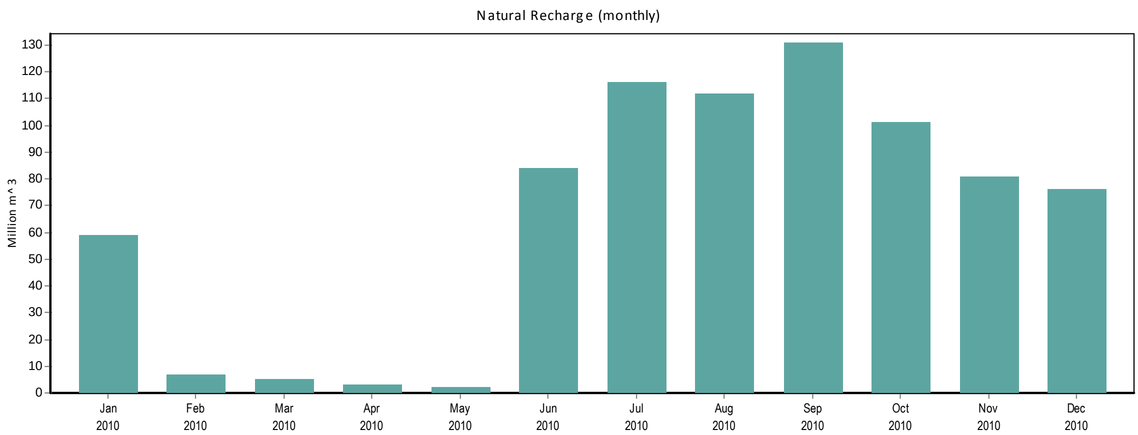

Figure 42: Monthly groundwater recharge in the model

Table 62: Water demand activities as prescribed in the model

Area (Gross)	Reference	Drought	Crop-Switch	SRI
Total Agriculture	252,000ha*	252,000ha*	252,000ha*	252,000ha*
Rice (% of total agriculture)	56.80%	56.80%	Each year 5% area is brought under drip irrigation system	Each year 5% area is brought under drip irrigation system
Sugarcane	6%	6%	6%	6%
Pulse	15%	15%	15%	15%
Groundnut	6%	6%	6%	6%
Gingelly	5%	5%	5%	5%
Horticulture	13%	13%	13%	13%
Households (000)	510	510	510	510
Industry (Million products)*	25	25	25	25

For the agriculture sector values are largely based on the latest district agriculture plan (http://agricoop.nic.in/Agriculture%20contingency%20Plan/TN/TN9-Thanjavur%203.2.2011.pdf), Household information is taken from the census data and for Industry a ball-park number around 5% total water use (given agriculture takes about 90% and HH takes about <5%) is assumed.

Table 63: Water use rate for each activity as prescribed in the model

Annual water use per unit of activity (m3/unit)	Reference	Drought	Crop-Switch	SRI
Agriculture				
Rice	16802	16802	1800	12685
Sugarcane	20000	20000	20000	20000
Pulse	2200	2200	2200	2200
Groundnut	6000	6000	6000	6000
Gingelly	5000	5000	5000	5000
Horticulture	10000	10000	10000	10000
Mixed crop*	1800	1800	1800	1800
Households (000)	150	150	150	150
Industry (Million products)	6	6	6	6

For agriculture sector the values are taken from Geethalaxmi et al 2011; For HH based on field data and for Industry just a ball-park number (less confidence): *

Monthly variation in water demand

- Household and Industrial water demand remains same the whole year long
- In agriculture water demand delta region is known for three rice crops i.e. Kar/Kuruvai /Sornavari (April to July), Samba/ Thaladi/Pishanam (August to November) and Navarai/ Kodai (December to March)- hence rice water use remains the year- long (i.e. farmers will plant if water is there), additionally more water intensive crops such as Sugarcane, vegetables and fruits are perennial in natural (http://www.tn.gov.in/crop/AreaProduction.htm)

Assumptions made in WEAP

Table 64: Key data and assumptions under each scenario

	Supply side	**Demand side**	**Climate**
Reference	The current stream-flow and groundwater dynamics assumed to continue till 2035	Current activity and water use to continue	Current climate assumed to continue till 2035
Drought	Water supply simulated by model based on the climate data for this scenario	Current activity and water use to continue	Rainfall deficit (50%) every 3rd consecutive year, associated drought related losses
Crop-Switch	Water supply simulated by model based on the climate data for this scenario	Current activity and water use to continue, except each year 5% rice area is experiences 'crop-switch'	Rainfall deficit (50%) every 3rd consecutive year, associated drought related losses
SRI	Water supply simulated by model based on the climate data for this scenario	Current activity and water use to continue, except each year 5% rice area is experiences 'SRI'	Rainfall deficit (50%) every 3rd consecutive year, associated drought related losses

SRI method as described by Geethalaxmi et al 2011 “Fourteen-day-old seedlings were transplanted with a spacing of 22.5 × 22.5 cm. Weeding was done three times using conoweeder at 10 days interval from the tenth day after transplanting. Irrigation was done after the disappearance of water and formation of hairline cracks in the soil”

Table 65: Key demand-side assumptions common to all the scenarios

Key Assumption	2010	2011-2035	Scale	Unit
Households increase	510	Growth(0.85%)	Thousand	HHold
Increase in per capita water consumption	150	Growth(1%)	Percent	cap
Efficiency improvement	6	Growth(-0.5%)		m^3
Irrigation intensity rice	16.8	Growth(0.5%)		m^3
Growth in Industrial activity	25	Growth(3%)	Thousand	Prod.
Irrigation intensity sugarcane	20	Growth(0.5%)		m^3
Crop_switch_mixed increase	0	0	Percent	
Crop_Switch_Rice_dec	56	56	Percent	
SRI_increase	0	0	Percent	
SRI_rice_decrease	56	56	Percent	

Climate data

Definition of the drought scenario is shown in the figure below

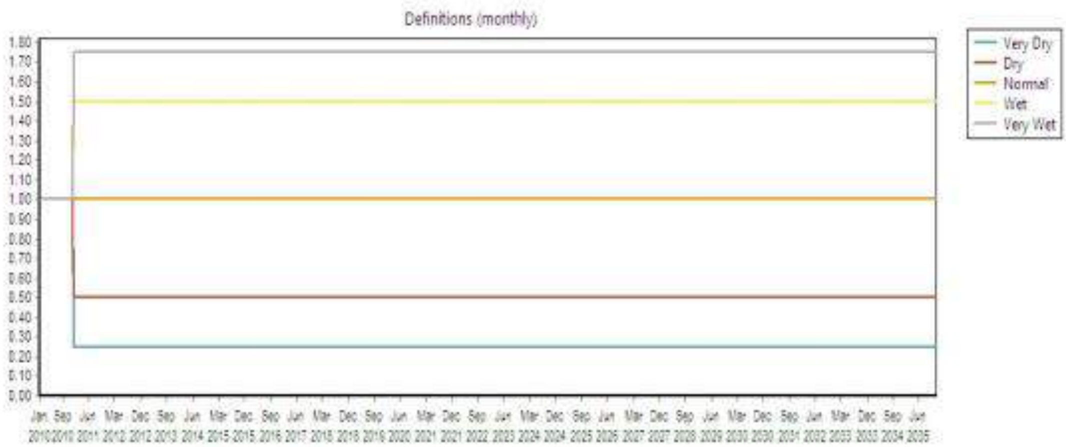

Figure 43: Definition of a dry year and a normal year as applied in the model

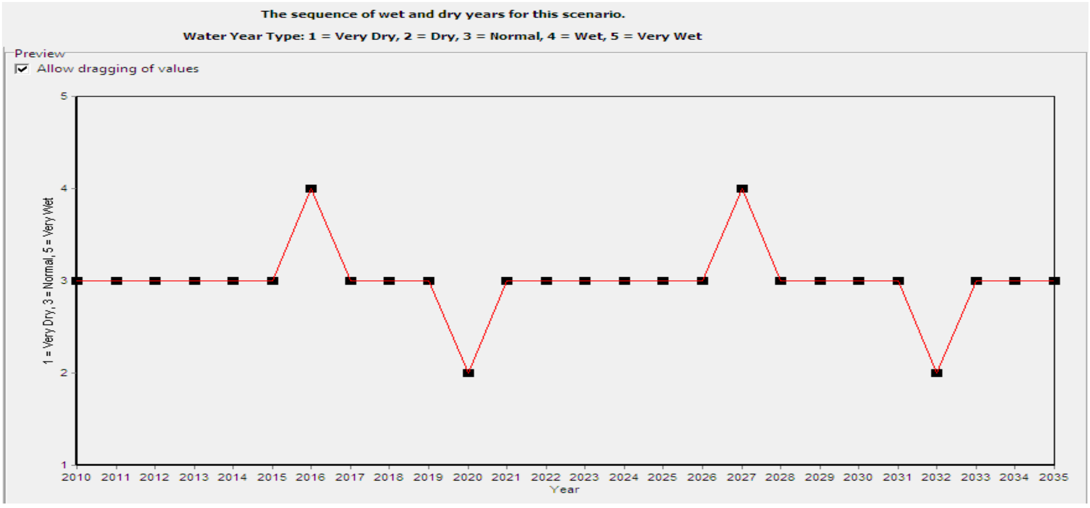

Figure 44: Description of the Reference scenario

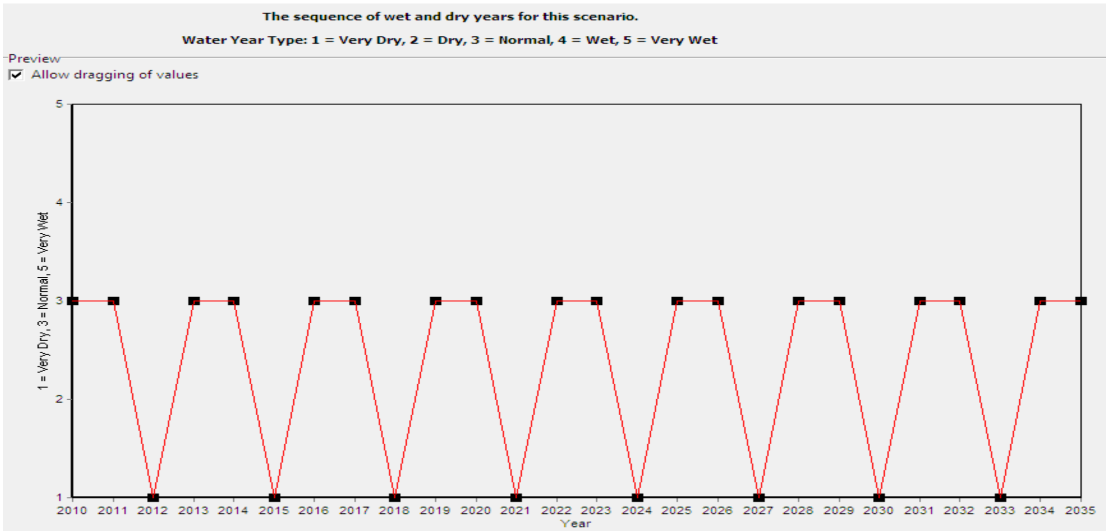

Figure 45: Description of the drought scenario

2. *Water supply and demand modelling for the Madanpokhara catchment in western Nepal*

Delineation of the catchment boundary and the key streams shown with the help of Google Earth layer

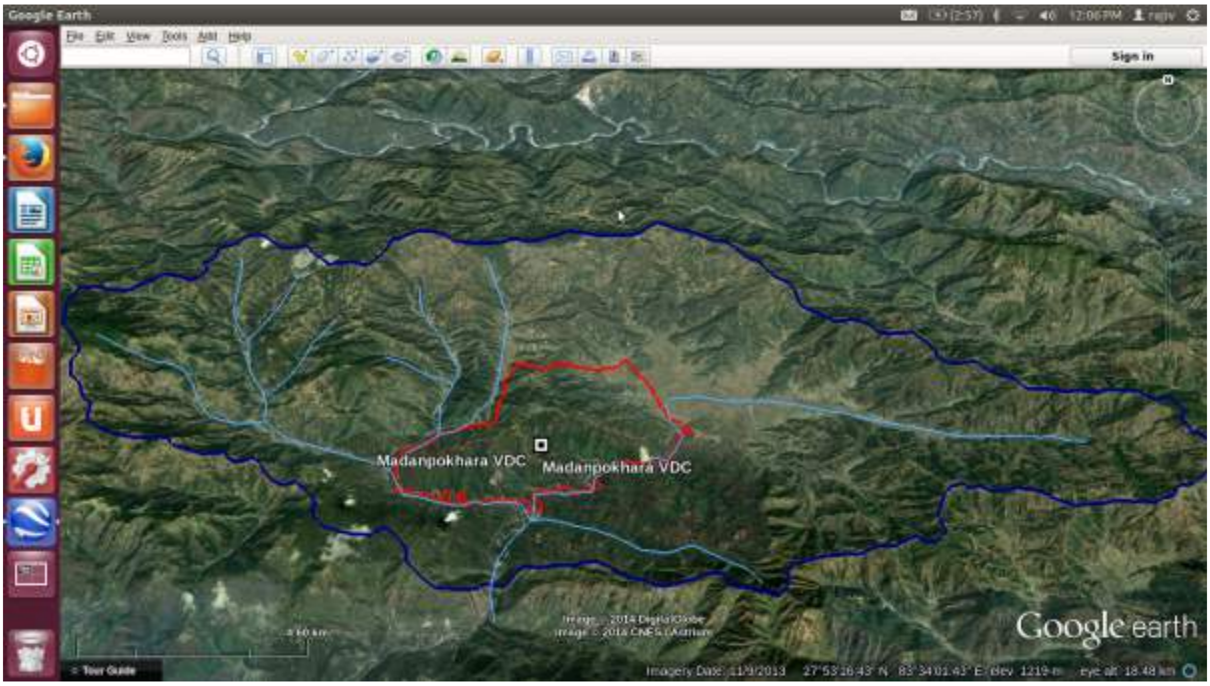

Figure 46: Google Earth image of the study catchment

Study area as parameterised in the WEAP model is shown in Figure 47

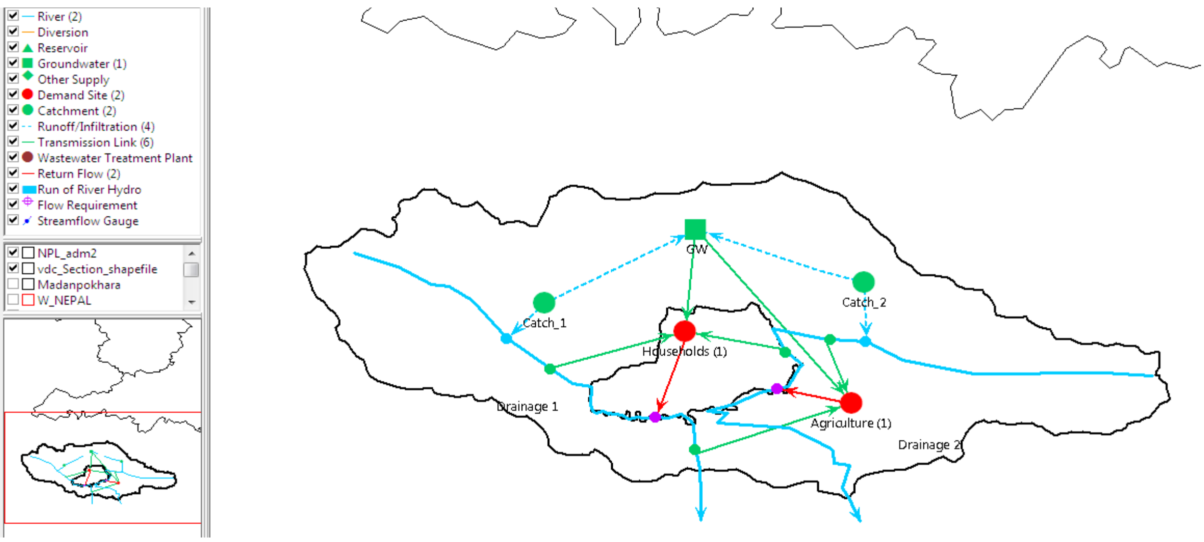

Figure 47: Study area parameterisation in the WEAP model

Water supply modelling

Surface water flow as well as groundwater recharge is modelled using the "Rainfall-Run-off – Soil moisture model" inbuilt in the WEAP system. It requires climatic data such as temperature, rainfall, humidity, wind-speed, and cloudiness as input.

Current climate data

Current climate is obtained from Syangia climate station situated near to Madanpokhara catchment and also on the same altitude levels. This particular climate station is selected due to its proximity to the study area and also due to availability of a two decade long climatology as shown in table 66. This station provides data only for temperature and rainfall (the most important variables) and other climate datasets are obtained from Kathmandu climate station.

Table 66: Selected climate data station for climate analysis

Station Name	Basin Office	Types of Station	District	Lat Long		Elevation (in metres)	NMS Estd. Date	Period
SYANGJA	N	CLIMATOLOGY	Syangia	28.06	83.53	868	Nov-72	1989-2008
Madanpokhara				27.8	83.5	560 to 1240		

Figure 48 below shows the current temperature climatology of the area based on the climate data from Syangia station over 1989-2008. This suggests that currently the area witnesses an average annual temperature of about 22.6 deg C.

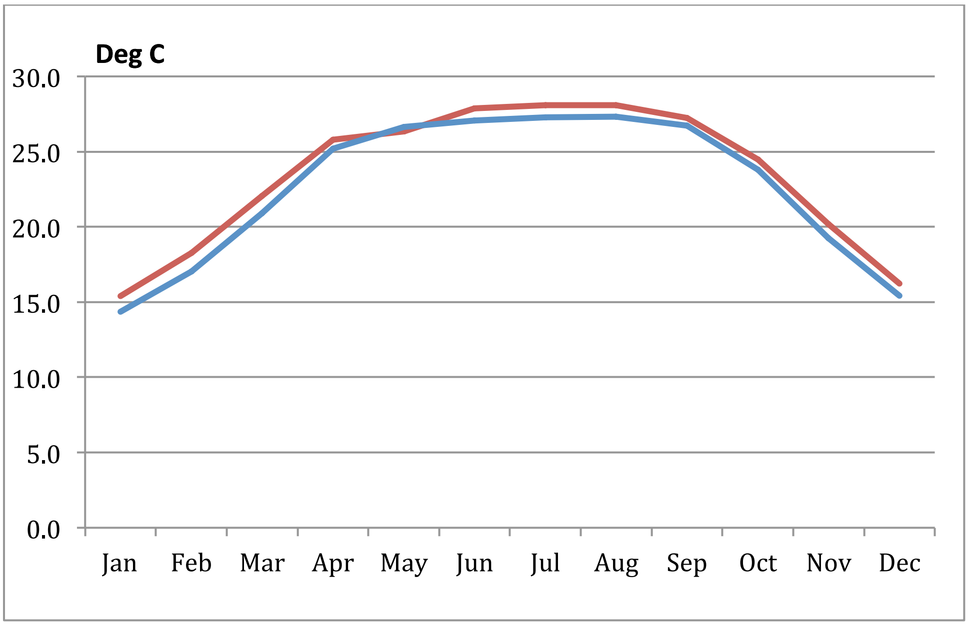

Figure 48: Temperatures under the current climate (black) and climate change projections (red)

Figure 49 shows the current precipitation climatology of the area based on the climate data from Syangia station over 1989-2008. This suggests that currently the area witnesses an average annual rainfall of about 1916 mm.

Climate projections are obtained from the CORDEX database from IITM, Pune. We selected the SMHI model and its RCP4.5 scenario for the climate change analysis. Historical and projected climate data were obtained from SMHI model. The Historical simulations were compared with the station based temperature and precipitation observations. Based on this comparison the projections for RCP4.5 were bias corrected and this bias corrected temperature and precipitation projections were used in this analysis.

We find that on average the annual temperature increases by 0.74 deg C over the period (1989-2008 to 2006-2035) and the precipitation increases only slightly about 1%, but the point to be noted is that precipitation tends to rise in the months when water is in plenty and tends to decrease further in the water constraint months.

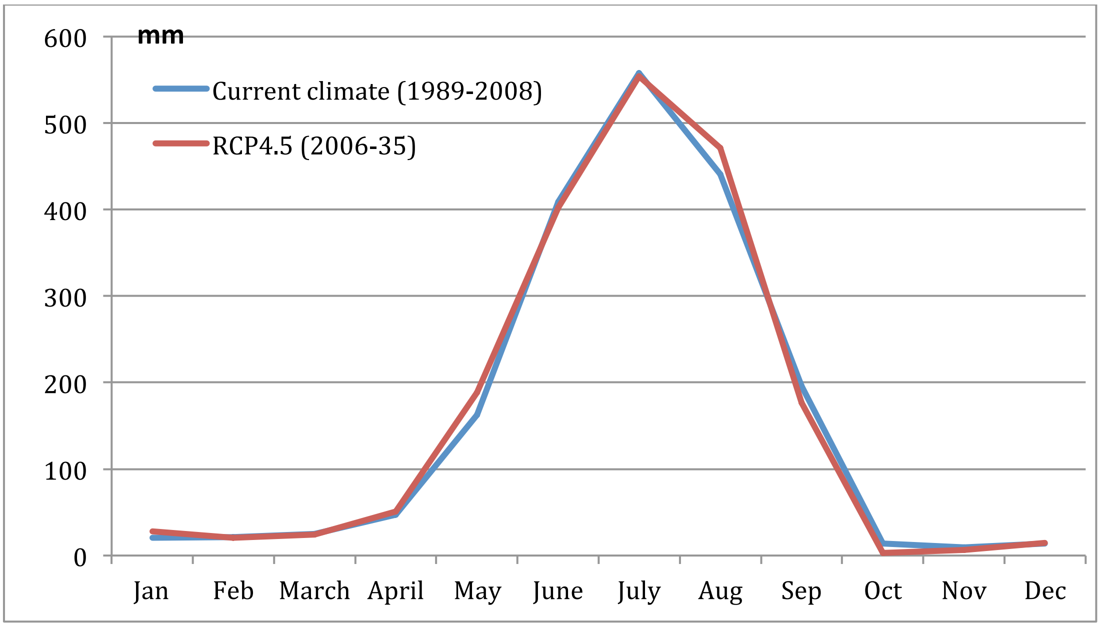

Figure 49: Rainfall under the current and projected climate

Model Validation

Figure 50 shows the simulated stream-flow under the current and climate change scenarios. This stream-flow curve is based purely on catchment scale modelling of the climate data, and we do not have ground stream-flow observations to validate this.

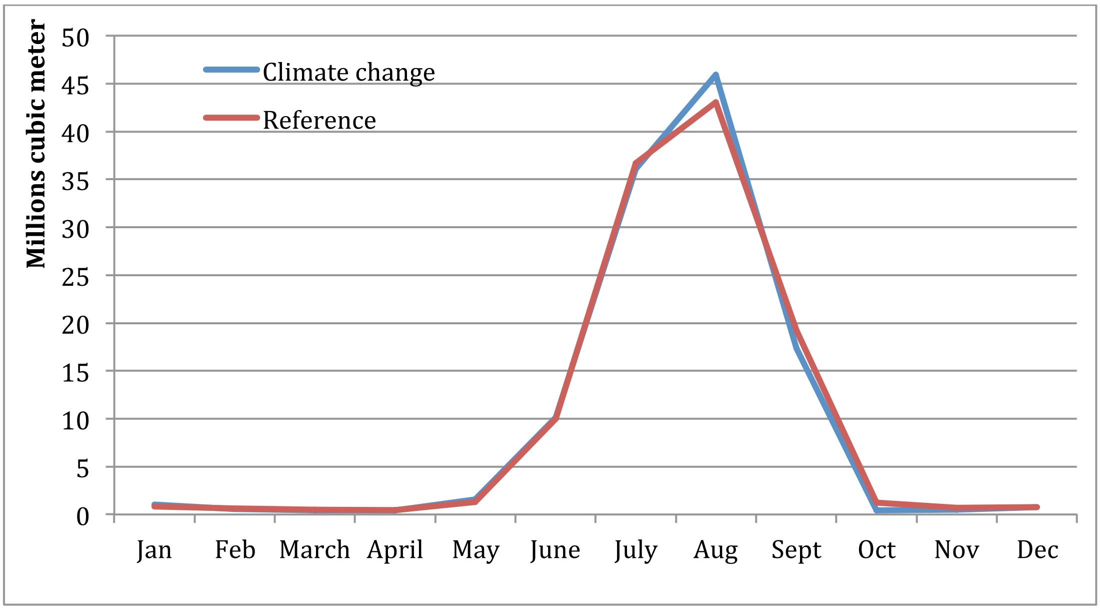

Figure 50: Simulated stream flow in the Madanpokhara catchment under Reference and climate change scenarios

Figure 51 shows the simulated groundwater inflow information in the catchment for different months

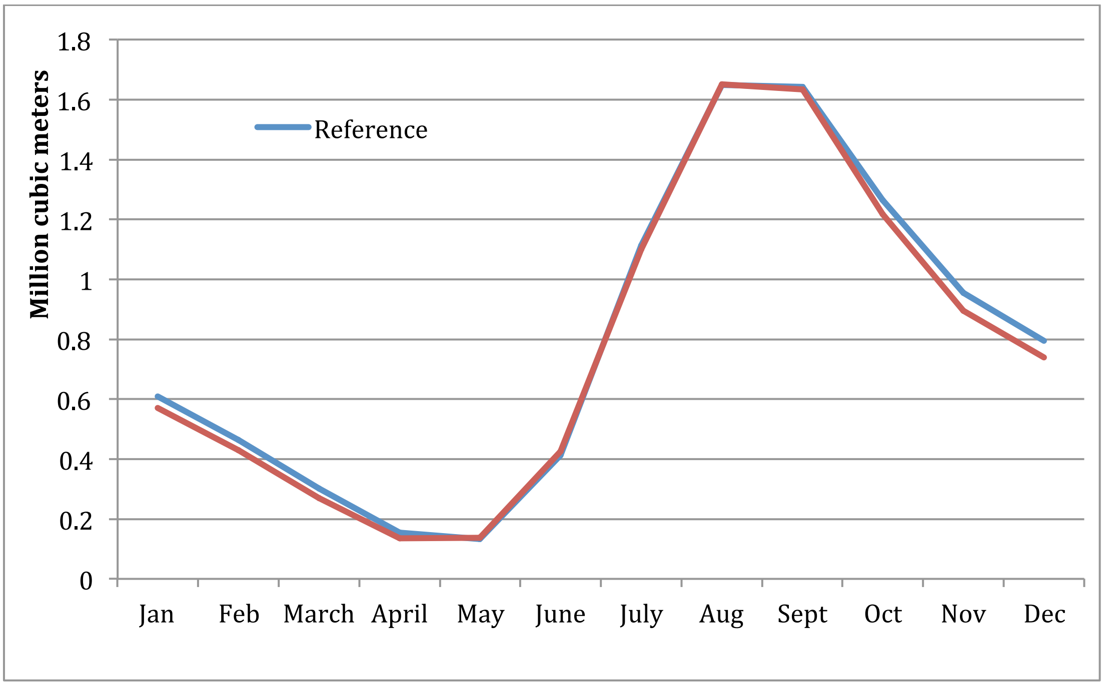

Figure 51: Simulated groundwater inflow for the Madanpokhara catchment under the two scenarios

Computation of current and projected REF-Potential evapotranspiration

Based on the climate data for temperature, precipitation, humidity, RH, wind speed and location the Ref-PET was computed by the WEAP model. The result is shown below:

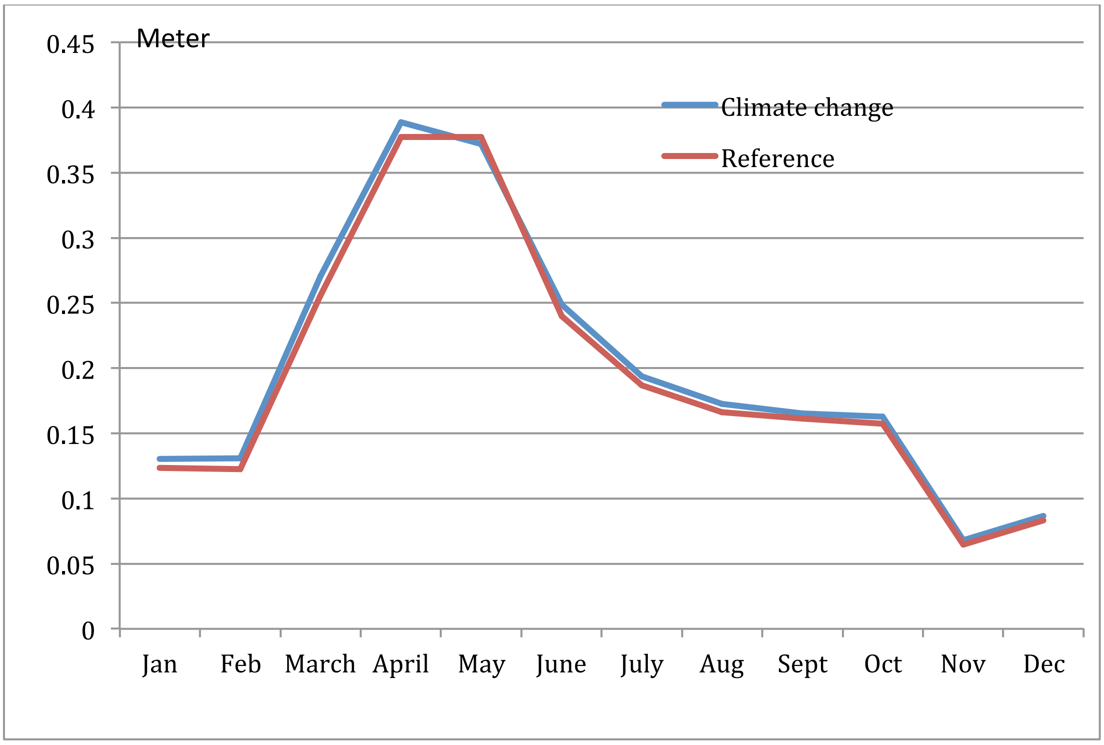

Figure 52: Simulated PET (in meters) for Madanpokhara catchment for the two scenarios

Table 67: Demand side parameterisation for the agriculture sector

	Area (gross)	Water intensity
Total Agriculture	2800ha*	
Rice	47%	15*10^3 m3/ ha/crop
Wheat	32%	6*10^3m3/ha/crop
Oils	14%	1.9*10^3m3/ha/crop
Vegetables	7%	15*10^3m3/ha/crop
Orchards (Bari)	4680ha	Part of ET
Natural forests	9684ha	Part of ET
Grasslands	1830ha	Part of ET

* Assuming a cropping intensity of 1.1

Households

Total Population = 50,000 (Population of Madanpokhara = 6,222 in 2011); then given that average household size = 5.04; number of households are about = 10000. It is assumed that per household annual water use is 150m^3. Per annum population growth trend is 3.3%

Assumptions

There is only one assumption that the population increases by 3.3% per annum till 2035. In response to the population increase the household water demand increases in the same proportion.

Annex 4: Workshop Agenda

Climate Change Vulnerability and Adaptation		
Date: Tuesday, August 26 – 27, 2014		
Venue: Moevenpick Hotel, 115 Gokula Extension, HMT Road (near BEL Circle), Bangalore		
Day1 – 09:00 am onwards – Registration		
9:30 – 10:30 am – Introductory Panel		
10 min	Welcome Remarks	Anshu Bhardwaj, CSTEP, Bangalore
10 min	Climate Change Adaptation and Development	Samar Verma, Senior Programme Officer, Think Tank Initiative, IDRC
15 min	Climate Change Impacts in South Asia	Sumana Bhattacharya, Head, Climate Change and Environment, Intercooperation Social Development India; Coordinator of India's 1st and 2nd National Communication to UNFCCC in MoEF.
15 min	Climate Change Challenges for Karnataka	Shri. S.V. Ranganath, Former Chief Secretary, Karnataka
10:30 – 10:45 am – Tea Break		
10:45 am – 12:15 pm: Understanding Vulnerability Assessment and Adaptation; Chair: Sujatha Byravan, CSTEP		
15 min	Agricultural Vulnerability and Participatory Methods for Assessment	Ulka Kelkar, TERI, Bangalore
15 min	Assessing Farmers' Vulnerability to Climate Change and Variability in Rainfed and Irrigated Agriculture: Perceptions and Adaptation Strategies in Cauvery Basin	Shrinivas Badiger, ATREE, Bangalore
15 min	Integrated Framework for Vulnerability Assessment in the Himalayas	Mustafa Ali Khan, Swiss Development Corporation, Delhi
15 min	Climate Change Adaptation in Rural Areas in India — A joint MoEF and GIZ project	Somya Bhatt, GIZ, Delhi
30 min	Discussion	
12:15 – 1:30 pm: Methods for Assessment and Building Resilience; Chair: Kavi Kumar, Madras School of Economics		
Methods and Tools for modelling Adaptation. (Presentation over Google Talk or Skype)		Tom Downing, Global Climate Adaptation Partnership, Oxford.

1:30 – 2:30 pm – Lunch		
2:30 – 5:30 pm: Vulnerability Assessment from the Top Down and Bottom Up; Chair: Anshu Bhardwaj, CSTEP		
15 min	Understanding Drivers of Vulnerability in Tamil Nadu Districts	Debapriya Das, CSTEP, Bangalore
15 min	Water Supply and Demand Modelling in India and Nepal	Rajiv Chaturvedi, IISc., Bangalore
15 min	Discussion	
3:15 – 3:30 pm – Tea Break		
30 min	Report Card Approach to Assessing Vulnerability and Preparedness to Climate Change	Suresh Raghavan, Public Affairs Centre, Bangalore
30 min	Shared Learning Dialogue Approach to Building Stakeholder Capacity and Resilience	Ajaya Dixit, ISET, Kathmandu, Nepal
30 min	Videos, Visuals, Local Narratives	ISET and PAC
30 min	Discussion	
Day 2		
9:30 – 11:15 am: Building Resilience in Urban Landscapes; Chair: Sudhir Chella Rajan		
15 min	Climate Vulnerability and Building Resilience in Cities	Sumetee Gajjar, IIHS, Bangalore
15 min	Walkability & Climate Resilience in Cities	Geetam Tiwari, IIT Delhi, Delhi
15 min	Adapting to Climate Change in Urbanizing Watersheds	Sharad Lele, ATREE, Bangalore
15 min	Understanding Urban Vulnerability and Building Resilience in Gorakhpur	Shiraz Wajih, Gorakhpur Environmental Action Group, Gorakhpur
15 min	Water Walks and Water tanks; Building Resilience in Madurai	A. Madhan Kumar, DHAN Foundation, Madurai
30 min	Discussion	
11:15 – 11:30 am – Tea Break		
11:30 am – 1:00 pm : State or Landscape Level Vulnerability Assessments and Policy; Chair: Sharad Lele, ATREE		
15 min	Vulnerability Assessments, Lessons from Uttarakhand	Mihir Bhatt, Senior Advisor, CDKN

15 min	Macro-level Vulnerability Assessments—Examples from Indian States	Divya Mohan, TERI, Delhi
15 min	Vulnerability and Adaptation in the Indus Ecoregion	Farrukh Zaman, WWF, Pakistan
15 min	TBC	Arif Rahman, LEAD Pakistan
30 min	Discussion	
1:00 – 2:00 pm – Lunch		
2:00 – 4:00 pm – Panel Discussion		
Discussion on lessons and challenges related to linking the local to national development and climate policy. Lead questions for panelists are: What are the strategic elements that link local learning to the state and national policies? What are the linkages to low carbon inclusive development? Moderator: Suresh Raghavan, PAC		
Speakers	• Chandra Bhushan, Centre for Science and Environment, Delhi • Kavi Kumar, Madras School of Economics, Chennai	• Sudhir Chella Rajan, IIT Madras • Purnamita Dasgupta, IEG, University of Delhi
4:00 pm – Tea		

Annex 5: Concept Note for Conference

Concept Note for Vulnerability and Adaptation Conference; 26, 27 August 2014

Over the past several years many different approaches have been developed towards understanding the main drivers of vulnerability to climate change. One of the main objectives of this conference is to share preliminary findings from a recently completed short consortium project on climate change vulnerability and adaptation in South Asia and invite comments from experts. The project involves both top-down and bottom-up methods to understanding vulnerability in two separate regions in South Asia. The consortium partners are Center for Science Technology and Policy (CSTEP), Public Affairs Centre (PAC), Bangalore and Institute for Social and Environmental Transition (ISET), Nepal.

Another equally important objective of this conference is for participants to gain a broader understanding of the methods being used to assess vulnerability to climate change at the local level and at larger scales for certain sectors or across a state or region. We know that each approach has certain benefits and limitations, but what are the strategic opportunities and advantages for climate change adaptation offered by any given approach?

As a community of climate change researchers, we also need to think about the lessons and challenges related to linking the local to national development and climate policy. Both qualitative and quantitative methods as well as bottom-up and top-down approaches are valuable in this context and this conference would provide an opportunity to discuss possible synergies among them. For instance, what are the strategic elements that link local learning on vulnerability to the state and national policies? What are the linkages to overall development in an inclusive low carbon pathway? Finally, we would like to engage with and strengthen the larger community and network of people and organisations in South Asia that carry out both academic and community-level work on climate change adaptation.

Annex 6: List of Speakers at the Conference

Name	Organisation
Badiger, Shrinivas	ATREE, Bangalore
Bhardwaj, Anshu	CSTEP, Bangalore
Bhatt, Mihir	CDKN, New Delhi
Bhatt, Somya	GIZ, New Delhi
Bhattacharya, Sumana	Climate Change and Environment, Intercooperation Social Development, New Delhi
Bhushan, Chandra	CSE, New Delhi
Byravan, Sujatha	CSTEP, Bangalore
Chaturvedi, Rajiv	IISc, Bangalore
Das, Debapriya	CSTEP, Bangalore
Dasgupta, Purnamita	IEG, New Delhi
Dixit, Ajaya	ISET, Kathmandu
Downing, Tom	Global Climate Adaptation Partnership, Oxford
Gajjar, Sumetee	IIHS, Bangalore
Kelkar, Ulka	TERI, Bangalore
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