ASIA-PACIFIC NETWORK FOR GLOBAL CHANGE RESEARCH

ARCP Final Report



Project Reference Number: ARCP2015-09CMY-HEATH

Development of an evidence-based climate change adaptation toolkit to help improve community resilience to climate change impacts in Uttarakhand, India.

The following leading collaborators worked on this project:

1. Lance Heath, Sustineo/Australian National University, Australia, lance.heath@sustineo.com.au lance.heath@anu.edu.au, AUSTRALIA (Proponent)
2. Prakash Tiwari, Kumaun University, INDIA pctiwari@yahoo.com
3. Bedoshruiti Sadhukhan, ICLEI, INDIA, shruti.sadhukhan@iclei.org
4. Prem Chapagain Tribhuvan University NEPAL ps.chapagain@gmail.com
5. Ailikun, MAIRS, CHINA, aili@mairs-essp.org
6. Ashan Uddin Ahmed, Centre for Global Change, BANGLADESH, ahsan.ua@gmail.com
7. Paul McShane, Monash Sustainability Institute, Monash, AUSTRALIA, paul.mcshane@monash.edu

Table of Content

Figures

Tables

Project Overview

Project Duration	**:**	Jan 2014 – Dec 2017
Funding Awarded	**:**	US$ 40,000 for Year 1; US$ 45,000 for Year 2
Key organisations involved	**:**	Australian National University, ANU Climate Change Institute, Canberra, Australia ACT (Dr Lance Heath, Dr Geraldine Li, Dr Nasreen Khan, Dr Tingbao Xu, Assoc Prof Katherine Morton, Ms Colette Gilmour). Sustineo, Canberra, Australia ACT 2612 (Dr Lance Heath, Ms Minkyung Sul, Ms Emma Pankhurst, Ms Eleanor Robson, Ms Victoria Plbeam, Ms Dianne Manning). Kumaun University, Department of Geography, Nainital, Uttarakhand India (Professor Prakash Tiwari, Dr Bhagwati Joshi; Students: Mohan Singh, Ayush Tiwari, Kevala Dheeraj Pant, Kailash Chandra, Tewari, Vaseem, Rahul Kumar, Kevla Nand (Kumaun University, Bhimtal, Nainital, Abhinav Tiwari (National Institute of Technology, Bhopal, Pooja Nainwal) . ICLEI (International Council for Local Environmental Initiatives) South Asia Office, New Delhi, India (Mr Sunandan Tiwari, Ms Bedoshruiti Sadhukhan). Tribhuvan University, Central Department of Geography, (Assoc Prof Prem Chapagain, Dr Baijayanti Mala Pokhrel, Prof Narendra Raj Khanal). MAIRS, Institute of Atmospheric Physics, Chinese Academy of Sciences (Dr Ailikun). Southwest University, (Prof Jianzhong Yan). Institute of Atmospheric Physics, Chinese Academy of Science (Dr Shaukat Ali) School of Atmospheric Sciences, Nanjing University, (Dr Xiaorui Niu) School of Atmospheric Sciences, Lanzhou University (Dr Xiaodan Guan) Centre for Global Change (Dr Ashan Uddin Ahmed) Monash Sustainability Institute, Monash University (Dr Paul McShane, Dr Terence (Terry) Chan, Dr Jeremy Aarons, Mr Simon Rowntree).

Project Summary

The Himalaya-Tibetan Plateau, also known as the Water Tower of Asia or the Third Pole, is home to the highest mountains and glaciers in the world. Melt water from this huge reserve feeds major Asian river basins, such as the Indus, Ganges, Brahmaputra, Yangtze and Mekong. Changing monsoon patterns, more extreme weather events and continued glacial melting have long-term implications for the region's water, energy and food security. This project utilised the ICLEI/Asian Cities Climate Change Resilience Network (ACCCRN) toolkit, referred to as IAP Toolkit, to assist local governments assess their climate risks and vulnerabilities, and to make adaptive response plans accordingly. The IAP Toolkit was applied to the rural watershed of Ramgad in Uttarakhand, India and is the first rural jurisdiction in India to use the IAP. The IAP produced over 40 resilience interventions for vulnerable communities. The results of this work also revealed that adaptive capacity and resilience in this rural jurisdiction were much lower compared to those of urban settings. Perhaps, rural regions typically have less resources available to measure threats, disruptions and impacts compared to their city counterparts. There is also a lack of information to help communities to respond to climate induced threats and disruptions.

Keywords: Climate Change, Resilience, Adaptive Capacity, Himalaya, IAP Toolkit.

Project outputs and outcomes

Outputs	Outcomes
A Core Climate and Stakeholder Group was formed to implement the IAP	**The IAP identified five vulnerable rural systems for the Ramgad watershed**
The level of vulnerability and adaptive capacity to climate change impacts was determined	**A Vulnerability and Risk Assessment matrix was produced**
Over 40 Rural Intervention Strategies were developed	**Intervention strategies were developed**
	Intervention strategies were aligned with existing rural plans to combat climate change impacts
A recommendation was developed for determining the effectiveness of the IAP in rural areas	**Improvements in the IAP process for rural systems were identified**

Key facts/figures

Overall climate risks for the Ramgad Watershed are:

  - Climate Risk 1: Increase in temperature overall.
  - *Climate Risk 2: The wet season will become wetter with an increased incidence of extreme weather events resulting in more flash flooding and landslides.*
  - *Climate Risk 3: The dry season will become drier with more severe droughts.*

- Based on a series of rigorous discussions in the Shared Learning Dialogues (SLDs), five fragile systems were identified for the watershed of Ramgad.
  1. Availability and Supply of Water for Drinking and Irrigation
  2. Road Connectivity
  3. Community Health and Well Being
  4. Rural Livelihood and Economy
  5. Forest Resources
- The impacts derived from climate scenarios (increased temperature, decreased precipitation and an increase in extreme events), were then superimposed on all five fragile rural systems.
- The climate fragility statements for <u>Availability and Supply of Water for Drinking</u> and Irrigation are:
  - Climate Risk 1: A decrease in winter rainfall and an increase in temperature during winter will increase the gap between the demand and supply of water.
  - Climate Risk 2: An increase in rainfall and a decrease in summer temperatures could lead to high intensity rainfall and a change in groundwater dynamics (high runoff and a decrease in water-soil infiltration).
  - Climate Risk 3: Incidences of high intensity rainfall will disrupt and damage water infrastructure and distribution system.
  - Climate Risk 4: Water sources may become dry due to prolonged droughts thus affecting water availability.
- The Climate Fragility Statement for <u>Road Connectivity</u> is:
  - Climate Risk 1: Incidences of high intensity rainfall will disrupt roads and bridges which will in turn affect the rural economy, livelihood and community health.
- The Climate Fragility Statement for <u>Community Health and Wellbeing</u> is:
  - Climate Risk 1: Reduced availability of water will impact the rural food system, hygiene, sanitation and community health.
- The Climate Fragility Statement for <u>Rural Livelihood and Economy</u> is:
  - Climate Risk 1: A decrease in rainfall, frequent droughts and increasing incidences of high intensity rainfall will affect crop-rotation, agricultural productivity, livelihood, tourism and the rural economy.
- Fragility Statement for <u>Forest Resources</u> is
  - Climate Risk 1: Increase in temperature and a decrease in rainfall will increase the incidence of forest fire, loss of biodiversity, depletion of medicinal plants and a reduction in the availability of fuel-wood and fodder.
- The Risk Assessment revealed *high* to *extreme* risk for all rural systems
- The Vulnerability Assessment showed the villages Satbunga, Bohrakote, Naikana and Nathuwakhan highly vulnerable to the impacts of climate change
- Poor households, Women, Vegetable Growers, Tourist Enterprises and Fruit Producers are all vulnerable to the impacts of climate change
- The Actor analysis revealed Non-Government Organisations (NGOs), Tourist Enterprises, Health Department, Horticulture Department, Gram Panchayat, Forest

Department and Jal Sansthan are more effective at responding to shocks and disruptions than the other groups surveyed.

- The sensitivity of the IAP Toolkit scoring system could be improved to truly reflect the rural environment.
- Climate and hydrological data analysis could be improved by using the appropriate software
- A series of intervention strategies were developed for each rural system and these were prioritised according to their redundancy, flexibility, responsiveness, access to information, flexibility and impact.
- Over 40 Resilience Interventions were developed for the Ramgad watershed.
- Some of the intervention strategies are cost effective and could be implemented immediately while others require considerable injection of funds and the political willingness of policy makers to turn such intervention into a reality.
- Resilience interventions were integrated into the rural plans
- 8 Young scientist form Kumaun University were trained on using the IAP Toolkit

Potential for further work

This is the first time the IAP has been used in India in a rural context. The IAP was designed for use in cities and urban environments such as the city of Nainital. The IAP revealed, through the Shared Learning Dialogue (SLD) workshops, that some aspects relating to the scoring system could be improved to truly reflect the rural environment. The reasons for these observations are probably varied, but one reason for this difference is to do with the nature of rural systems and the fact that they typically have less resources to measure threats and their associated impacts. This is also compounded by the physical distances between cities that have better infrastructure and resources at their disposal (i.e better hospitals and equipment, human resources etc) and rural environments that quite often lack basic amenities, infrastructure and the ability to mobilise human resources *en masse*. Therefore, the IAP system of scoring may not be suitable for assessing the adaptive capacity of actors to respond to shocks and disruptions. An alternative ranking scale is required to reflect a more realistic level of adaptive capacity for each actor. This area of research should be explored and tested in more detail in future IAP studies that examine the adaptive capacity of rural environments.

Reliable climate information is essential to the quantitative assessment of climate impacts in mountain regions and for improving regional resilience and adaptive capacity to such impacts. Mountain regions have various regional climate characteristics, for example terrain-oriented rainfall patterns. Typically, mountainous regions of the Himalaya lack weather stations due to the steep and rugged terrain. This is the case for the Ramgad watershed in which there is only one weather station available at Mukteshwar. Therefore, the Ramgad watershed can be defined as a hydro-meteorological data deficit region. Software programs that use an elevation-dependent algorithm to create spatial representations of rainfall and temperature in mountainous regions should form the basis for further work in this area. The climate surface maps generated from these software packages can then be used with a high degree of confidence to model rainfall/runoff in agricultural catchments by using a suite of hydrological software. The results from this analysis can inform policymakers on a range of watershed management issues including the optimisation of rainfall capture and storage and to predict the bioclimatic distribution of organisms in response to a changing climate. It is highly recommended that future work should focus on the application of these software packages to

build a reliable account of the spatial distribution of rainfall and temperature across the Ramgad watershed. Consequently, it will also provide a greater understanding and knowledge of the hydrological and bioclimatic processes within the Ramgad watershed environment.

The IAP also revealed a major deficiency in the accessibility and flow of information to those most in need. The development of a Knowledge Management Framework can help improve the follow and accessibility of information to farmers, tourist operators, forest managers, community leaders and policymakers. Efforts should be made to initiate planning for the establishment of Knowledge Management Framework platform for the Ramgad.

Lastly, ICLEI with support from the Rockefeller Foundation, has finalised the IAP for the city of Nainital, which is approximately 40 km from the Ramgad watershed in the state of Uttarakhand, India. Because of the proximity of these two IAP study regions, future work should identify and examine crucial climate change adaptation linkages between the urban (City of Nainital) and rural (Ramgad rural watershed) sectors, and could form the basis for a new research endeavour.

Publications

Several scientific publications are currently planned for 2018

Awards and honours

No awards or honours

Pull quote

The application of the IAP Toolkit in developing countries has highlighted the importance of using such tools to build resilience and adaptive capacity for vulnerable communities in rural India. Australia can learn a lot from this experience too.

Dr Lance Heath (The Australian National University)

Acknowledgments

We gratefully acknowledge our collaborator ICLEI for the use of the IAP and a special thanks to Bedoshruiti Sadhukhan and Sunandan Tiwari from ICLEI for their in-kind support with the workshop facilitation and for conducting the IAP exercises with the Stakeholder Group. A special thanks to Professor PC Tiwari and his team of researchers and students for coordinating the field work and surveys. Lastly, we would like to thank APN and the APN Secretariat for their patience and support.

1. Introduction

The Himalaya-Tibetan Plateau, also known as the Water Tower of Asia or the Third Pole, is home to the highest mountains and glaciers in the world. Melt water from this huge reserve feeds major Asian river basins, such as the Indus, Ganges, Brahmaputra, Yangtze and Mekong. This region is home to an estimated 1.4 billion people or approximately one quarter of the world's population. These river basins support the wellbeing of some of the poorest people and most densely populated regions on the planet through the provision of water for drinking, irrigation and hydro-power generation (Heath et al.,2014). In addition, biomass based subsistence agriculture is the main form of rural livelihood and food supply in the Himalaya (Tiwari and Joshi, 2012a & b). However, changing monsoon patterns, more extreme weather events and continued melting of glaciers have long term implications for the region's water, energy and food security (Aase et al., 2013; IPCC, 2007a, band c and IPCCC, 2014).

The Himalayan region has seen an increase in the annual mean temperature and has borne the full brunt of climate change. Among the numerous complex outcomes, we can expect to see the increasing consequences of climate change for river flows, groundwater recharge, food and energy security, migration, ecosystem services and human livelihood. These have inextricable implications for the many and varied rural communities that call the Himalayas home, and has emphasised the need to strengthen resilience and adaptive capacity for some of the World's most vulnerable people. Building resilience to future climatic disruptions calls for a broad framework centred on system resilience and adaptive capacity and transformative adaptive capacity. From a policy perspective, mainstreaming adaptation into development and management strategies requires a proactive, holistic and systematic approach, that do not regard adaptation measures as something distinct or excluded from other policies. Local ownership of the adaptive process is critical in ensuring adoption and buy-in, and ultimately, its longevity and effectiveness. In relation to effective knowledge creation, the incorporation of local knowledge and peoples' perceptions are imperative to understanding the complex and rapid changes that impact on upstream communities in response to a rapidly changing climate.

This activity utilised the ICLEI/Asian Cities Climate Change Resilience Network (ACCCRN) toolkit, referred to as the ICLEI ACCCRN Process (or IAP) (ICLEI, 2014) to help local governments assess their climate risks and vulnerabilities, and to make adaptive response plans accordingly. The ACCCRN, which was pioneered by the Rockefeller Foundation, has supported practitioners to build inclusive urban climate change resilience in over 50 rapidly urbanising cities throughout Asia.

The aim of the project was to use the IAP to formulate a resilience strategy for the rural watershed of Ramgad in the state of Uttarakhand, India. This region is the second rural area in which the IAP has been trialled and it is the first for India. As part of the Asian Cities Climate Change Resilience Network (ACCCRN) program, ICLEI with support from the Rockefeller Foundation, has also formulated a Resilience Strategy for the city of Nainital located within 40kms of the Ramgad watershed. Both the APN and the ACCCRN funded projects will help identify crucial climate change adaptation and resilience linkages and strategies between the urban and rural sectors.

2. Methodology

The Ramgad Resilience Strategy was developed by using the ICLEI ACCCRN Process (IAP), (ICLEI, 2014), which was pioneered with support from Rockefeller Foundation. The IAP Toolkit has assisted communities within the Ramgad watershed to identify fragile rural systems, climate risks and vulnerable people and places, and to develop a series of resilience interventions. The IAP methodology or "workbook" is freely available on line at:

http://resilient-cities.iclei.org/fileadmin/sites/resilient-cities/files/Images_and_logos/Resilience_Resource_Point/ICLEI_ACCCRN_Process_WORKBOOK.pdf

2.1 Overview of ICLEI ACCRN Process (IAP)

The IAP Toolkit has a total of six phases containing a set of sixteen tools to enable local governments to evaluate the climate risks of various systems in the context of vulnerability, and to formulate and implement a series of resilience interventions in response to those fragile systems identified. The IAP workbook is available on-line free of charge and is presented in a step-by-step format, as shown in figure 1 below.

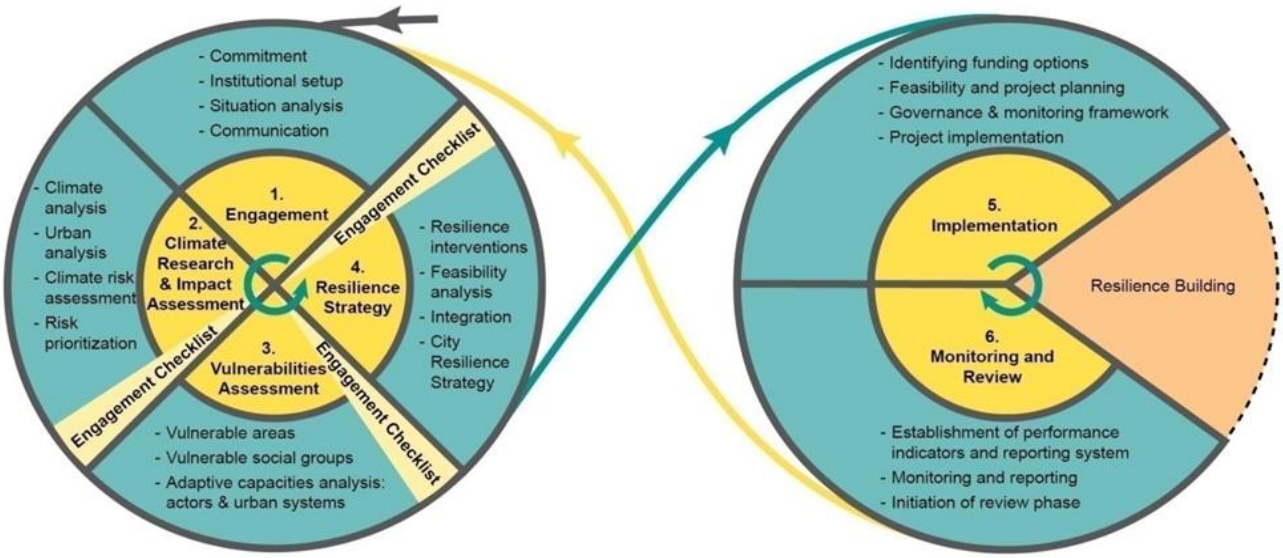


Figure 1. ICLEI ACCCRN Process (IAP) (ICLEI, 2014, p6)

Phase 1 - Engagement:

This first phase focuses on acquiring political support or "buy-in" from the relevant watershed authorities and community groups. It also allows for the formation of a Climate Core Team and Stakeholder Group. The Climate Core Team's primary responsibility is to ensure the proper execution of the project's activities through every phase of the process. Ideally, the climate core team should consist of representatives from Government Departments or individuals who are regarded as decision-makers within the community; whereas the Stakeholder Group is

normally convened by citizen representatives from various relevant institutions and organisations within the watershed. An important role of the Climate Core Team is to develop a communication plan to highlight key messages to be conveyed to the public and a plan for its implementation.

Phase 2 - Climate Research and Impact Assessment:

This phase involves a Shared Learning Dialogue (SLD) with the Climate Core Team and the Stakeholder Group. This interaction aims to have a mutual learning and sharing of experiences. An assessment of past climate trends and future climate projections is undertaken using climate research data which is then validated through analysis of regional climate data as well as local perceptions from rural stakeholders. Fragile systems are then identified, and a risk assessment is carried out to prioritise these rural systems in terms of their likelihood to be impacted by a changing climate and the associated consequences resulting from these impacts.

Phase 3- Vulnerabilities Assessment:

This phase identifies the key vulnerabilities of each fragile rural system. It determines the spatial vulnerability for each fragile system. It also identifies the vulnerable population and the potential supporting "Actors" for each system. This information is collected in consultation with the stakeholder group and the adaptive capacity of the rural systems is determined through the SLD process.

Phase 4- Resilience Strategy:

The relevant resilience interventions for the watershed are then identified from the results obtained from the previous phases. Resilience interventions are then prioritised according to a set of resilience indicators, their feasibility and applicability to the watershed. The next step is to develop and ratify the resilience strategy through political support.

Phase 5&6- Implementation and Monitoring & Review:

Following the identification of potential resilience interventions for the watershed, project implementation plans are then prepared and options for financing these projects are explored. At all times, the Government has the final mandate with respect to the monitoring and review process and the Climate Core Team maintains an active involvement during the entire process.

2.2 Rationale for the ICLEI ACCCRN Process (IAP) for the Ramgad Watershed

The Ramgad Watershed was identified for the implementation of the ICLEI ACCCRN Process (IAP) for the following reasons:

1) Climatic conditions in the Ramgad Watershed region are changing (change in precipitation, temperature and an increase in extreme weather events) leading to a decline in availability of water for drinking, irrigation and sanitation. These changes are having an adverse impact on community health, particularly for young children and women who are frequently affected by water-borne diseases.

2) These observed changes are also leading to a variety of hydrological hazards and disasters in the region. The incidences of flash floods have been increasing, resulting in frequent slope failures, landslides, debris and mud flow. A dramatic change in the amount of precipitation is causing agricultural droughts.

3) The policies and existing plans of government provide limited provision for climate change adaptation and risk governance.

4) Although significant advances in weather forecasting and climate modelling have been made over the last decade, leading to significant improvement in early warning systems and long-term adaptation planning, the use or reliance on these climatic models and projections for the Earth's future climate is not enough to help vulnerable communities build resilience and adapt to a changing climate. The IAP toolkit incorporates bio-physical, socio-economic, and cultural data to assess risk and identify vulnerabilities.

5) IAP was originally designed for use in cities and has not been used in a rural context in India. Clearly, there was a need to develop a new toolkit from scratch or to enhance the relevance of the IAP toolkit for peri-urban and rural areas. This APN ARCP project has created an opportunity to develop a toolkit for rural areas.

6) Ramgad provides food and other resources to the city of Nainital, a popular lakeside tourist destination for many Indians and foreigners. The project will allow for the investigation of rural and city linkages at a later date.

Figure 2 summarises the impacts of changing climatic conditions on ecosystem services and socio-economic sectors in the Ramgad watershed.

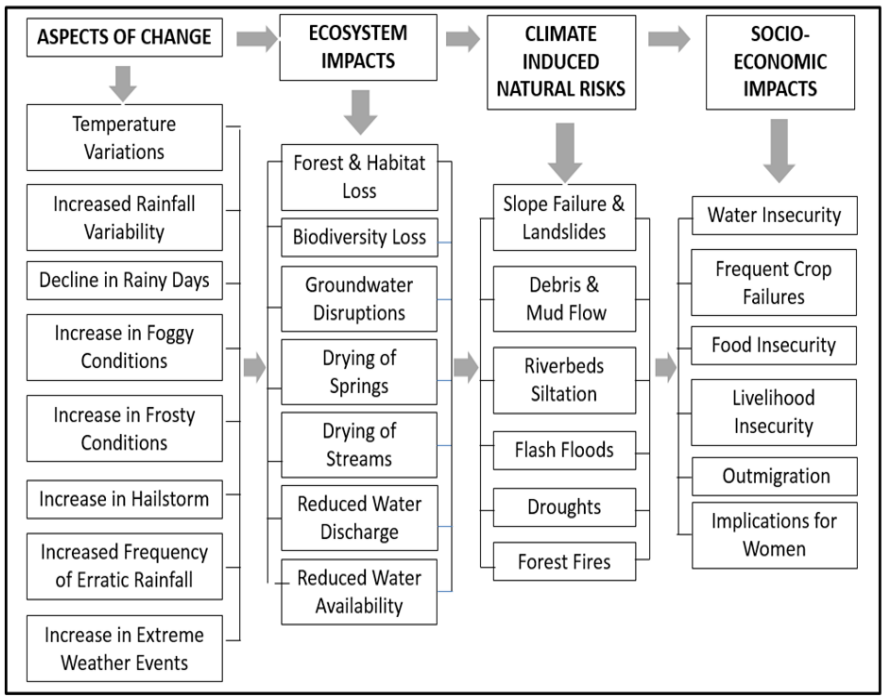
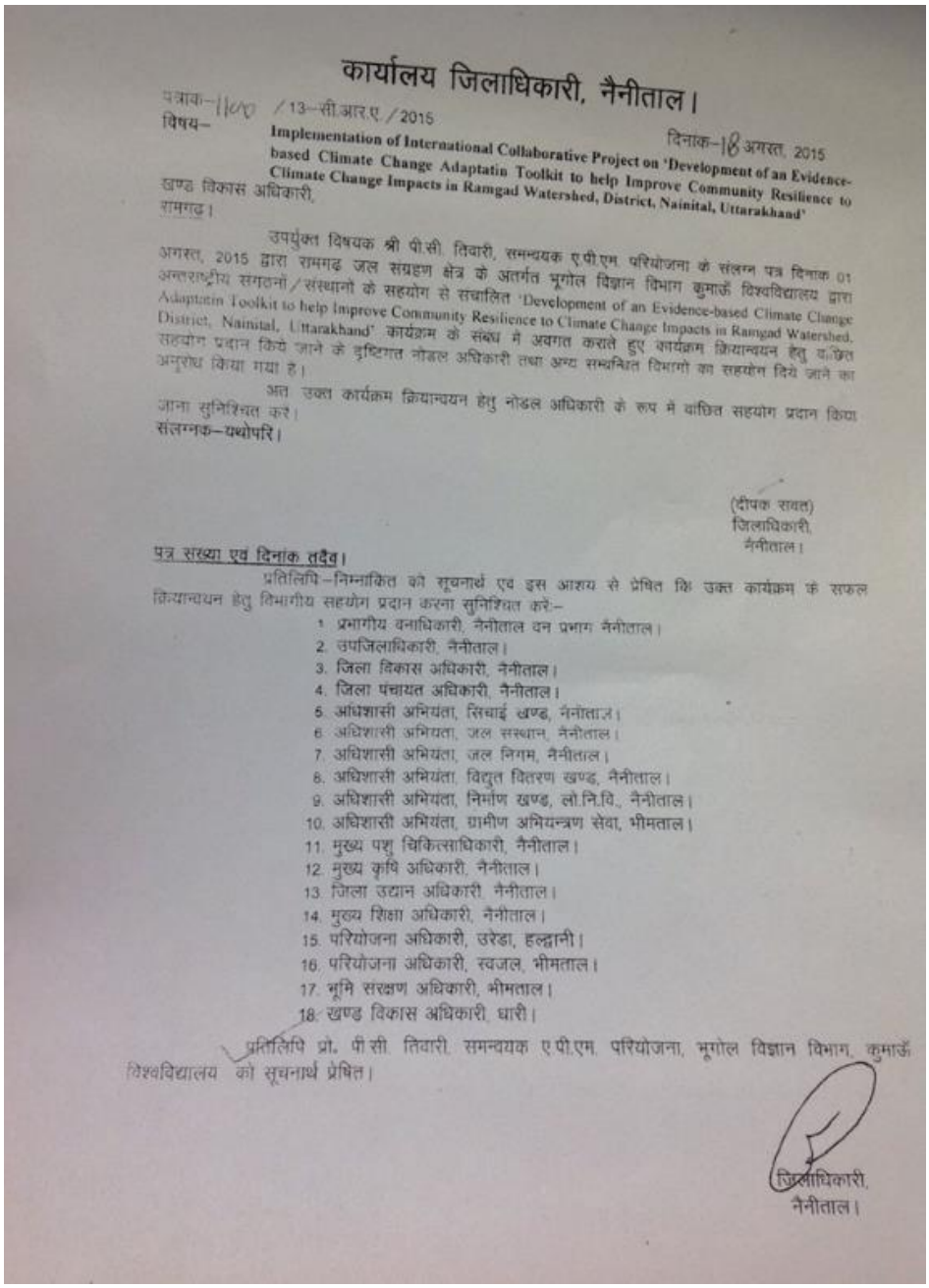


Figure 2. The impacts of changing climatic conditions on ecosystem services and socio-economic sectors (From Tiwari and Joshi 2015, p18)

2.3 Engagement (Phase 1)

Since the IAP methodology follows a participatory approach, stakeholders from the Ramgad watershed identified key stakeholders and the Climate Core Team for implementation of the IAP. The Ramgad watershed District Counsellor spearheaded the IAP with support from Kumaun University and ICLEI South Asia. A Memorandum of Understanding (MOU) was signed by the relevant authorities to proceed with the IAP implementation. Figure 3 is a copy of the signed MOU.



कार्यालय जिलाधिकारी, नैनीताल।

पत्रांक–1107 /13–सी.आर.ए./2015 दिनांक–18 अगस्त, 2015

विषय– **Implementation of International Collaborative Project on 'Development of an Evidence-based Climate Change Adaptatin Toolkit to help Improve Community Resilience to Climate Change Impacts in Ramgad Watershed, District, Nainital, Uttarakhand'**

खण्ड विकास अधिकारी,
रामगढ़।

उपर्युक्त विषयक श्री पी.सी. तिवारी, समन्वयक ए.पी.एम. परियोजना के संलग्न पत्र दिनांक 01 अगस्त, 2015 द्वारा रामगढ़ जल संग्रहण क्षेत्र के अंतर्गत भूगोल विज्ञान विभाग कुमाऊँ विश्वविद्यालय द्वारा अन्तर्राष्ट्रीय संगठनों/संस्थानों के सहयोग से संचालित 'Development of an Evidence-based Climate Change Adaptatin Toolkit to help Improve Community Resilience to Climate Change Impacts in Ramgad Watershed, District, Nainital, Uttarakhand' कार्यक्रम के संबंध में अवगत कराते हुए कार्यक्रम क्रियान्वयन हेतु वांछित सहयोग प्रदान किये जाने के दृष्टिगत नोडल अधिकारी तथा अन्य सम्बन्धित विभागों का सहयोग दिये जाने का अनुरोध किया गया है।

अतः उक्त कार्यक्रम क्रियान्वयन हेतु नोडल अधिकारी के रूप में वांछित सहयोग प्रदान किया जाना सुनिश्चित करें।

संलग्नक–यथोपरि।

(दीपक रावत)
जिलाधिकारी,
नैनीताल।

पत्र संख्या एवं दिनांक तदैव।

प्रतिलिपि–निम्नांकित को सूचनार्थ एवं इस आशय से प्रेषित कि उक्त कार्यक्रम के सफल क्रियान्वयन हेतु विभागीय सहयोग प्रदान करना सुनिश्चित करें:–

1. प्रभागीय वनाधिकारी, नैनीताल वन प्रभाग नैनीताल।
2. उपजिलाधिकारी, नैनीताल।
3. जिला विकास अधिकारी, नैनीताल।
4. जिला पंचायत अधिकारी, नैनीताल।
5. अधिशासी अभियंता, सिंचाई खण्ड, नैनीताल।
6. अधिशासी अभियंता, जल संस्थान, नैनीताल।
7. अधिशासी अभियंता, जल निगम, नैनीताल।
8. अधिशासी अभियंता, विद्युत वितरण खण्ड, नैनीताल।
9. अधिशासी अभियंता, निर्माण खण्ड, लो.नि.वि., नैनीताल।
10. अधिशासी अभियंता, ग्रामीण अभियन्त्रण सेवा, भीमताल।
11. मुख्य पशु चिकित्साधिकारी, नैनीताल।
12. मुख्य कृषि अधिकारी, नैनीताल।
13. जिला उद्यान अधिकारी, नैनीताल।
14. मुख्य शिक्षा अधिकारी, नैनीताल।
15. परियोजना अधिकारी, उरेडा, हल्द्वानी।
16. परियोजना अधिकारी, स्वजल, भीमताल।
17. भूमि संरक्षण अधिकारी, भीमताल।
18. खण्ड विकास अधिकारी, धारी।

प्रतिलिपि प्रो. पी.सी. तिवारी, समन्वयक ए.पी.एम. परियोजना, भूगोल विज्ञान विभाग, कुमाऊँ विश्वविद्यालय को सूचनार्थ प्रेषित।

जिलाधिकारी,
नैनीताल।

Figure 3. Memorandum of Understanding (MOU) signed letter from Ramgad Watershed District Counsellor

Stakeholder engagement workshop (Nainital 2015) (Photo Lance Heath)

Following the formation of the Climate Core Team and Stakeholder Group, a baseline questionnaire was undertaken to identify whether the impacts of climate change have been recognised in the watershed and how those impacts influence activities in development sectors. The questionnaire also identifies what kind of support administrators and policy makers can acquire to respond effectively to shocks and disruptions. The aim of the baseline questionnaire is to also collect social-economic data and information for informing the IAP.

2.4 Climate Research and Impact Assessment (Phase 2)

For the Ramgarh region in the district of Nainital in India, downscaled climate change projections were derived for this region from the CORDEX South Asia domain (50 km resolution). The climate projections were based on the Intergovernmental Panel on Climate Change (IPCC) A1B emission scenarios for the time period 2041 - 2060 compared to the baseline period (1981-2000). Changes in seasonal mean minimum and maximum temperatures were determined for the Ramgarh region, India. An analysis of past climate was also undertaken with data obtained from the Indian Meteorological Department.

A participatory workshop or SLD was conducted with the Stakeholder Group and Climate Core Team to identify and discuss the fragile rural systems for the Ramgad watershed. The process identified and prioritised five rural systems. The results of this analysis are discussed in section 3 under the heading of results and discussion. A timeline of hazards and past extreme weather events was also constructed.

The five fragile rural systems identified were then critically analysed considering both the direct and indirect impacts of climate risks based on the historical climate data and future climate change projections.

Each fragile rural system is defined by a climate fragility statement or series of statements. A risk assessment matrix is then devised to assess the status of each climate risk statement(s) by determining the likelihood and consequence of each statement occurring. A rating and scoring system is used for both the likelihood and consequence. The description of each is shown in Table 1 & 2.

Students from Kumaun University, Nainital who took part in the IAP (2015) (Photo: Lance Heath)

Table 1. Likelihood rating and scoring system from the ICLEI/ACCCRN IAP workbook

Likelihood rating	Description	Score
Almost certain	Is highly likely to occur, could occur several times per year. Likelihood probably greater than 50%	5
Likely	Reasonable likelihood, may arise once per year. Likelihood 50/50 chance	4
Possible	May occur, perhaps once in 10 years Likelihood less than 50% but still quite high	3
Unlikely	Unlikely but should still be considered, may arise once in 10 to 25 years	2
Rare	Likelihood probability significantly greater than zero. Unlikely in foreseeable future – negligible probability	1

Table 2. Consequence rating and scoring system from the ICLEI/ACCCRN IAP workbook

Consequence rating	Impact on system	Impact on poor and vulnerable	Score
Catastrophic	System fails completely and is unable to deliver critical services,, may lead to failure of other connected systems	Severe impacts on poor and vulnerable groups in the city leading to situations of extreme destitution	5
Major	Serious impact on the system's ability to deliver critical services, however not complete system failure;	Loss of confidence and criticism in city government; ability to achieve city vision and mission seriously affected; Significant impacts on poor and vulnerable groups in the city that seriously affects their lives and livelihoods	4
Moderate	System experiences significant problems, but still able to deliver some degree of service	Moderate impacts on the lives and livelihoods of the poor and vulnerable groups in the city	3
Minor	Some minor problems experienced, reducing effective service delivery, possibly affecting certain other systems or groups	Minor impacts on the lives and livelihoods of the poor and vulnerable groups in the city	2
Insignificant	Minimal impact on system – may require some review or repair, but still able to function	Minimal impacts on the lives and livelihoods of the poor and vulnerable groups in the city	1

The climate is determined by multiplying the likelihood by its consequences. For example, a likelihood value of 5 (almost certain) times its consequence, also 5 (Catastrophic) results in an overall risk score of 25 which is “Extreme”. A risk matrix table is developed summarising the risk for each rural system and its climate fragility statement(s) (Table 3).

Table 3. Risk matrix table (Source: ICLEI/ACCCRN IAP Workbook)

Likelihood	Consequences				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	Medium (RS* = 5)	Medium (RS = 10)	High (RS = 15)	Extreme (RS = 20)	Extreme (RS = 25)
Likely	Low (RS = 4)	Medium (RS = 8)	High (RS = 12)	High (RS = 16)	Extreme (RS = 20)
Possible	Low (RS = 3)	Medium (RS = 6)	Medium (RS = 9)	High (RS = 12)	High (RS = 15)
Unlikely	Low (RS = 2)	Low (RS = 4)	Medium (RS = 6)	Medium (RS = 8)	Medium (RS = 10)
Rare	Low (RS = 1)	Low (RS = 2)	Low (RS = 3)	Low (RS = 4)	Medium (RS = 5)

2.5 Vulnerability Assessment (Phase 3)

Another Shared Learning Dialogue (SLD) session was convened to undertake a vulnerability assessment for the Ramgad watershed. The aim of this SLD exercise was to critically evaluate the sensitivity, exposure and adaptive capacity of the five fragile rural systems and to identify vulnerability “hotspots”, thus reflecting the fragility of districts within the Ramgad watershed. These “hotspots” were arrived at by overlaying all the vulnerable districts identified under each fragile rural system.

This phase of the toolkit involves producing maps of the high priority climate risks and to assess the impact on the most vulnerable groups of people within the community. Supporting groups or “Actors” who can assist those most vulnerable to climate change impacts are then identified. The identification of key supporting groups (“Actors”) is an essential first step in improving adaptive capacity.

The IAP states that the “Actors” (i.e. individuals, households and public/private sector organisations), play a critical role towards building rural resilience. Their ability to contribute to resilience and adaptation is broadly dependent upon the following three key capacities quoted from the IAP Workbook:

Capacity to organise and respond - the capacity to organise and re-organise in response to threat or disruption. For example, slum communities residing in a flood prone area have received training on how to purify water for drinking and maintaining hygienic conditions to prevent the outbreak of post flood diseases. Or, trained Search and Rescue Teams exist within the community that can respond effectively during floods.

Resources – access to the resources necessary to respond (manpower, technology, funds) Example: slum communities residing in a flood prone area have been provided with water filters that will ensure that they have safe drinking water even during flood situations. Or, the Search and Rescue Teams have the necessary equipment and medicines.

Access to information – availability of data and information necessary to develop effective plans and actions and to improve responses to disruptions. Example: slum communities residing in a flood prone area have access to improved information that can be locally managed e.g. Early Warning Systems, which would enable them to respond more effectively. Or, regular refresher and updating training courses for the members of the Search and Rescue Teams. Actors are rated and scored for each of the three capabilities as shown in Table 4.

The level of adaptive capacity of rural actors is determined from the adaptive capacity score derived from Table 4 and is assigned an adaptive capacity ranking of low, medium or high (Table 5).

Table 4. Capabilities Rating and Scoring (Source: ICLEI/ACCCRN IAP Workbook)

Key Capacities of Actors	Score
Capacity to Organise and Respond	
Low capacity to organise and re-organise in response to threat or disruption	1
Medium capacity to organise and re-organise in response to threat or disruption	2
High capacity to organise and re-organise in response to threat or disruption	3
Resources	
Low access to the resources necessary to respond (manpower, technology, funds)	1
Medium access to the resources necessary to respond (manpower, technology, funds)	2
High access to the resources necessary to respond (manpower, technology, funds)	3
Access to Information	
Low availability of data and information necessary to develop effective plans and actions and to improve responses to disruptions	1
Medium availability of data and information necessary to develop effective plans and actions and to improve responses to disruptions	2
High availability of data and information necessary to develop effective plans and actions and to improve responses to disruptions	3

Table 5. Levels of Adaptive Capacity of Rural Actors (Source: ICLEI/ACCCRN IAP Workbook)

Adaptive Capacity Score	Level of Adaptive Capacity
1 – 8	Low
9 – 17	Medium
18 – 27	High

The next step in the IAP is to determine the adaptive capacity of the rural systems. This is the capacity of systems to absorb shocks and their response to these shocks. It therefore plays an important role in determining the resilience of these systems. The adaptive capacity of each fragile rural system of the Ramgad watershed was determined based on the guiding questions outlined in the IAP workbook (Page 85).

For each fragile rural system, we described its adaptive capacity in terms of five broad categories:

Economic: does the system have the financial resources to undertake the necessary actions to manage Climate Change – e.g. budget allocation, tax base, ability to charge fees? Is it able to operate as a "business" or does it follow the traditional public service model?

Technology/ Infrastructure: does the system have the necessary technological knowledge and resources? Is current infrastructure adequate to cope with additional stresses from Climate Change? Are major changes to technology needed? What is the capacity to introduce required changes?

Governance: is responsibility for this system clearly established? Does the responsible entity have the necessary authority to make the required changes? Is there sufficient support from higher levels of government? Are the stakeholders coordinated and supportive of necessary change?

Social: does the community have the understanding and resources necessary to play their part in this system? Does the system have in-built mechanisms to incorporate community and user input and feedback? Does the system recognize the needs of poor and vulnerable groups in the community?

Ecosystems: what is the capacity of this system to protect or restore the ecosystem? Is there adequate understanding and data about the current status of the different ecosystems within the city, their strengths and weaknesses?

For each fragile system five categories of adaptive capacity are then ranked as high/medium/low (Table 6). A second table combines the actor analysis with the adaptive capacity of the rural systems (Table 7).

Table 6. For each fragile system five categories of adaptive capacity are then ranked as high/medium/low (Source: ICLEI/ACCCRN IAP Workbook).

Fragile urban system	Economic	Technology/ Infrastructure	Governance	Societal	Ecosystem Services
e.g. Water supply	**Low** (funds not available for new infrastructure)	**Medium** (access to improved technology can be accessed through engagement of private companies)	**Medium** (coordination with Irrigation and Public Health Dept to be improved)	**High** (increasing demand from citizens for improved water supply systems)	**Low** (water bodies being lost in the city)

Table 7. Bringing it all together: Assessing the Adaptive Capacity of the Rural or Urban System (Source: ICLEI/ACCCRN IAP Workbook)

Climate Fragility Statements	Vulnerable Areas	Urban Actors		Adaptive Capacity of the System		
		Vulnerable Actors	Potential Supporting Actor	Low	Medium	High
e.g.: Contamination of water supply due to flooding made worse by lack of alternative sources	*Ward 5*	• *Slum Dwellers* • *Resident Welfare Association* • *NGOs*	• *Private sector* • *Water Authority*	*Economic* *Ecosystem Services*	*Technology* *Governance*	*Societal*

2.6 Gap Analysis

Having determined and assessed the key fragilities of the Ramgad watershed's critical rural systems, this section of the IAP methodology highlights the various data gaps present in these systems by identifying the need for more data to be collected or further research to be undertaken for a given system. The scoping exercise, climate ready review, and urban system analysis collectively help in gathering data about these systems. This section draws from the information gathered under these IAP tools.

2.7 Resilience Strategy (Phase 4)

A list of resilience interventions targeting improved rural resilience and reduced climate risk for all fragile rural systems was developed. For this part of the IAP, the proposed interventions are first assessed for their contributions to urban resilience using a set of resilience indicators, namely: Redundancy, Flexibility, Responsiveness and Access to Information (Table 8). The higher scoring interventions are then assessed for feasibility and impact based on their Technical, Political and Financial or Cost feasibility and their applicability to the Ramgad watershed (Table 9).

The link between these resilience interventions with on-going and planned projects was established and their potential to be integrated into existing rural plans was explored. A communication plan was also developed for the project.

Table 8. Prioritising Resilience Interventions (Source: ICLEI/ACCCRN IAP Workbook)

Potential Climate Resilience Interventions	Resilience Indicators				Overall Resilience 4/4: High 3/4: Medium 2/4: Average 1/4: Low
	Redundancy (yes/no)	Flexibility (yes/no)	Responsiveness/ re-organisation (yes/no)	Access to Information (yes/no)	
e.g. Roof top water harvesting to be made mandatory to deal with water stress due to anticipated increasing temperatures and decreasing precipitation	*Yes* *Supports a higher degree of self sufficiency at the household level*	*Yes* *System allows for water to be channelized towards recharging groundwater as well*	*Yes* *In case of shutdown of the city's water supply system, households have stored rainwater for use*	*No* *City helplines exist, but responsibility lies with individual households*	*Medium*

Table 9. Feasibility and Impact Scoring Sheet (Source: ICLEI/ACCCRN IAP Workbook)

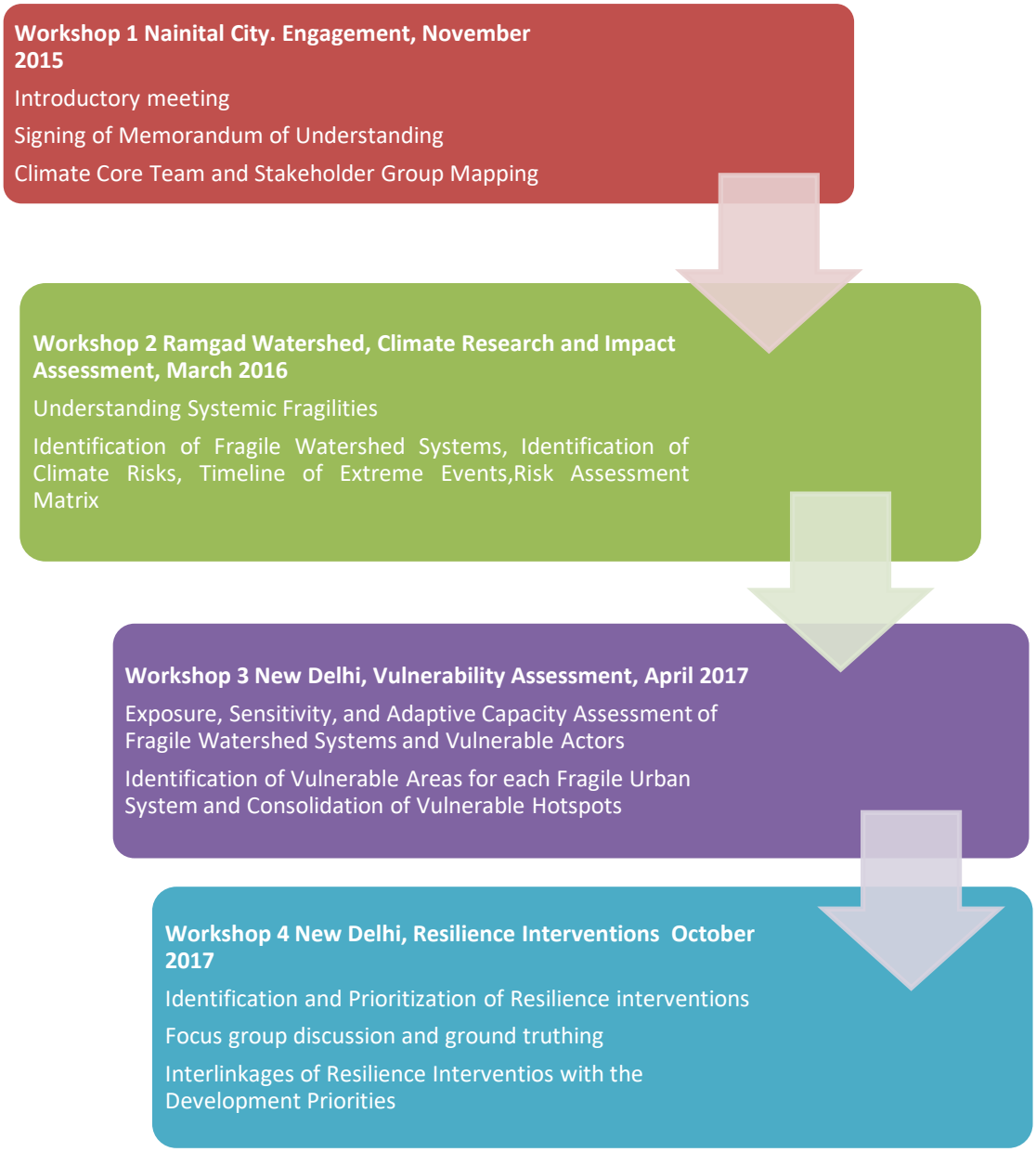
Feasibility				Impact
Potential Climate Resilience Interventions	Technically (high/medium/low)	Politically (high/medium /low)	Cost (high/medium /low)	(short/medium/long term)
e.g. Roof top water harvesting to be made mandatory to deal with water stress due to anticipated increasing temperatures and decreasing precipitation	High (technology is easily available)	Medium (would require a change in building by- laws and building codes)	High (not an expensive option to implement with substantial results)	Short term

The last step in the IAP is linking resilience interventions to ongoing programs. According to the IAP Workbook: the watershed management authorities are more than likely to have a comprehensive set of on-going plans, programs and projects. Wherever possible, climate resilience interventions should be linked with, or built into, existing departmental plans, programs and projects. It more practical for policy makers to integrate the resilience strategies into existing plans, programs and projects than to adopt a new set of initiatives and plans. This approach should strengthen the resilience of the watershed and at the same time reduce the need for unnecessary duplication. Each resilience intervention is then assessed to determine whether it belongs to an existing program or whether it is an ongoing/upcoming or planned intervention (Table 10).

Table 10. Linking Resilience Interventions to on-going Programs (Source: ICLEI/ACCCRN IAP Workbook)

Resilience Interventions	Relevant Programs	Ongoing/upcoming/ planned	Can the program be leveraged – yes/no; if yes how?
e.g. Roof top water harvesting to be made mandatory to deal with water stress due to anticipated increasing temperatures and decreasing precipitation	*Housing Scheme for the Urban Poor*	*Upcoming (following financial year)*	*Yes. Design of buildings can be modified to include a rooftop water harvesting and safe storage system*

Figure 4. Timeline of the various IAP phases followed in Ramgad Watershed.



3. Results & Discussion

3.1 Rural Profile

3.1.1 Location and watershed characteristics

Ramgad watershed is situated in the Lesser Himalayan ranges in the district Nainital in the newly carved Himalayan State of Uttarakhand (Figure 5). The watershed is between 29°24' to 29°29' N latitudes and 79°29' to 79°39'E longitudes and encompasses a geographical area of nearly 75.8 km^2 and is between 1025 and 2346 m in altitude. Ramgad is the one of principal tributaries of River Kosi and is characterised by several geological formations evidenced by rock displacement, slope failure and multi-cyclic river terraces.

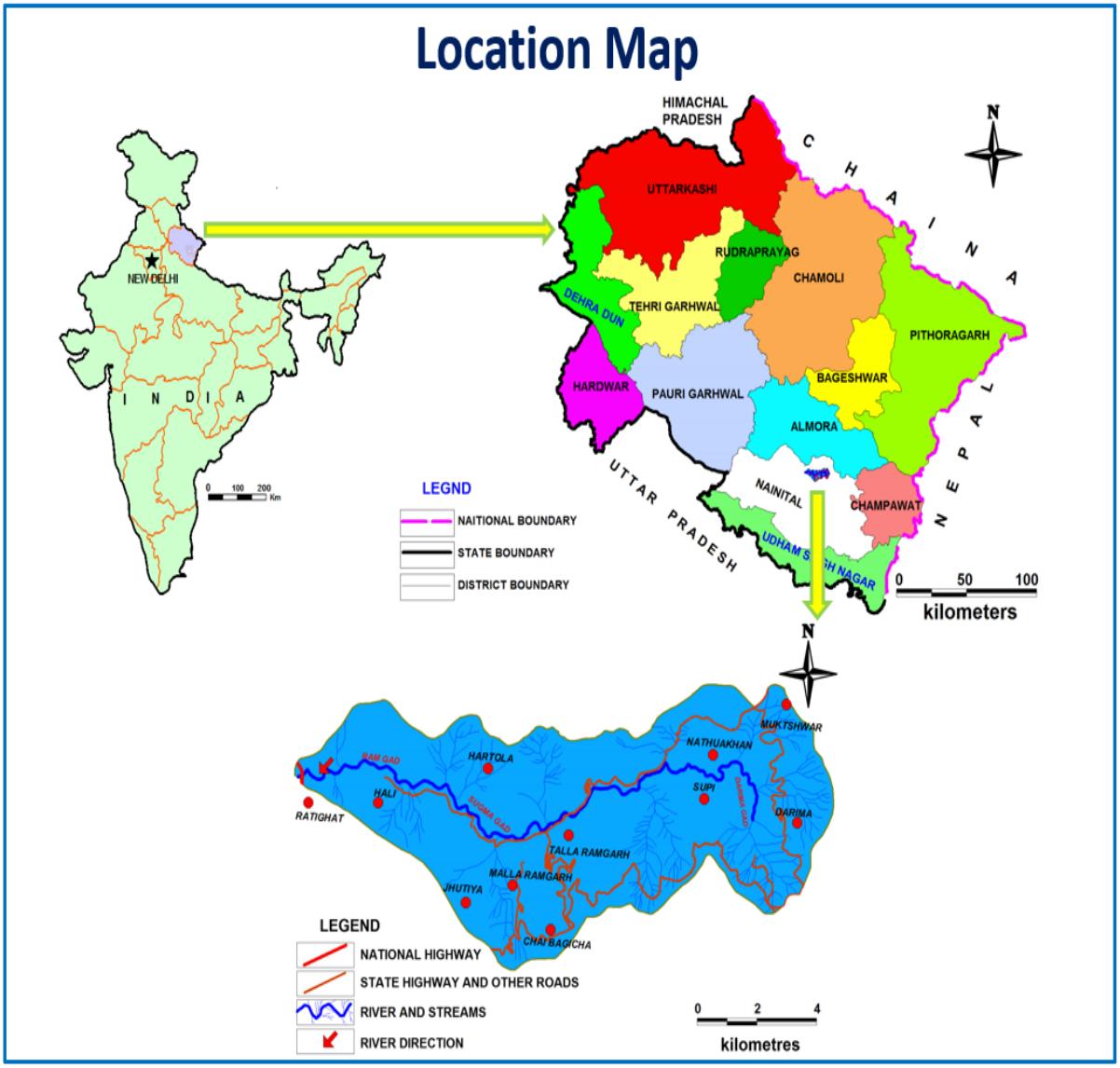


Figure 5. Ramgad Watershed situated in the lesser Himalayan ranges in the State of Uttarakhand (Source: Kumaun University, Department of Geography).

As in other parts of the Himalaya Mountains, natural streams and springs constitute the main sources of rural water supply (Figure 6).

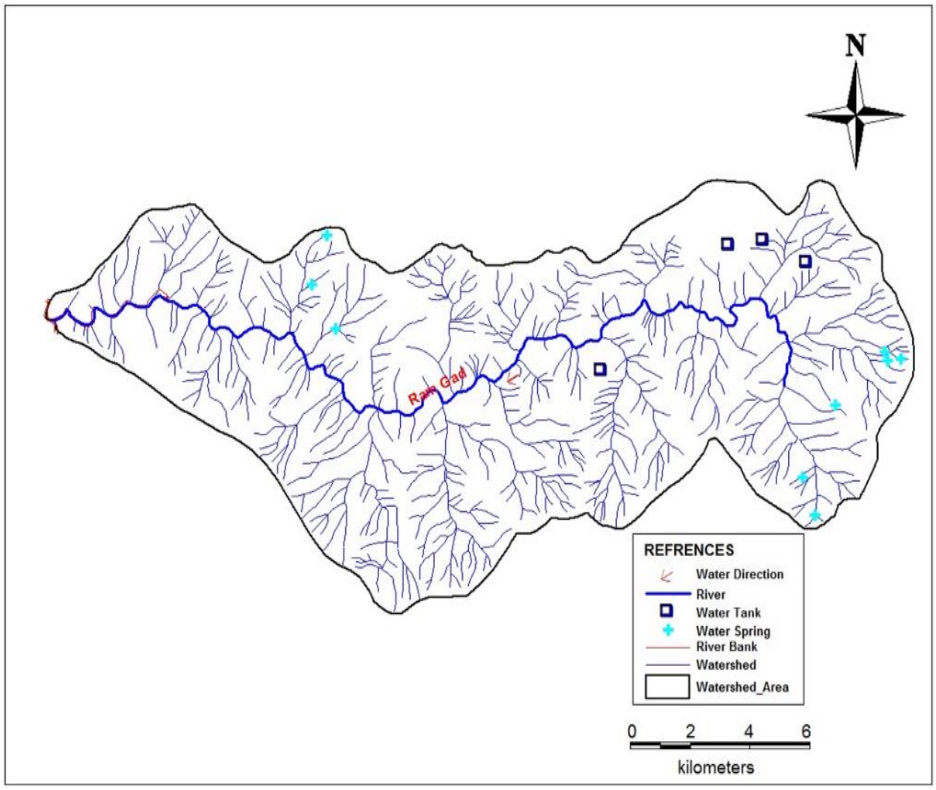


Figure 6. Ramgad river basin showing the delineated watershed and accompanying streamlines (Source: Kumaun University, Department of Geography).

Out of the total geographical area (75.80 km^2) of the headwater, 39.80 km^2 or 52.51% is forested of which more than 75% is controlled and managed by Forest Department of Uttarakhand. This category of forest has been designated as Reserved Forest and is situated outside the village boundaries.

The community forests are within the village boundaries, which mainly consists of Civil Forests, Panchayat Forests and the Joint Forest Management (JFM). More than 24.24 km2 or 31.98% of total area of the watershed is under agricultural production, whereas surface water resources are confined to 1.16 km2 or to 1.54% of the total area of the watershed. As in other parts of Kumaun Lesser Himalaya, the traditional forest based subsistence farming constitutes the main source of rural livelihood (Tiwari and Joshi 2012a). However, the process of natural resource development has been changing rapidly, mainly in response to population growth and this has resulted in an increase in the demand for food, fodder, fuel wood and other natural resources. Consequently, the activities of cultivation, horticulture, tourism and grazing are extended over large areas of the region. These changes are resulting in the exploitation of natural resources, land use intensification, and disruption of mountain ecosystem services. The resource utilisation profile for the Ramgad watershed is shown in Figure 7.

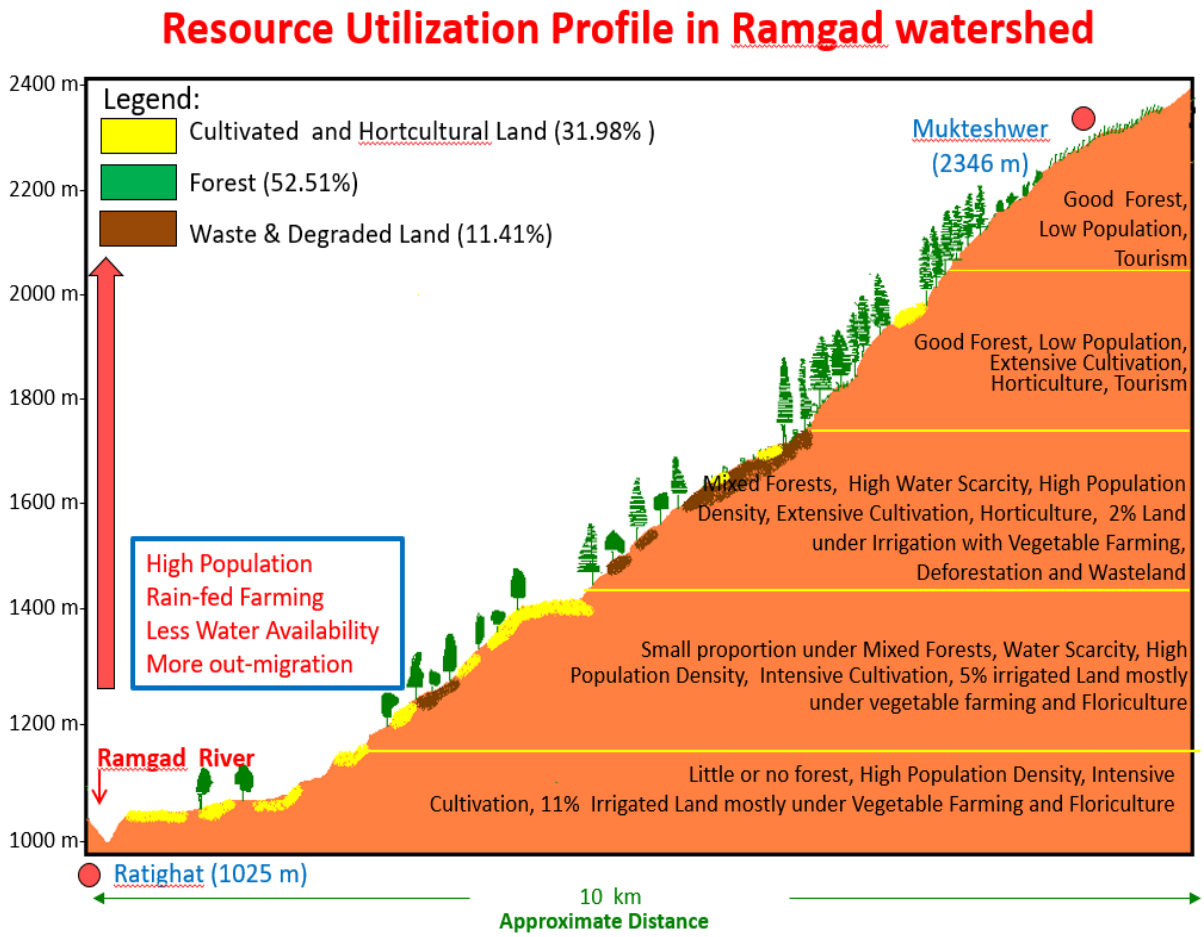


Figure 7. Ramgad resource utilisation profile (Source: Prakash C. Tiwari, Kumaun University, Department of Geography).

The Ramgad watershed is a hydro-meteorological data deficit region as there is only one weather station located at Mukteshwer. Table 11 summarises the natural and geographical profile of the Ramgad watershed.

Table 11. Summary of Natural and Geographical profile

Natural Parameters	Current
Total Geographical Area	75.8 km2
Altitude	Between 1025 and 2346
Total Length of Master Stream	25.81 km (with a fall of 1025 m)
Agricultural Land	32% of Total Geographical Area
Forest Area	53% of Total Geographical Area

3.1.2 Demographic profile

The total population of the headwater is around 22,000 persons in 2015, with 31 revenue villages. Out of the total population, 51% are males and 49% are females. The population density is around 287 persons/ Km^2 and more than 90% of the population has an average land holding of around 1 hectare. Table 12 summarises the Socio-economic Parameters for the Ramgad watershed.

Table 12. Socio-economic Parameters

Socio-economic Parameters	Current
Natural Location	Lesser Himalaya (Middle Himalaya)
Administrative Location	District Nainital, Ramgarh Block, Uttarakhand
Villages	31 Villages
Total Population	21751 Persons (51% Males and 49% Females)
Population Density	287 Persons/Km^2
Land Holding Size	1 ha (more than 90%)
Forest Councils	In 22 Villages

3.1.3 Rural Administration

The administrative location of the Ramgad is situated in District Nainital, Ramgarh Block, in the state of Uttarakhand, India. The Ramgad watershed has a Chief Development Officer who oversees administration of the entire catchment and its 26 Villages.

Other than the council, nodal agencies for providing public amenities and administration, agencies/departments of state government that are directly involved in Ramgad planning and development at the national, state and district level are as follows:

National Level

- Indian Institute of Remote Sensing
- Indian Veterinary Research Institute (GOI)

State Level

- Uttarakhand: Chief Development Officer District

District

- District: Nainital
- Tahsil: Sub Divisional Magistrate
- Dev Block: Ramgarh
- Village council (one for each village: total of 26)

Relevant Government Departments

- Agricultural
- Drinking Water
- Medical
- Public Works
- Livestock
- Irrigation
- Forrest
- Electricity
- Soil Conservation
- Education
- Transportation
- Rural Engineering Services
- Horticulture
- Tourism

Ramgad Watershed with the greater Himalaya in the background (Photo: Prakash.C Tiwari).

3.2 Past Hazards & Climatic Events

The state of Uttarakhand is highly prone to natural disasters ranging from seasonal events such as forest fires, cloudbursts and flush flooding to unpredictable disasters such as earthquakes.

The Lesser Himalaya is vulnerable to landslides and the Ramgad region falls in the Zone IV of earthquake zoning map of India (Government of Uttarakhand, 2011). Zone IV is categorised as “severe to very severe”. The Ramgad is also subject to landslides caused by excessive rainfall and runoff. During the summer months the watershed also experiences wild forest fires.

A timeline of hazards and extreme weather events was constructed based on historical records and peoples’ perceptions. Figure 8 is the resulting timeline of events and their associated impacts on the community of Ramgad.

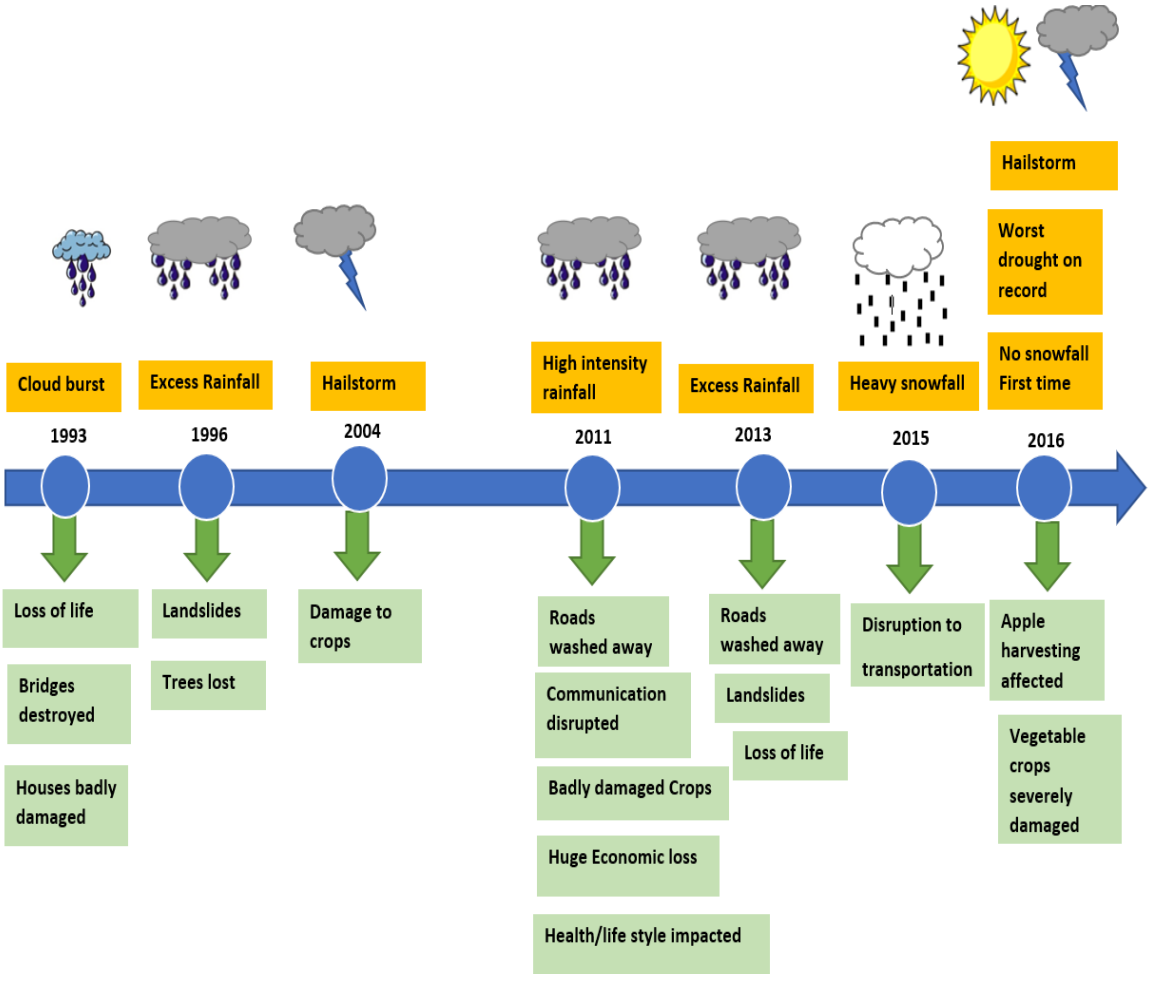


Figure 8. Timeline of hazards and extreme weather events and their impact on the community of Ramgad.

3.3 Climate Scenarios in the Watershed

Since the altitude of the Ramgad watershed varies from 1025 m to 2346 m from the mean sea level, the region experiences varying micro-climatic effects. Broadly speaking, the watershed catchment area comes under cool temperate climatic conditions. There is a great contrast between the climate of the valleys and that of the up-slopes, high altitude areas and exposed ridges.

Since the meteorological data are available only for Mukteshwar, situated at an altitude of 2346 m on northern water divide, it would not have been possible to interpret precisely the micro-climatic variations across the watershed. The wide valleys areas have sub-tropical climatic conditions, whereas, the ridges and mountain ranges experience cool temperate climate. However, it can be deduced, based on the continuous field observations in the area during the last three years, that the altitude, slopes and its aspect, exposure and direction of mountain ranges and valleys, regulates the distribution of temperature in the region.

The altitudinal differences observed in the region results is a very high degree of variation in the distribution of temperature over short spatial distances. The temperature decreases rapidly as one moves up from the valley floors to higher altitude areas. The climatic conditions of enclosed valley floors are entirely different from those of exposed ridges. Mukteshwar situated on the ridge has a mean monthly temperature ranging from 3.60 °C in the month of February to 15.22 °C in the month of June with an annual average of 10.74 °C. Since, there are large altitudinal variations in the region, the temperature at lower elevations and particularly at the valley floor is much higher. An analysis of the spatial distribution (as opposed to the sole use of point data) in rainfall and temperature would help provide a more realistic understanding of the changes in climate across the watershed over time.

Mountain regions have various regional climate characteristics, for example terrain-oriented rainfall patterns. Typically, mountainous regions of the Himalaya lack weather stations due to the steep and rugged terrain. This is the case for the Ramgad watershed in which there is only one weather station available at Mukteshwar. Therefore, the Ramgad watershed can be defined as a hydro-meteorological data deficit region. Software programs that use an elevation-dependent algorithm to create spatial representations of rainfall and temperature in mountainous regions should form the basis for further work in this area.

3.3.1 Past climate trends

The average annual rainfall is 904 mm with mean monthly rainfall ranging between 184 mm in the month of November and 2335 mm in the month of August in Mukteshwar. Temperature across the region has increased with 2007 to 2012 being the warmest recorded for all the districts. The district of Nainital, Champawat and Udham Singh Nagar districts recorded the maximum rise in temperature. The Mukteshwar weather station had recorded the largest increase in temperature during the month of March (early spring) and but a smaller increase in temperature over time was recorded during August approaching the end of the monsoon season (Figure 9). The seasonal difference is likely to be due to an increase in cloud density and cover during the monsoon season resulting in lower temperatures.

An analysis of over 30 years of rainfall data from the Mukteshwar weather station has revealed an increase in rainfall since 1979 (Figure 10) for the month of August, which is the height of the monsoon season. The results suggest the monsoon season has increased in intensity, perhaps due to higher evaporation and greater inertia in the Asia Monsoon climate system.

However, during the drier months of December, January and February there has been a sharp decline in the amount of rainfall, which is consistent with the overall trend experienced across the Himalaya. Figure 10 shows the amount of precipitation and the daily mean, maximum and minimum temperature from the period 1979 to 2012.

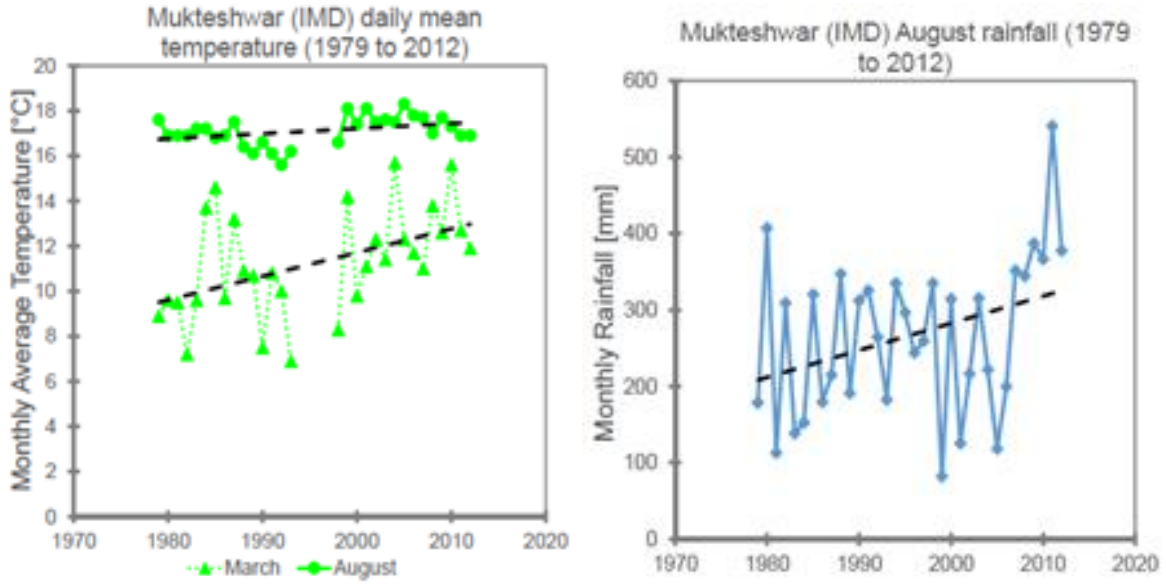


Figure 9. Changes in temperature and precipitation from period 1979 to 2012

Ramgad watershed at sunset (Photo Lance Heath).

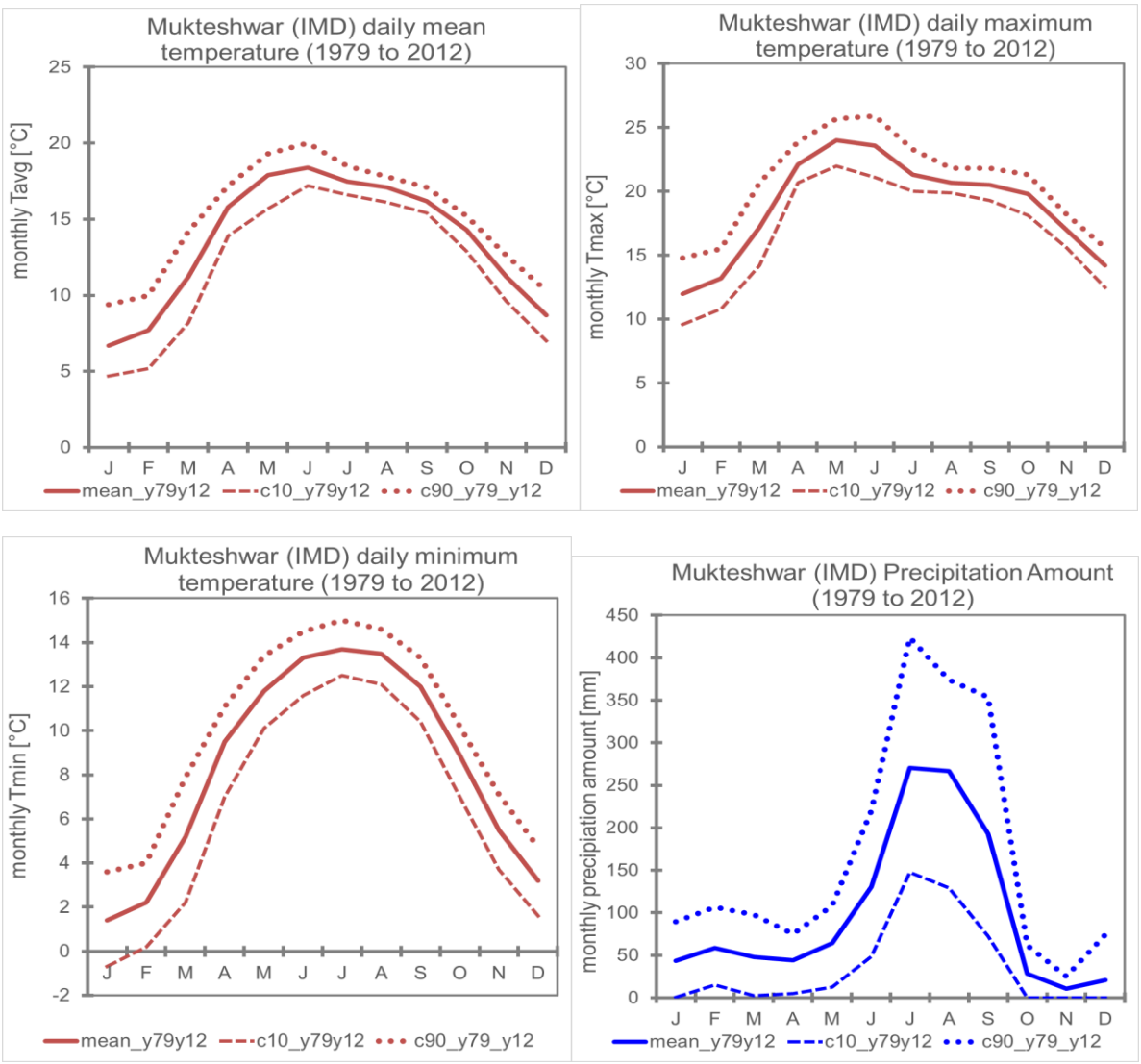


Figure 10. Past climate trends for the Ramgad Watershed (Mukteshwar weather station)

3.3.2 Climate Change Projections and Climate Scenario Statements

Climate change scenarios for the Nainital/Ramgad region were sourced from CORDEX South Asia domain (50 km resolution). The climate projections were based on the Intergovernmental Panel on Climate Change (IPCC) A1B emission scenarios for the time period 2041 - 2060 compared to the baseline period (1981-2000). The seasonal mean and future change in surface temperature (°C) and precipitation (mm/d) from multi-models under IPCC AR4 A1B emission scenarios (middle level) over Nainital/Ramgad region are shown in the Annexure A.

Based on the climate change scenarios for the Ramgad region, there will be a decrease in the maximum temperature by 1° C during the summer monsoon season (June, July and August) and a decrease in the minimum temperature by 0.39° C for the same period. Temperatures during the winter months (December, January and February) are expected to increase. The maximum temperature will increase by1.53° C in December, January and February and the minimum temperature will increase by 2.26° C for the same period (i.e winter months).

For precipitation, climate change projections indicate that there will be an overall increase in mean precipitation by as much as 10% during the summer monsoon period (June, July and August) but a decrease in rainfall during the winter months by as much as 15%. Table 13 and Figure 11 is a synopsis of the expected change in climate and their corresponding climate change scenario statements.

The climate risks likely to affect Ramgad are therefore:

Climate Risk 1: Increase in temperature overall and a decrease in rainfall overall.

Climate Risk 2: The wet season will become wetter with an increased incidence of extreme weather events resulting in more flash flooding and landslides.

Climate Risk 3: The dry season will become drier with more severe droughts.

Projected Climate Trends A1B Scenario (2041-2060) compared to the baseline period (1981-2000)

	Ramgarh (Nainital), India	
	Summer Monsoon (June-July-August)	**Winter (Dec-Jan-Feb)**
Temperature	Decrease in Max Temperature by 1°C Decrease in Min Temperature by 0.39 °C	Increase in Max Temperature by 1.5 °C Increase in Min Temperature by 2.3 °C
Precipitation	Overall increase in mean rainfall by 11% or 55 mm, or total of 559 mm over wet season	Overall decrease in mean rainfall by 15% or 34 mm, or total of 194 mm over dry season
Extreme Events	The wet season will become wetter Increase incidence of flooding, GLOFs, flash floods and landslides	The dry season will become drier Higher temperatures will lead to more severe droughts

Figure 11. A diagrammatic representation of the projected climate change trend under the A1B Scenario (2041-2060) compared to the baseline period (1981-2000).

Table 13. Climate Scenario Statements

Changing Climate Condition	Geographical Area	Greenhouse Gas Emissions Scenario	Climate Change Scenario Statement	Source
Temperature change	Himalayan Region (Western Himalayas constituting Ramgarh, Uttarakhand) Indian Sub-region of study area is Ramgarh Basin (Watershed): •Latitude: 29.41-29.50N (29°24' - 29°29' N) •Longitude: 79.66-79.75E (79°29' to 79°39'E) •Geographical Area: 75.8 km2 (approximate) Resolution: 50kmx50km •Altitude: Between 1025 and 2346 m from mean sea level	A1B scenario, Ensemble IPCC AR4	Decrease in Max Temp by 1DegC in June, July, August Increase in Max Temp by 1.53DegCin December, January February Decrease in Min Temp by 0.39DegC in June, July, August Increase in Min Temp by 2.26DegC in December, January, February	Ailikun, Ali, S., Niu, X., and Guan, X., 'Future Projections of Case Study Areas in Nepal and India', power point presentation 2014
Precipitation change	Himalayan Region (Western Himalayas constituting Ramgarh, Uttarakhand) Indian Sub-region of study area is Ramgarh Basin (Watershed): •Latitude: 29.41-29.50N (29°24' - 29°29' N) •Longitude: 79.66-79.75E (79°29' to 79°39'E) •Geographical Area: 75.8 km2 (approximate) Resolution: 50kmx50km •Altitude: Between 1025 and 2346 m from mean sea level	A1B scenario, Ensemble IPCC AR4	Overall increase in rainfall for June, July, August by 10.85% or 55mm Overall decrease in Rainfall for December, January, February by 14.68% or 34mm This implies the dry is drier and wet is wetter	Ailikun, Ali, S., Niu, X., and Guan, X., 'Future Projections of Case Study Areas in Nepal and India', power point presentation 2014

3.4 Climate Impact Assessment

Climate impact assessment of rural systems helps to evaluate their fragilities with respect to the climate impacts identified in section 3.3. These rural systems are classified as either 'core systems' such as water, and 'secondary systems' such as health, sanitation and education. The secondary systems are highly dependent upon the core systems.

Based on a series of rigorous discussions in the SLDs, five fragile systems were identified for the watershed of Ramgad.

1. Availability and Supply of Water for Drinking and Irrigation
2. Road Connectivity
3. Community Health and Wellbeing
4. Rural Livelihood and Economy
5. Forest Resources

The risks associated with the fragilities of all five rural systems were calculated by the Stakeholder Group during an SLD using the risk assessment exercise tool outlined in section 2.4.

3.4.1 Rural System Analysis

3.4.1.1 Availability and Supply of Water for Drinking and Irrigation

Situation analysis

The pattern of rainfall has been changing rapidly resulting in greater variability both in the amount of rainfall as well as in the temporal distribution of rainfall during the year. As a result, the amount of rainfall is declining, and the number of rainy days are also decreasing year by rear. The frequency of snowfall and snow cover has also been in sharp decline, and there has been no snowfall in the higher reaches of the watershed during the winter. It has been observed that snowfall now occurs one or two times during the entire winter season between November and February. The erratic changes in precipitation and higher temperature are causing severe agricultural droughts in the watershed. Furthermore, the incidence of high intensity rainfall is devastating agricultural land, irrigation canals and other agricultural infrastructure (Tiwari and Joshi, 2015).

The observed and measured changes in precipitation have disrupted the hydrological regime of the watershed, resulting in reduced groundwater recharge from increased run-off from high intensity rainfall events. Consequently, the natural streams and springs which constitute the only source of water in the middle Himalayan mountain ranges are becoming dry and the rate of groundwater discharge is declining. These hydrological changes are reducing the availability of freshwater for both drinking and irrigation (Tiwari and Joshi, 2015).

The decreasing amount of rainfall has also played a very important role in drastically reducing the recharge of groundwater in the region. Studies carried out in other parts of Kumaun Himalaya revealed that 45-46% of the natural springs have dried in the catchment of Gaula in the district of Nainital (Valdiya and Bartarya, 1991), and 270 out of 360 natural springs have dried in Kosi Catchment in the district of Almora (, 2009).

Fragility Statement(s) and Climate Fragility Statement(s)

Given the current *Availability and Supply of Water for Drinking and Irrigation* the ***Fragility Statement*** for this rural system is:

"The system is fragile because the water sources are sensitive to small changes in the environment, population growth and ecological stress (i.e emerging dominance of pine trees). This in turn impacts on drinking water supply, human health and agricultural production".

The impacts from the climate scenarios (increased temperature, decreased precipitation and an increase in extreme events), were then superimposed on this fragile rural system. The ***climate fragility statements*** for ***Availability and Supply of Water for Drinking and Irrigation*** are:

Climate Risk 1: A decrease in winter rainfall and an increase in temperature during winter will increase the gap between the demand and supply of water.

Climate Risk 2: An increase in rainfall and a decrease in summer temperatures could lead to high intensity rainfall and a change in groundwater dynamics (high runoff and a decrease in water-soil infiltration).

Climate Risk 3: Incidences of high intensity rainfall will disrupt and damage water infrastructure and distribution system.

Climate Risk 4: Water sources may become dry due to prolonged droughts thus affecting water availability.

3.4.1.2 Road Connectivity

Situation analysis

These observed changes in climatic parameters are leading to a variety of hydrological hazards and disasters in the region. There has been a high incidence of flash flooding resulting in frequent slope failures, landslides, debris and mud flow. The hydrological hazards are causing massive damage to buildings, agricultural land, roads, bridges, irrigation and drinking water supply systems and livestock. A disrupted road network from landslides is the most concerning issue resulting from such impacts. Village communities become isolated from essential services and agricultural produce cannot be transported to market and distribution centres. The lack of preparedness planning and design have been blamed for inadequate road connectivity during natural disasters.

Fragility Statement(s) and Climate Fragility Statement(s)

Given the status of *Road Connectivity,* the ***Fragility Statement*** for this rural system is:

"Road infrastructure is fragile due to the lack of resilience and preparedness planning. Therefore, road connectivity is adversely affected if the road system is disrupted thus impacting on the rural economy and livelihoods."

The impacts from the climate scenarios (increased temperature, decreased precipitation and an increase in extreme weather events), were then superimposed on this fragile urban system. The ***climate fragility statements*** for ***Road Connectivity*** is:

Climate Risk 1: Incidences of high intensity rainfall will disrupt roads and bridges which will in turn affect the rural economy, livelihood and community health.

3.4.1.3 Community Health and Wellbeing

Situation analysis

Human health is highly dependent upon access to ecosystem services, particularly food, nutrition and fresh water. Safe drinking water and sanitation have enormous implications for human health and wellbeing. Improved community access to safe drinking water and sanitation could drastically reduce the incidence of water-borne diseases, which may contribute significantly towards reducing mortality rates. As in other parts of the Middle Himalayan mountains, the declining availability of water for drinking and sanitation is also having an adverse impact on community health, particularly affecting young children and women with many inflicted by water-borne diseases (Tiwari and Joshi, 2013).

The changing pattern of rainfall has decreased both the number of annual rainy days as well as the amount of rainfall, thus lessening the recharge of groundwater in the region. Consequently, the water resources are dwindling and the availability of water for domestic purposes and irrigation has decreased considerably in recent years. This has not only placed stress on the water supply system but has also reduced agricultural productivity thus undermining community health through decreased availability of water for domestic purposes and a reduction in the quality and quantity of food (Tiwari and Joshi, 2012b).

The scarcity of potable drinking water is forcing households to collect water from longer distances without considering its quality and, consequently, there is a considerable risk of water borne diseases resulting from the consumption of contaminated water supplies. It was observed that the average travel distances involved in collecting water has increased from 1.5 km to 3.5 km between 2001 and 2015. This increase in the distance travelled has adversely affected the health of rural women by increasing their workload. This has led to less time being made available to take proper care of their own hygiene and sanitation on the one hand, and the care and health of their young children and elderly members of the family on the other (Tiwari and Joshi, 2013).

Fragility Statement(s) and Climate Fragility Statement(s)

Given the status of ***Community Health and Wellbeing***, the ***Fragility Statement*** for this rural system is:

"Health facilities and human health resources are unable to respond to poor water sanitation, supply and hygiene resulting from unexpected shocks to the system".

The impacts from the climate scenarios (increased temperature, decreased precipitation and an increase in extreme weather events), were then superimposed on this fragile urban system. The ***Climate Fragility Statement*** for ***Community Health and Wellbeing*** is:

Climate Risk 1: Reduced availability of water will impact the rural food system, hygiene, sanitation and community health.

3.4.1.4 Rural Livelihood and Economy

Situation analysis

As in other parts of Uttarakhand Himalaya, the nature of the terrain in the Ramgad Watershed imposes severe limitations on the scale of productive activities as well as on the efficiency of infrastructural facilities. As a result, biomass based subsistence agriculture constitutes the main source of food supply and provides a necessary livelihood for nearly 77% of the population, even though the availability of arable land is severely limited and agricultural productivity is low in the region (Tiwari and Joshi, 2012a and b).

Climate change, the depletion of water resources, fluctuating food prices and a recent economic recession have led to a decrease in local food production, reduced purchasing power and a downturn in local employment opportunities. The region has become highly vulnerable to food insecurity. The decreasing rainfall and number of rainy days as well as the subsequent depletion of water resources in association with the resultant loss of irrigation potential have stressed the agricultural systems in the Ramgad watershed. As a result, production of agriculture in the region has declined from 583 Kg/Ha/Year in 2001 to 430 Kg/Ha/Year in 2015 thus bringing a total decrease by about 154 kg or 26% during the period (Tiwari and Joshi, 2012b). The different villages in the catchment are facing a food deficit of between 72% and 80% with annual average food deficit of 67% nationally (National Institute of Nutrition (NIN), Government of India). Furthermore, the recent economic recession and consequential loss of employment opportunities have resulted in losses of between 20% – 25% of local purchasing power, thus resulting in a considerable threat to food security and health in the entire region (Tiwari and Joshi, 2012b).

Owing to constraints on the subsistence economy, a large proportion of the adult male population migrate to the cities in search of viable means of employment. The remittances sent by the families of the migrated population constitutes the principal source of cash income and food purchasing power for a majority of the rural population. The food security in the region therefore is highly dependent upon the availability of food from local agricultural production.

Nearly 62% of households have been identified as food insecure. Marginal and small farmers, landless households, which mainly include socially disadvantaged communities and families with marginal or very small income, constitute the highest sector within the rural community (Tiwari and Joshi, 2012b).

Fragility Statement(s) and Climate Fragility Statement(s)

Given the status of, ***Rural Livelihood and Economy*** the ***Fragility Statement*** for this rural system is:

"On-going economic hardship, droughts, extreme weather events, and the lack of a reliable water resource, have led to an increase in out-migration, food insecurity, and a loss of purchasing power."

The impacts from the climate scenarios (increased temperature, decreased precipitation and an increase in extreme weather events), were then superimposed on this fragile urban system. The Climate Fragility Statements for ***Rural Livelihood and Economy*** is:

Climate Risk 1: A decrease in rainfall, frequent droughts and increasing incidences of high intensity rainfall will affect crop-rotation, agricultural productivity, livelihood, tourism and the rural economy.

3.4.1.5 Forest Resources

Situation analysis

The traditional forest based subsistence farming constitutes the main type of rural livelihood (Figure 12). However, the process of natural resource development has been changing fast mainly in response to a growing population and the subsequent increase in the demand for food, fodder, fuel wood and other natural resources. Consequently, the activities of cultivation, horticulture, tourism and grazing are extended over large areas of the region. These changes are resulting in exploitation of natural resources, land use intensification, and disruption of mountain ecosystem services.

One of the main concerns with respect to forest resources is the increased threat of forest fires from higher temperatures and lower humidity.

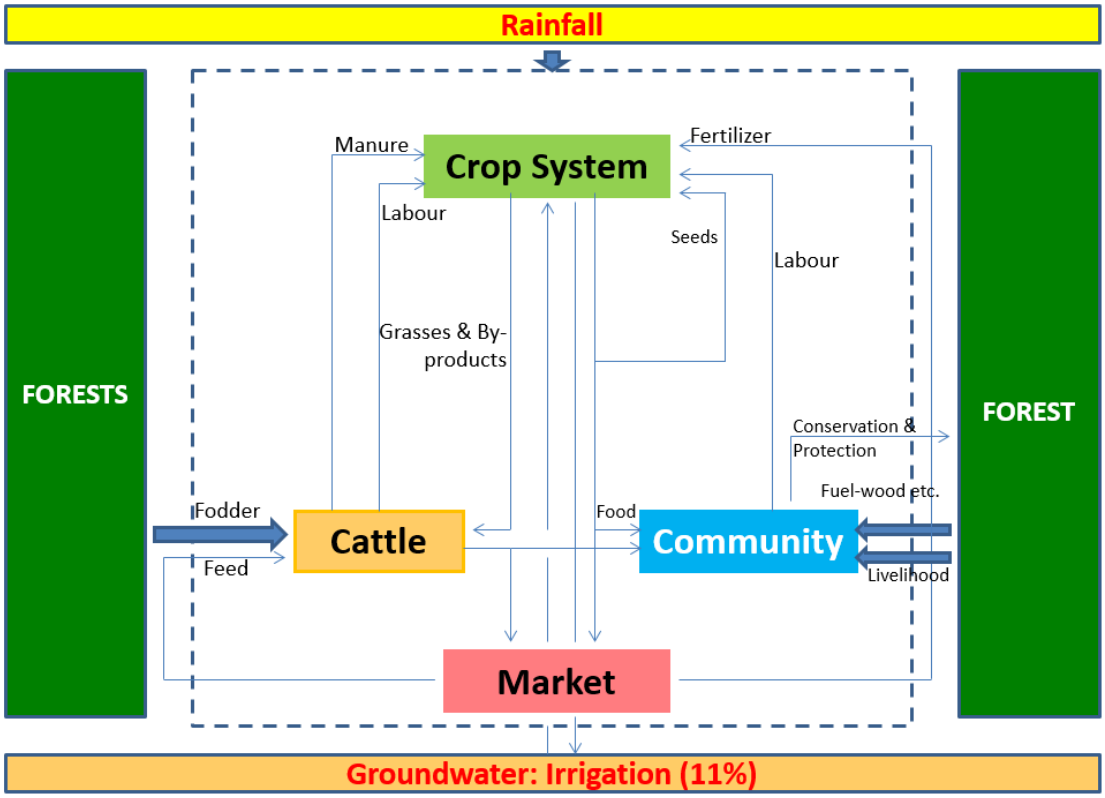


Figure 12. As in other parts of Kumaun Lesser Himalaya, the traditional forest based subsistence farming constitutes the main type of rural livelihood (Source: Tiwari and Joshi, 2014).

Fragility Statement(s) and Climate Fragility Statement(s)

Given the status of, ***Forest Resources***, the ***Fragility Statement*** for this rural system is:

"The traditional forest based subsistence farming constitutes the main type of rural livelihood which is under threat from a growing population and the subsequent increase in the demand for food, fodder, fuel wood and other natural resources."

The impacts from the climate scenarios (increased temperature, decreased precipitation and an increase in extreme weather events), were then superimposed on this fragile urban system. The ***Climate Fragility Statements*** for ***Forest Resources*** is:

Climate Risk 1: Increase in temperature and a decrease in rainfall will increase the incidence of forest fire, loss of biodiversity, depletion of medicinal plants and a reduction in the availability of fuel-wood and fodder.

A summary of the climate fragility statements for all five fragile rural systems are presented in Table 14.

Table 14. Climate Impacts on Fragile Systems (Fragility Statement & Climate Fragility Statement)

Rural system	Fragility statement	Climate fragility statement			
Availability and Supply of Water for Drinking and Irrigation	The system is fragile because the water sources are sensitive to small changes in the environment, population growth and ecological stress (i.e emerging dominance of pine trees). This in turn impacts on drinking water supply, human health and agricultural production.	A decrease in winter rainfall and an increase in temperature during winter will increase the gap in the demand and supply of water.	An increase in rainfall and a decrease in summer temperatures will lead to high intensity rainfall and a change in groundwater dynamics (high intensity rainfall may lead to greater runoff and less infiltration).	Incidences of high intensity rainfall will disrupt and damage water infrastructure and distribution system.	Water sources may become dry due to prolonged droughts affecting water availability.
Road Connectivity	Road infrastructure is fragile due to the lack of resilience and preparedness planning. Therefore, road connectivity is adversely affected if the road system is disrupted thus impacting on the rural economy and livelihoods.	Incidences of high intensity rainfall will disrupt roads and bridges which will in turn affect the rural economy, livelihood and community health.			
Community Human Health and Wellbeing	Health facilities and human health resources are unable to respond to poor water sanitation, supply and hygiene resulting from unexpected shocks to the system.	Reduced availability of water will impact the rural food system, hygiene, sanitation and community health.			
Rural Livelihoods and Economy	On-going economic hardship, droughts, extreme weather events, and the lack of a reliable water resource, have led to an increase in out-migration, food insecurity, and a loss of purchasing power	A decrease in rainfall, frequent droughts and increasing incidences of high intensity rainfall will affect crop-rotation, agricultural productivity, livelihood, tourism and the rural economy.			
Forest Resources	The traditional forest based subsistence farming constitutes the main type of rural	Increase in temperature and a decrease in rainfall will increase the incidence of forest fire, loss of biodiversity, depletion of medicinal plants and a reduction in the availability of fuel-wood and fodder.			

Rural system	Fragility statement	Climate fragility statement			
	livelihood which under threat from a growing population and the subsequent increase in the demand for food, fodder, fuel wood and other natural resources				

3.4.2 Risk Assessment

By using the participatory based risk assessment methodology outlined in section 2.4, the climate fragility statements are prioritised in order of their degree of risk that each expected climate impact poses for the identified fragile systems (Figure 13).

The risk score for each climate fragility statement developed in section 3.4.1 (Rural System Analysis) is calculated by multiplying the likelihood of an event to occur and its consequences if the event was to occur.

The process followed for risk scoring is detailed in Annexure B. Table 15 shows the risk status of the five climate fragility statements.

Figure 13. A risk assessment exercise was conducted in the Ramgad region with input from the Stakeholder Group (Workshop 2) (Photo: Lance Heath).

Table 15. Risk Assessment of Climate Fragility Statements

Rural System	***Climate Risks (Climate Fragility Statements)***	***Risk Status***
Availability and Supply of Water for Drinking and Irrigation	A decrease in winter rainfall and an increase in temperature during winter will increase the gap in the demand and supply of water.	Extreme
	An increase in rainfall and a decrease in summer temperatures will lead to high intensity rainfall and a change in groundwater dynamics (high intensity rainfall may lead to greater runoff and less infiltration).	High
	Incidences of high intensity rainfall will disrupt and damage water infrastructure and distribution system.	High
	Water sources may become dry due to prolonged droughts affecting water availability.	Extreme
Road Connectivity	Incidences of high intensity rainfall will disrupt roads and bridges which will in turn affect the rural economy, livelihood and community health.	High
Community Human Health and Wellbeing	Reduced availability of water will impact the rural food system, hygiene, sanitation and community health.	Extreme
Rural Livelihoods and Economy	A decrease in rainfall, frequent droughts and increasing incidences of high intensity rainfall will affect crop-rotation, agricultural productivity, livelihood, tourism and the rural economy.	Extreme
Forest Resources	Increase in temperature and a decrease in rainfall will increase the incidence of forest fire, loss of biodiversity, depletion of medicinal plants and a reduction in the availability of fuel-wood and fodder.	Extreme

The participatory risk assessment exercise yielded alarming results for the all climate fragility statements. For the rural system Availability and Supply of Water for Drinking and Irrigation, two out of the four climate fragility statements yielded an extreme climate risk status. Likewise, the climate fragility statements for the rural systems Community Human Health and Wellbeing, Rural Livelihoods and Economy and Forest Resources also yielded an extreme climate risk status. The remaining climate fragility statements all scored a high-risk status.

3.5 Vulnerability Assessment

3.5.1 Overview

An essential element to build resilience is a need to fully understand the extent of vulnerability of the rural environment to climate change. The extent of vulnerability is dependent upon the geographical location, demography, infrastructure, socio economic condition, ecological condition of the rural area.

The IPCC defines vulnerability as *the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change* (IPCC, 2001). Vulnerability is a function of a system's level of exposure, its sensitivity, and its adaptive capacity (Figure 14).

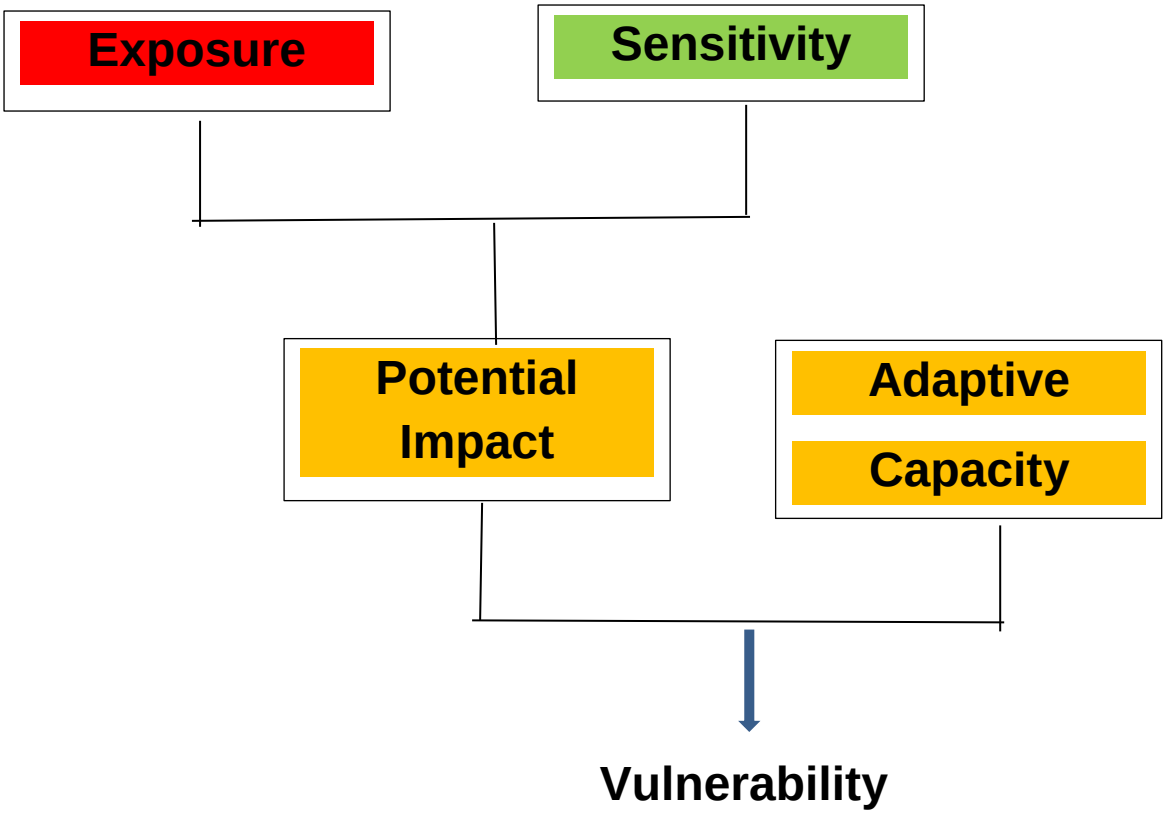


Figure 14. Vulnerability is a function of a system's level of exposure, its sensitivity, and its adaptive capacity. Source: Australian National University (2009). Adapted from Allen Consulting Group (2005).

Vulnerability assessment through the IAP involves the identification of vulnerable areas and actors for all the prioritised fragile rural systems identified and an analysis of the adaptive capacities.

Vulnerability assessment of the Ramgad watershed was carried out by taking into account the following elements:

1. Identification of Vulnerable Places and People: Highly vulnerable areas or "hotspots" were identified and mapped to visualise the vulnerable areas affected by maximum number of fragile rural systems. These "hotspots" were arrived at by overlaying all the vulnerable districts identified under each fragile rural system.

2. Identification of Vulnerable Actors and their Adaptive Capacity: The “Actors” or organisations and groups that can build rural resilience were identified and assessed in terms of their capacity to:

- organize and respond to threat or disruption,
- access available resources necessary to respond (manpower, technology, funds) and
- access to information necessary to develop effective plans and actions and to improve responses to disruptions. These determine the adaptive capacity/resilience of the identified actors for a fragile rural system.

3. Assessment of Capacities of Rural Systems: Adaptive capacity of rural systems is defined as its “capacity to absorb and respond to shocks” and consequently determines the system’s resilience to climate change impacts. The adaptive capacity of each fragile rural system was determined in the context of economy, technology/infrastructure, governance, social systems and ecosystems.

The following sections identify the vulnerable areas or “hotspots”, vulnerable actors and adaptive capacity of the fragile rural systems using the Climate Fragility Statements developed in section 3.4.1 with input from the Stakeholder Group.

3.5.2 Identification of vulnerable areas of Fragile Rural Systems

3.5.2.1 Availability and Supply of Water for Drinking and Irrigation: Vulnerable Areas

Four villages were identified and mapped as being vulnerable for this rural system, namely Satbunga, Bohrakote, Naikana, Nathuwakhan (Table 16 and Figure 15).

Table 16. Most vulnerable villages (Rural System: Availability and Supply of Water for Drinking and Irrigation)

Climate Fragility Statements	Area/Village most vulnerable
A decrease in winter rainfall and an increase in temperature during winter will increase the gap in the demand and supply of water.	Satbunga, Bohrakote, Naikana, Nathuwakhan
An increase in rainfall and a decrease in summer temperatures will lead to high intensity rainfall and a change in groundwater dynamics (high intensity rainfall may lead to greater runoff and less infiltration).	Satbunga, Bohrakote, Naikana, Nathuwakhan
Incidences of high intensity rainfall will disrupt and damage water infrastructure and distribution system.	Satbunga, Bohrakote, Naikana, Nathuwakhan
Water sources may become dry due to prolonged droughts affecting water availability.	Satbunga, Bohrakote, Naikana, Nathuwakhan

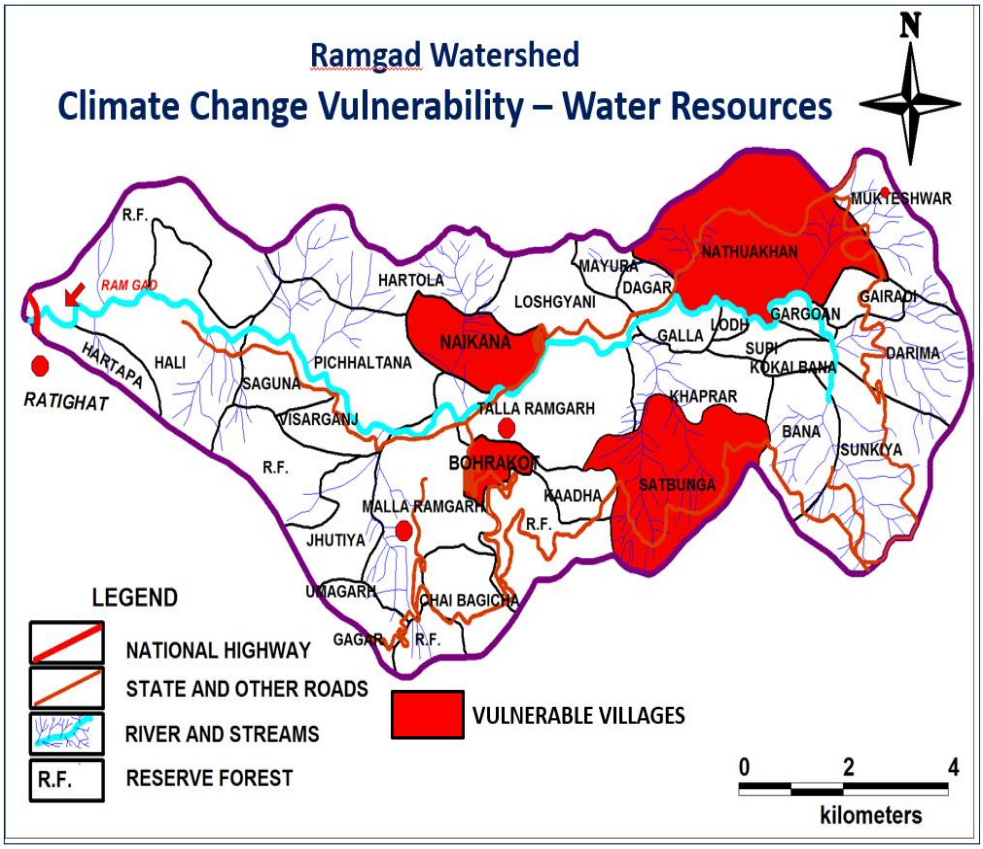


Figure 15. Vulnerable areas for the rural system Availability and Supply of Water for Drinking and Irrigation

3.5.2.2 Road Connectivity: Vulnerable Areas

Four villages were identified and mapped as being vulnerable for this rural system, namely Satbunga, Bohrakote, Naikana, Nathuwakhan (Table 17 and Figure 16).

Table 17. Most vulnerable villages (Rural System: Road Connectivity)

Climate Fragility Statements	Area/Village most vulnerable
Incidences of high intensity rainfall will disrupt roads and bridges which will in turn affect the rural economy, livelihood and community health.	Satbunga, Bohrakote, Naikana, Nathuwakhan

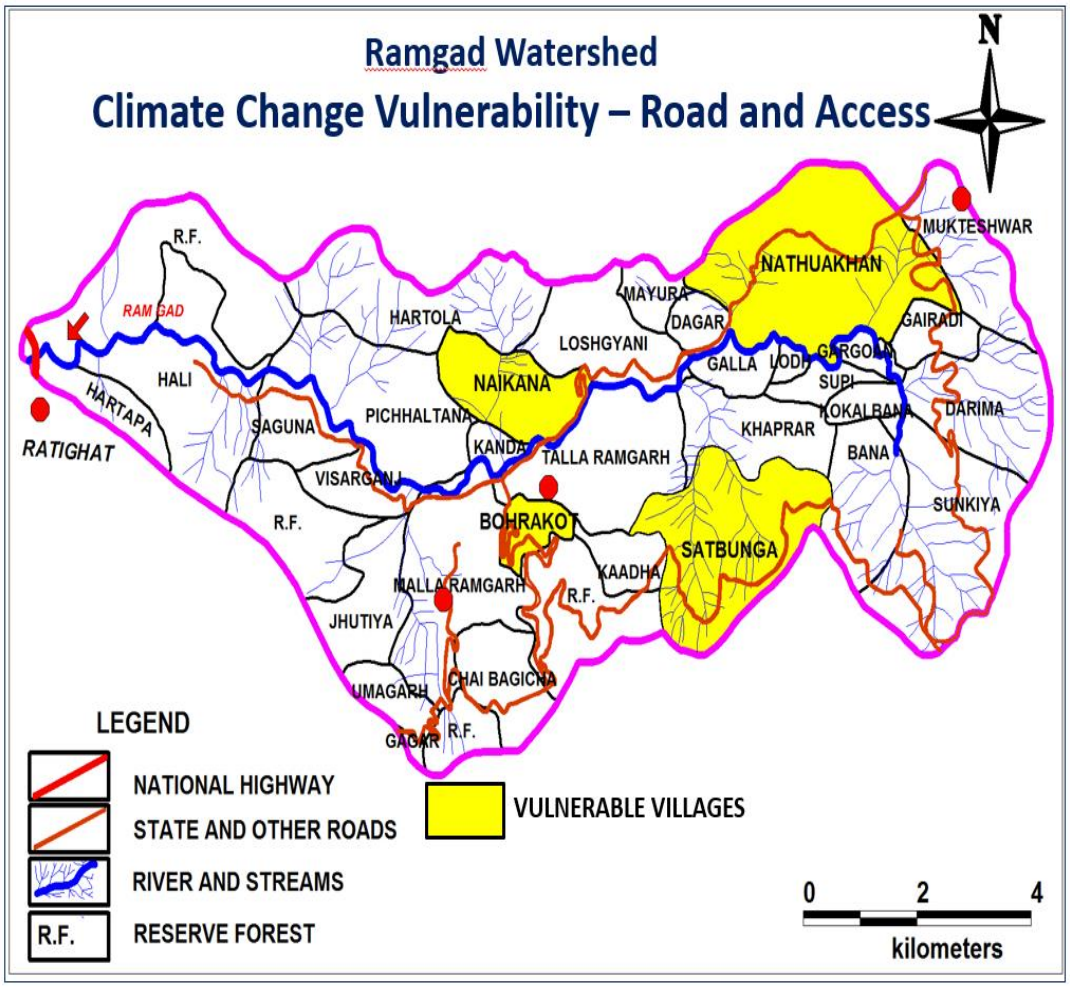


Figure 16. Vulnerable areas for the rural system Road Connectivity

3.5.2.3 Community Human Health and Wellbeing: Vulnerable Areas

Four villages were identified and mapped as being vulnerable for this rural system, namely Satbunga, Bohrakote, Naikana, Nathuwakhan (Table 18 and Figure 17).

Table 18. Most vulnerable villages (Rural System: Community Human Health and Wellbeing)

Climate Fragility Statements	Area/Village most vulnerable
Reduced availability of water will impact the rural food system, hygiene, sanitation and community health.	Satbunga, Bohrakote, Naikana, Nathuwakhan

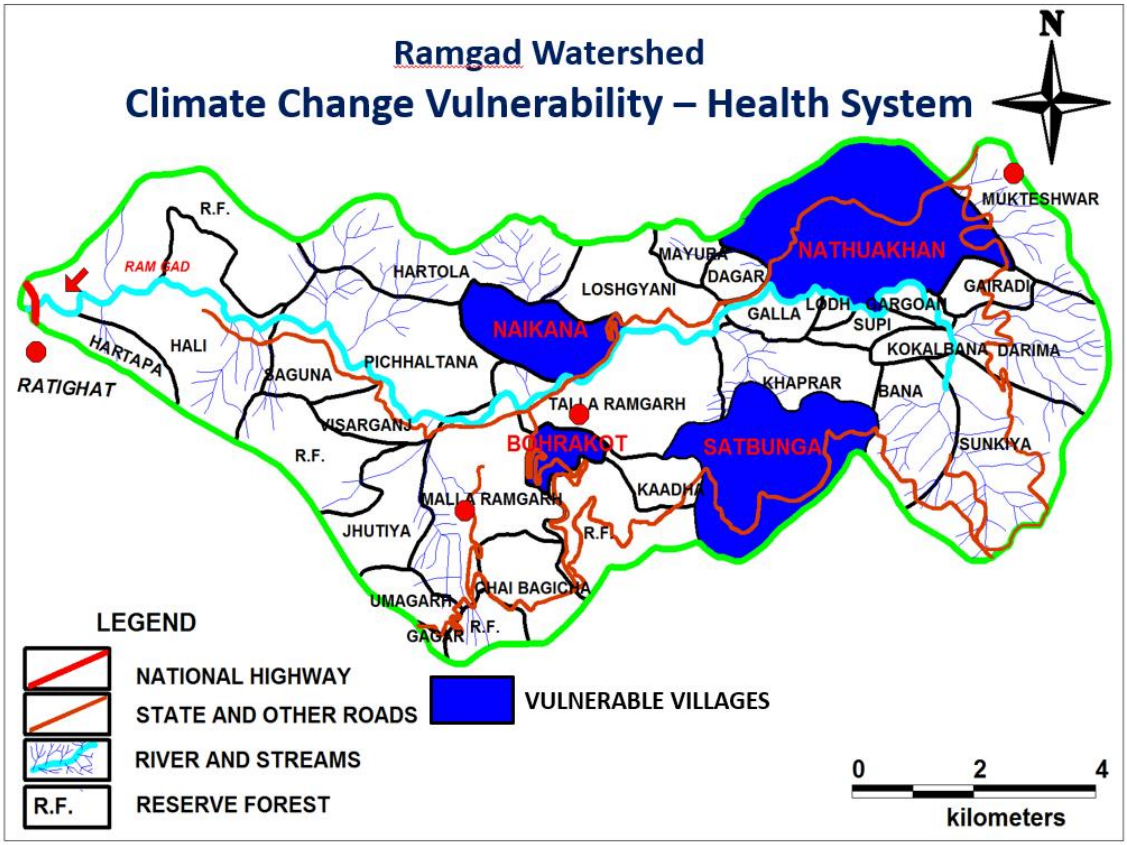


Figure 17. Vulnerable areas for the rural system Community Human Health and Wellbeing.

3.5.2.4 Rural Livelihoods and Economy: Vulnerable Areas

Four villages were identified and mapped as being vulnerable for this rural system, namely Satbunga, Bohrakote, Naikana, Nathuwakhan (Table 19 and Figure 18).

Table 19. Most vulnerable villages (Rural System: Community Human Health and Wellbeing)

Climate Fragility Statements	Area/Village most vulnerable
A decrease in rainfall, frequent droughts and increasing incidences of high intensity rainfall will affect crop-rotation, agricultural productivity, livelihood, tourism and the rural economy.	Satbunga, Bohrakote, Naikana, Nathuwakhan

3.5.2.5 Forest Resources: Vulnerable Areas

One village was identified and mapped as being vulnerable for this rural system, namely Satbunga, (Table 20 and Figure 18).

Table 20. Most vulnerable villages (Rural System: Community Human Health and Wellbeing)

Climate Fragility Statements	Area/Village most vulnerable
Increase in temperature and a decrease in rainfall will increase the incidence of forest fire, loss of biodiversity, depletion of medicinal plants and a reduction in the availability of fuel-wood and fodder.	Satbunga

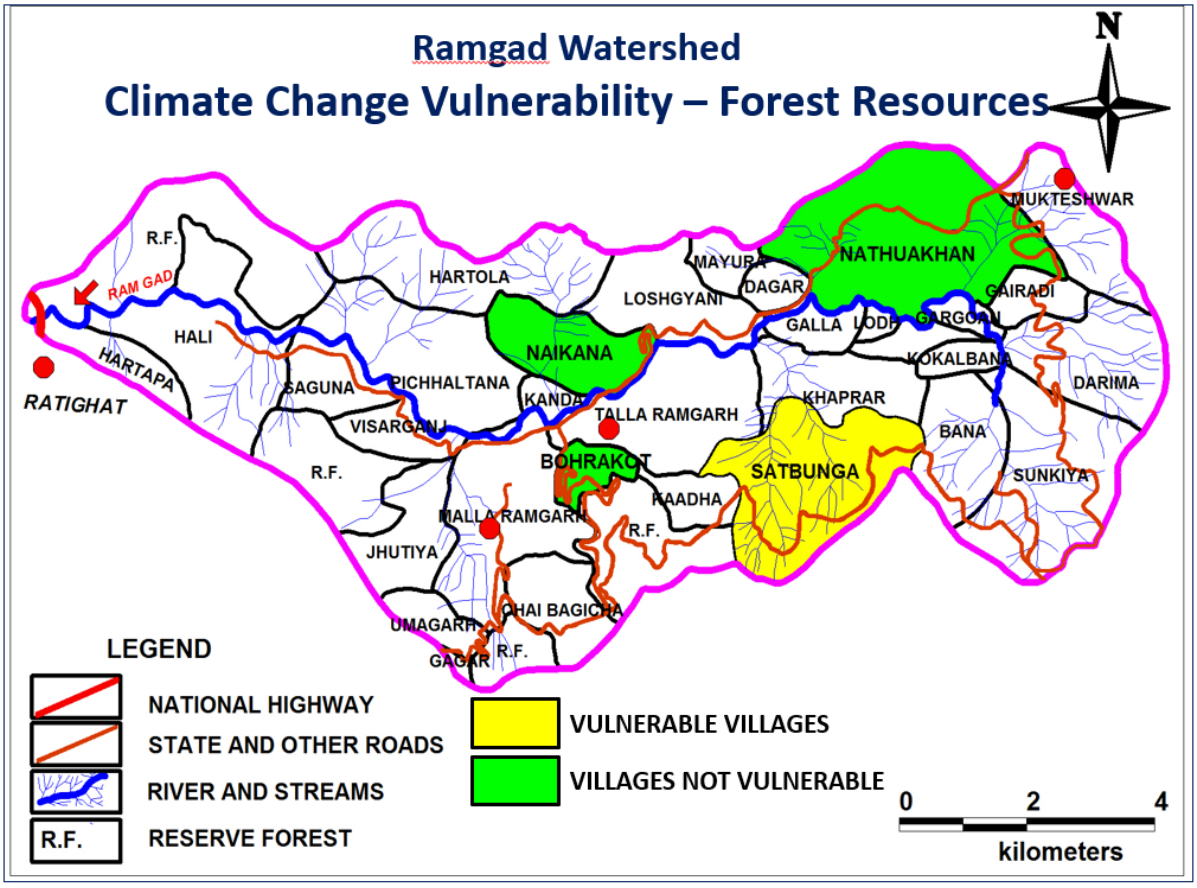


Figure 18. Vulnerable areas for the rural system Forest Resources

The aim of this part of the IAP is to produce maps of the Ramgad Watershed that identify high priority climate risks across the catchment and the groups most vulnerable to these risks. The results of this assessment showed that the villages Satbunga, Bohrakote, Naikana, Nathuwakhan, surveyed as part of the IAP, exhibited a high level of vulnerability to climate change for all rural systems except for the rural system Forest Resources. The village of Satbunga was the only village that showed a high level of vulnerability to climate change for this system.

Mapping “vulnerability hotspots” according to a vulnerability category helps to visualise the areas within the district that require immediate attention for future interventions to build resilience that are identified in later sections of this report.

3.5.3 Actor Analysis

The Table 21 to 25 summarises of the results of the actor analysis for all rural systems. The level of adaptive capacity of the actors for each climate fragility statement was ranked according to the ranking system shown in Tables 4 and 5 on pages 21 and 22 respectively. The actors were identified and assessed in terms of their capacity to *organize and respond* to threat or disruption, *access to resources* necessary for response and *access to information* to improve responses to disruptions.

Table 21. Analysis of the adaptive capacities of local actors identified for the rural system Availability and Supply of Water for Drinking and Irrigation

Climate Fragility Statements	Villages	People and Institutions	Capacity to Organise and Respond	Resources	Access to Information	Total Score	Adaptive Capacity
1) A decrease in winter rainfall and an increase in temperature during winter will increase the gap in the demand and supply of water. 2) An increase in rainfall and a decrease in summer temperatures will lead to high intensity rainfall and a change in groundwater dynamics (high intensity rainfall may lead to greater runoff and less infiltration).	Satbunga	Women	1	1	1	1	Low
		Gram Panchayat	1	1	1	1	Low
		Forest Panchayat	1	1	1	1	Low
		Tourist Enterprises	1	2	1	2	Low
		Jal Sansthan	1	2	1	2	Low
		NGOs	2	2	1	4	Low
	Bohrakote	Poor Households	1	1	1	1	Low
		Women	1	1	1	1	Low
		Gram Panchayat	2	1	1	2	Low
		Forest Panchayat	2	1	1	2	Low

Climate Fragility Statements	Villages	People and Institutions	Capacity to Organise and Respond	Resources	Access to Information	Total Score	Adaptive Capacity
3) Incidences of high intensity rainfall will disrupt and damage water infrastructure and distribution system. 4) Water sources may become dry due to prolonged droughts affecting water availability.	Bohrakote	Tourist Enterprises	1	2	1	2	Low
		Jal Sansthan	1	2	1	2	Low
		NGOs	2	2	1	4	Low
	Naikana	Poor Households	1	1	1	1	Low
		Women	1	1	1	1	Low
		Gram Panchayat	2	1	1	1	Low
		Jal Sansthan	1	2	1	1	Low
	Nathuwakhan	Poor Households	1	1	1	1	Low
		Women	1	1	1	1	Low
		Gram Panchayat	1	1	1	1	Low
		Forest Panchayat	2	1	1	1	Low
		Tourist Enterprises	2	2	1	4	Low
		Jal Sansthan	1	2	1	2	Low

Table 22. Analysis of the adaptive capacities of local actors identified for the rural system Road Connectivity

Climate Fragility Statements	Villages	People and Institutions	Capacity to Organise and Respond	Resources	Access to Information	Total Score	Adaptive Capacity
Incidences of high intensity rainfall will disrupt roads and bridges which will in turn affect the rural economy, livelihood and community health.	Satbunga	Vegetable Growers	1	1	1	1	Low
		Fruit Producers	1	1	1	1	Low
		Gram Panchayat	1	1	1	1	Low
		Forest Panchayat	1	1	1	1	Low
		Tourist Enterprises	1	2	1	2	Low
		(PWD)	2	2	1	4	Low
		NGOs	2	2	8	8	Low
	Bohrakote	Vegetable Growers	1	1	1	1	Low
		Fruit Producers	1	1	1	1	Low
		Gram Panchayat	2	1	1	2	Low
		Forest Panchayat	2	1	1	2	Low
		Tourist Enterprises	1	2	1	2	Low
		PWD	1	2	1	2	Low
		NGOs	2	2	2	8	Low
	Naikana	Vegetable Growers	1	1	1	1	Low
		Fruit Producers	1	1	1	1	Low
		Gram Panchayat	2	1	1	1	Low
		PWD	1	2	1	1	Low
	Nathuwakhan	Vegetable Growers	1	1	1	1	Low
		Fruit Producers	1	1	1	1	Low

Climate Fragility Statements	Villages	People and Institutions	Capacity to Organise and Respond	Resources	Access to Information	Total Score	Adaptive Capacity
Incidences of high intensity rainfall will disrupt roads and bridges which will in turn affect the rural economy, livelihood and community health.	Nathuwakhan	Gram Panchayat	1	1	1	1	Low
		Forest Panchayat	2	1	1	1	Low
		Tourist Enterprises	2	2	1	4	Low
		Public Works Department	1	2	1	2	
		NGOs	2	2	2	8	Low

Table 23. Analysis of the adaptive capacities of local actors identified for the rural system Community Human Health and Wellbeing

Climate Fragility Statements	Villages	People and Institutions	Capacity to Organise and Respond	Resources	Access to Information	Total Score	Adaptive Capacity
Reduced availability of water will impact the rural food system, hygiene, sanitation and community health.	Satbunga	Poor Households	1	1	1	1	Low
		Women	1	1	1	1	Low
		Gram Panchayat	1	1	1	1	Low
		Health Department	2	2	1	4	Low
		Jal Sansthan	1	2	1	2	Low
		NGOs	2	2	1	4	Low
	Bohrakote	Poor Households	1	1	1	1	Low
		Women	1	1	1	1	Low
		Gram Panchayat	2	1	1	2	Low

Climate Fragility Statements	Villages	People and Institutions	Capacity to Organise and Respond	Resources	Access to Information	Total Score	Adaptive Capacity
Reduced availability of water will impact the rural food system, hygiene, sanitation and community health.	Bohrakote	Health Department	2	2	1	4	Low
		Jal Sansthan	1	2	1	2	Low
		NGOs	1	2	1	2	Low
	Naikana	Poor Households	1	1	1	1	Low
		Women	1	1	1	1	Low
		Gram Panchayat	2	1	1	1	Low
		Health Department	2	2	1	4	Low
		Jal Sansthan	2	2	1	4	
	Nathuwakhan	Poor Households	1	1	1	1	Low
		Women	1	1	1	1	Low
		Gram Panchayat	1	1	1	1	Low
		Health Department	2	1	1	1	Low
		Jal Sansthan	2	2	1	4	Low
		NGOs	1	2	1	2	Low

Table 24. Analysis of the adaptive capacities of local actors identified for the rural system Rural Livelihoods and Economy

Climate Fragility Statements	Villages	People and Institutions	Capacity to Organise and Respond	Resources	Access to Information	Total Score	Adaptive Capacity
A decrease in rainfall, frequent droughts and increasing incidences of high intensity rainfall will affect crop-rotation, agricultural productivity, livelihood, tourism and the rural economy	Satbunga	Poor Households	1	1	1	1	Low
		Women	1	1	1	1	Low
		Tourist Enterprises	2	2	1	4	Low
		Gram Panchayat	1	1	1	1	Low
		Agricultural Department	1	2	2	1	Low
		Horticulture Department	2	2	1	4	Low
		Irrigation Department	2	1	1	2	Low
		NGOs	1	2	1	2	Low
	Bohrakote	Poor Households	1	1	1	1	Low
		Women	1	1	1	1	Low
		Tourist Enterprises	2	1	1	2	Low
		Gram Panchayat	2	2	1	4	Low
		Agricultural Department	1	2	2	1	Low
		Horticulture Department	2	2	1	4	Low
		Irrigation Department	2	1	1	2	Low
		NGOs	1	2	1	2	Low
	Naikana	Poor Households	1	1	1	1	Low
		Women	1	1	1	1	Low
		Gram Panchayat	2	2	1	4	Low

Climate Fragility Statements	Villages	People and Institutions	Capacity to Organise and Respond	Resources	Access to Information	Total Score	Adaptive Capacity
A decrease in rainfall, frequent droughts and increasing incidences of high intensity rainfall will affect crop-rotation, agricultural productivity, livelihood, tourism and the rural economy	Naikana	Agricultural Department	1	2	2	1	Low
		Horticulture Department	2	2	1	4	Low
		Irrigation Department	2	1	1	2	Low
	Nathuwakhan	Poor Households	1	1	1	1	Low
		Women	1	1	1	1	Low
		Tourist Enterprises	2	1	1	2	Low
		Gram Panchayat	2	2	1	4	Low
		Agricultural Department	1	2	2	1	Low
		Horticulture Department	2	2	1	4	Low
		Irrigation Department	2	1	1	2	Low

Table 25. Analysis of the adaptive capacities of local actors identified for the rural system Forest Resources

Climate Fragility Statements	Villages	People and Institutions	Capacity to Organise and Respond	Resources	Access to Information	Total Score	Adaptive Capacity
Increase in temperature and a decrease in rainfall will increase the incidence of forest fire, loss of biodiversity, depletion of medicinal plants and a reduction in the availability of fuel-wood and fodder.	Satbunga	Poor Households	1	1	1	1	Low
		Women	1	1	1	1	Low
		Gram Panchayat	2	2	1	4	Low
		Forest Panchayat	1	1	1	1	Low
		Forest Department	2	2	2	8	Low
		NGOs	2	2	1	4	Low
	Bohrakote	Poor Households	1	1	1	1	Low
		Women	1	1	1	1	Low
		Gram Panchayat	2	1	1	2	Low
		Forest Panchayat	2	2	2	8	Low
		Forest Department	1	2	2	1	Low
		NGOs	2	2	1	4	Low
	Naikana	Poor Households	1	1	1	1	Low
		Women	1	1	1	1	Low
		Gram Panchayat	2	2	1	4	Low
		Forest Panchayat	1	2	2	1	Low
		Forest Department	2	2	2	8	
	Nathuwakhan	Poor Households	1	1	1	1	Low
		Women	1	1	1	1	Low

Climate Fragility Statements	Villages	People and Institutions	Capacity to Organise and Respond	Resources	Access to Information	Total Score	Adaptive Capacity
Increase in temperature and a decrease in rainfall will increase the incidence of forest fire, loss of biodiversity, depletion of medicinal plants and a reduction in the availability of fuel-wood and fodder.	Nathuwakhan	Gram Panchayat	2	1	1	2	Low
		Forest Panchayat	2	2	1	4	Low
		Forest Department	2	2	2	8	Low
		NGOs	2	2	1	4	Low

In the context of the IAP actor analysis, all actors received a “Low” score overall in terms of their adaptive capacity. No actor received a “Medium” or “High” score in terms of their adaptive capacity. In contrast, for the city of Nainital, four actors received a “High” score and five actors received a “Medium” score (Unpublished data).

For the rural system *Availability and Supply of Water for Drinking and Irrigation*, the Non-Government Organisations (NGOs) ranked better than the other actors overall in terms of their adaptive capacity. Very few local actors in this system scored above 2, suggesting the level of adaptive capacity to respond to shocks and disruptions is very low.

For the rural system *Road Connectivity*, the NGOs also outperformed all other organisations, community groups and institutions in ranking. NGOs had greater access to information over the other actors. Tourist enterprises and Public Works Department (PWD) were the next two groups to have scored highly in terms of their adaptive capacity.

As expected, the Health Department scored above the other actors in terms of their adaptive capacity under the rural system *Community Human Health and Wellbeing.* However, the Health Department scored poorly in the village of Nathuwakhan, being outperformed by Jal Sansthan. Both Jal Sansthan and the NGOs also scored higher than the other actors in all villages except Bohrakote.

For the rural system *Rural Livelihoods and Economy,* the Horticulture Department scored highly in all villages. Tourist enterprises scored better over the other actors (except for the Horticulture Department) in the village of Satbunga; whereas Gram Panchayat scored better over the other actors (except for the Horticulture Department) in the village of Bohrakote, Naikana and Nathuwakhan.

The Forest Department received the highest score over all the other actors for the rural system *Forest Resources*. Gram Panchayat, Forest Panchayat and NGOs had the next highest score in most villages.

Reflecting on the outcomes of the IAP for this region, the workshop participants found that rural resilience scores were all “low” compared to those of urban environments such as Nainital. This is probably because rural areas typically have less resources available to measure threats and impacts in the rural system. This is also compounded by the physical distances between cities that have better infrastructure and resources at their disposal (i.e better hospitals and equipment, human resources etc) and rural environments that quite often lack basic amenities, infrastructure as well as the ability to mobilise human resources *en masse*.

Furthermore, a lack of information about the way climate change is affecting the region and how to respond to it was found to be a major barrier to adaptation. Using this system of scoring may not be suitable for assessing the adaptive capacity of actors to respond to shocks and disruptions. Clearly, an alternative ranking scale is required to reflect a more realistic level of adaptive capacity for each actor.

3.5.4 Adaptive Capacity of Fragile Rural Systems

The adaptive capacity of all five fragile rural systems, determined in section 3.5.3, were then assessed against the five parameters of economy, technology, governance, societal and ecosystem services. The results of this assessment are summarised in Table 26.

There was a low adaptive capacity with respect to the “economic” parameter for nearly all potential supporting actors, suggesting a limited inherent economic ability to adapt to impacts (e.g. probably having no legal authority to raise funds and/or no strong tax base to call upon). Ecosystem services also ranked “low” for the Public Works Department, Irrigation Department and Gram Pamchayat. On the other hand, the Forest Department and Horticulture Department, Forest Panchayat and NGOs had scored a “high” level of adaptive capacity for the parameter “ecosystems services”. The Public Works Department also had a “high” level of adaptive capacity in terms of their technological knowledge and resources. However, this department and the Agricultural Department appear to have limited governance structures in place to adapt to impacts (e.g. perhaps no interagency collaboration or no support from higher levels). Interestingly, the NGOs scored a “high” level of adaptive capacity for three out of the five parameters, namely ecosystem services, societal and governance.

Table 26. Adaptive Capacity of Rural Systems assessed against the five parameters of Economy, Technology, Governance, Societal and Ecosystem Services.

Fragile Rural System	**Vulnerable Villages**	**Rural Actors**		**Adaptive Capacity of the System**		
		Vulnerable Communities	Actors	Low	Medium	High
Availability and Supply of Water for Drinking and Irrigation Road Connectivity Community Human Health and Wellbeing Rural Livelihoods and Economy Forest Resources	Satbunga Bohrakote Naikana Nathuakhan	Poor Households Women Tourist Enterprises Vegetable Grower Fruit Producers	Block Development Office	Economic Technology	Governance Societal	-
			Jal Sansthan	Economic	Technology	-
			Public Works Department	Governance Societal Ecosystem Services	Economic	Technology
			Agriculture Department	Economic Governance Societal	Technology Ecosystem	-
			Forest Department	Economic	Technology Governance Societal	Ecosystem Services
			Horticulture Department	Economic	Technology Governance Societal	Ecosystem Services
			Irrigation Department	Economic Ecosystem Services	Technology Governance Societal	-
			Gram Panchayat	Economic Ecosystem Services Technology	Societal Governance	-
			Forest Panchayat	Economic Technology	Societal	Ecosystem Services Governance
			NGOs	-	Economic Technology	Ecosystem Societal Governance

3.5.5 Gap Analysis

The gap analysis highlighted the various data gaps for all Ramgad rural systems. The gap analysis has helped to identity areas where data collection or further research is required. The gap analysis results are shown in Table 27.

Table 27. Gap Analysis for the Ramgad Watershed

Rural System	Climate Risk Statement	Data Available	Data Gaps
Availability and Supply of Water for Drinking and Irrigation	A decrease in winter rainfall and an increase in temperature during winter will increase the gap in the demand and supply of water.	Rainfall Data Water Supply Infrastructure	Spring and Stream Discharge Water Demand and Supply Drought Conditions
Road Connectivity	Incidences of high intensity rainfall will disrupt roads and bridges which will in turn affect the rural economy, livelihood and community health.	Rainfall Data Infrastructure Disruption	Agriculture, Food System, Livelihood and Health Impacts
Community Human Health and Wellbeing	Reduced availability of water will impact the rural food system, hygiene, sanitation and community health.	Rainfall Data Infrastructure Disruption	Agriculture, Food System, Livelihood and Health Impacts
Rural Livelihoods and Economy	A decrease in rainfall, frequent droughts and increasing incidences of high intensity rainfall will affect crop-rotation, agricultural productivity, livelihood, tourism and the rural economy.	Rainfall Data Infrastructure Disruption	Agriculture, Food System, Livelihood and Health Impacts
Forest Resources	Increase in temperature and a decrease in rainfall will increase the incidence of forest fire, loss of biodiversity, depletion of medicinal plants and a reduction in the availability of fuel-wood and fodder.	Temperature and Rainfall Forest Fires and Forest Area Affected	Biodiversity Loss

The Gap Analysis revealed serious data deficiencies around stream discharge and water demand and supply requirements. Information is also deficient in agriculture and food systems analysis. In addition, there has been little work done on determining the extent of biodiversity loss within the Ramgad watershed. On the positive side, however, weather data (rainfall and temperature) was found to be adequate and readily available. The Forest Department also had good historical data on the extent of forest fires and forest affected areas within the Ramgad region.

3.5.6 Communication Plan

Climate change is a relatively new topic for some people, and consequently it can raise anxiety levels or in some cases negative reactions among stakeholders unless the rationale is carefully explained. A Communication Plan was developed at the start of the process to help avoid these risks and gain the engagement of the relevant stakeholders in order to carry out the rural resilience process. Table 28 is a summary of the relevant stakeholders who were consulted and updated through various communication medium during the process.

Stakeholders (students and famers) from Ramgad watershed who attended the Resilience Workshop in New Delhi 2017 (photo Laura Heath)

Resilience Workshop New Delhi 2017 (photo: Laura Heath)

Table 28. Communication plan for the Ramgad Watershed

Identified Target Stakeholder	Key Message	Communication Medium	Timing	Achieved
Local Government Agencies	▪ Establishing hydro-meteorological observation system ▪ Mainstreaming Climate Adaptation ▪ Conservation of water resources ▪ Extension of health facilities ▪ Rural livelihood improvement	Meetings Project Reports Newsletters	Any Time	Communicated
Community Institutions	▪ Raising awareness of climate impacts ▪ Improving community participation in resource management ▪ Reviving traditional resource management system ▪ Regenerating traditional water sources	Meetings	Winter and Summer seasons	Communicated
School-Teachers and Schools Children	▪ Raising awareness of climate impacts in school children and community ▪ Conservation of water and other ecosystem services	Essay, poster, and debate competitions	Beginning, middle and end of academic session	Communicated

Identified Target Stakeholder	Key Message	Communication Medium	Timing	Achieved
Active Community Members and Youths	▪ Raising awareness of climate impacts in school children and community ▪ Conservation of water and other ecosystem services ▪ Preserving Local traditional knowledge ▪ Strengthening community institutions	Meetings Project Reports Newsletters Awareness Campaign	Any Time	Planned for Second Year
Women	▪ Conservation of water and other ecosystem services ▪ Improving girls' education ▪ Empowerment in natural resources	Meetings Awareness Campaign	Winter Season	Communicated

3.6 Resilience Interventions

The Climate Core Team, Stakeholder Group and a team of PhD candidates from Kumaun University identified over 40 potential resilience interventions across the five rural systems by drawing upon the results of the rural system analysis, vulnerable areas and people analysis and the adaptive capacity of rural systems analysis. Table 29 provides a list of potential resilience interventions developed for each rural system.

The next stage of the resilience intervention process, following the identification of potential sectoral resilience interventions, was their prioritisation, which was determined by assessing each intervention against set indicators, namely *redundancy, flexibility, responsiveness and access to information.* The resilience interventions were then assessed for their feasibility (technical, financial and political) and their overall impact (short, medium or long term). Tables 30 to 39 summaries the prioritisation, feasibility and impact of resilience interventions.

Table 29. Identification of Potential Resilience Interventions for each rural system

Rural System	***Climate Risks (Climate Fragility Statements)***	***Potential Resilience Interventions***
Availability and Supply of Water for Drinking and Irrigation	A decrease in winter rainfall and an increase in temperature during winter will increase the gap in the demand and supply of water. An increase in rainfall and a decrease in summer temperatures will lead to high intensity rainfall and a change in groundwater dynamics (high intensity rainfall may lead to greater runoff and less infiltration). Incidences of high intensity rainfall will disrupt and damage water infrastructure and distribution system. Water sources may become dry due to prolonged droughts affecting water availability.	• Tanker use • Afforestation with broad leaf species • Check drains • Infiltration Trenches • Rainfall water harvesting • Water reuse at the household level • Revive traditional sources of water management • Storing seasonal water in tanks • Water resource management & governance • Awareness regarding afforestation, water conservation & reduction of waste water
Road Connectivity	Incidences of high intensity rainfall will disrupt roads and bridges which will in turn affect the rural economy, livelihood and community health.	• Geological mapping and survey to identify and reduce risks • Adequate construction codes for roads & the need to follow engineering plans and guidelines & retaining walls • Construct good drainage systems like culverts • Afforestation beside roads • Use of oxen or horses for transporting goods temporarily • Installation of check dams (first order streams) • Temporary accessibility managed by local materials like wooden bridges, wherever possible

Rural System	*Climate Risks (Climate Fragility Statements)*	*Potential Resilience Interventions*
Community Human Health and Wellbeing	Reduced availability of water will impact the rural food system, hygiene, sanitation and community health.	• Awareness programs on hygiene and sanitation for local people • Availability of good medical facilities in community health centres. • Use of climate resilient varieties of seeds to maintain/increase food production • Revise BPL list to improve access to food security • Educational and socio-economic empowerment of women to improve hygiene, sanitation, & the health of the entire family • Water quality checks of water sources like streams in villages • Water quality checks of water sources like streams in villages • Promote Household level purification of water, chlorine tablets, boiling of water, etc • Maintenance of water sources, conservation and protection of sources from contamination

Rural System	*Climate Risks (Climate Fragility Statements)*	*Potential Resilience Interventions*
Rural Livelihoods and Economy	A decrease in rainfall, frequent droughts and increasing incidences of high intensity rainfall will affect crop-rotation, agricultural productivity, livelihood, tourism and the rural economy.	• Use new varieties of seeds which use less water • Reallocation of agricultural land use, revise cropping patterns • Action should be taken to protect crops from wild animals (i.e pigs & monkeys etc) • Protection of forests to ensure livelihood protection of forest produce users • Develop a sustainable land use policy (Needs to be done at a State level) Footnote • Diversification of livelihoods – bee keeping, fishery, poultry, etc - Alternative sources of employment to prevent out migration • Create awareness to conserve local ecosystem – to maintain ecosystem services • Sustainability of agricultural business models, assessment and improvement of producer consumer nexus, e.g. formation of cooperatives, establishing market linkages, food processing units, etc. (Mukteshwar Kisan Producer Company)

Rural System	*Climate Risks (Climate Fragility Statements)*	*Potential Resilience Interventions*
Forest Resources	Increase in temperature and a decrease in rainfall will increase the incidence of forest fire, loss of biodiversity, depletion of medicinal plants and a reduction in the availability of fuel-wood and fodder.	• Institutionalization of sustainable forest management & use practices - Strengthen forest panchayats to manage forests sustainably using good practices • Sustainable use of forest resources • Wild animals should be protected but consideration should be given to protecting farmer's livelihoods. Efforts to cultivate food in forested areas for wild animals to eat could be considered as a way of ameliorating the consumption of food crops. • Replace firewood with alternative sources such as solar & wind • Create awareness of medicinal plants to improve livelihoods and the economy • Delineation and management of fire lines in forests for forest fire management

Table 30. Prioritising Resilience Interventions for the rural system: Availability and Supply of Water for Drinking and Irrigation

Potential Resilience Interventions	Redundancy	Flexibility	Responsiveness	Access to information	Resilience Score
Tanker use	yes	yes	Yes	No	3/4 (Medium)
Afforestation with broad leaf species	No	yes	yes	No	2/4 (Average)
Check drains	yes	yes	yes	No	3/4 (Medium)
Infiltration Trenches	yes	yes	yes	No	3/4 (Medium)
Rainfall water harvesting	yes	yes	Yes	No	3/4 (Medium)
Water reuse at the household level	yes	Yes	yes	NO	3/4 (Medium)
Revive traditional sources of water management	yes	yes	yes	yes	4/4 (High)
Storing seasonal water in tanks	yes	yes	Yes		3/4 (Medium)
Water resource management & governance	yes	yes	yes	yes	4/4 (High)
Awareness regarding afforestation water conservation & reduction of water wastage	yes	yes	yes	yes	4/4 (High)

Dried Hand Pump (photo: Prakash Tiwari)

Table 31. Feasibility and Impact of Potential Resilience Interventions for the rural system: Availability and Supply of Water for Drinking and Irrigation

	FEASIBILITY			IMPACT
Potential Resilience Interventions	**Technically**	**Politically**	**Financial**	**Short/medium/long term**
Tanker use	low	medium	medium	Short
Afforestation with broad leaf species	high	high	high	Long
Check drains	high	high	high	Medium
Infiltration Trenches	high	high	high	Short
Rainfall water harvesting and recharge	high	medium	medium	Long
Water reuse at the household level	high	high	high	Short
Revive traditional sources of water management	high	high	medium	Short
Storing seasonal water in tanks	high	high	High	Long
Water resource management & governance	high	high	high	Long
Awareness regarding afforestation water conservation & reduction of water wastage	high	high	high	Long

Ramgad River and Minor Irrigation Canal (photo: Prakash Tiwari)

Table 32. Prioritising Resilience Interventions for the rural system: Road Connectivity.

Potential Resilience Interventions	Redundancy	Flexibility	Responsiveness	Access to information	Resilience Score
Geological mapping and survey to identify and reduce risks	Y	Y	Y	Y	4/4 (High)
Adequate construction codes for roads & the need to follow engineering plans and guidelines & retaining walls	N	y	y	N	2/4 (Medium
Construct good drainage systems such as culverts	N	Y	Y	N	2/4 (Medium)
Afforestation beside roads	N	Y	Y	N	2/4 (Medium)
Use of oxen or horses for transporting goods temporarily	Y	Y	Y	N	3/4 (Average)
Installation of check dams (first order streams)	Y	Y	Y	Y	4/4 (High)
Temporary accessibility managed by local materials like wooden bridges, wherever possible	Y	Y	Y	N	3/4 (Average)

Retaining walls and drainage culvets Ramgad watershed (photo: Lance Heath)

Table 33. Feasibility and Impact of Potential Resilience Interventions for the rural system: Road Connectivity

	FEASIBILITY			IMPACT
Potential Resilience Interventions	**Technically**	**Politically**	**Financial**	**Short/medium/long term**
Geological mapping and survey to identify and reduce risks	High	Low – policies in place, ground reality differs	Low	Long term
Adequate construction codes for roads & the need to follow engineering plans and guidelines & retaining walls	High	High	Low	Medium
Construct good drainage systems such as culverts	High	Medium	Low	Medium
Afforestation beside roads	High	High	High	Long
Installation of check dams (first order streams)	High	High	Medium	Short
Temporary accessibility managed by local materials like wooden bridges, wherever possible	High	High – temporary interventions if there is enough public pressure	High – community based work, not cost intensive	Short

Steep road access to farming land (photo: Lance Heath)

Table 34. Feasibility and Impact of Potential Resilience Interventions for the rural system: Community Health and Wellbeing

Potential Resilience Interventions	Redundancy	Flexibility	Responsiveness	Access to information	Resilience Score
Awareness programs on hygiene and sanitation for local people	N	N	Y	Y	2/4 (Average)
Availability of good medical facilities in community health centres (See Footnote)	Y	Y	Y	Y	4/4 (High)
Use of climate resilient varieties of seeds to maintain/increase food production	Y	Y	Y	N	3/4 (Medium
Revise BPL list to improve access to food security	N	N	N	Y	1/4 (Low)
Educational and socio-economic empowerment of women to improve hygiene, sanitation, & the health of the entire family	Y	Y	Y	Y	4/4 (High)
Water quality checks of water sources like streams in villages	Y	Y	Y	Y	4/4 (High)
Promote Household level purification of water, chlorine tablets, boiling of water, etc	Y	Y	Y	Y – generic qualitative information may be available	4/4 (High)
Maintenance of water sources, conservation and protection of sources from contamination	Y	Y	Y	Y – generic qualitative information may be available	4/4 (High)

Table 35. Feasibility and Impact of Potential Resilience Interventions for the rural system: Community Health and Wellbeing

	FEASIBILITY			IMPACT
Potential Resilience Interventions	**Technically**	**Politically**	**Financial**	**Short/medium/long term**
Awareness programs on hygiene and sanitation for local people	High	High	High	Long
Availability of good medical facilities in community health centres (See Footnote)	High	Low	Low	Long
Use of climate resilient varieties of seeds to maintain/increase food production	Medium	High	High	Medium
Revise BPL list to improve access to food security	High	Medium	Low	Medium
Educational and socio-economic empowerment of women to improve hygiene, sanitation, & the health of the entire family	High	High	Low	Long
Water quality checks of water sources like streams in villages	High	High	Medium	Short
Promote Household level purification of water, chlorine tablets, boiling of water, etc	High	High	High	Long
Maintenance of water sources, conservation and protection of sources from contamination	High	High	Low	Long

Table 36. Feasibility and Impact of Potential Resilience Interventions for the rural system: Rural Livelihoods and Economy

Potential Resilience Interventions	Redundancy	Flexibility	Responsiveness	Access to information	Resilience Score
Use new varieties of seeds which use less water	Y	Y	Y	N	3/4 (Medium)
Reallocation of agricultural land use, revise cropping patterns	Y	Y	Y	N	3/4 (Medium)
Action should be taken to protect crops from wild animals (i.e pigs & monkeys etc)	Y	Y	Y	N	3/4 (Medium)
Protection of forests to ensure livelihood protection of forest produce users	Y	Y	Y	N	3/4 (Medium)
Develop a sustainable land use policy (Needs to be done at a State level)					
Diversification of livelihoods – bee keeping, fishery, poultry, etc - Alternative sources of employment to prevent out migration	Y	Y	Y	Y	4/4 (High)
Create awareness to conserve local ecosystem & to maintain ecosystem services	Y	Y	Y	Y	4/4 (High)
Sustainability of agricultural business models, assessment and improvement of producer- consumer nexus, e.g. formation of cooperatives, establishing market linkages, food processing units, etc. (Mukteshwar Kisan Producer Company)	Y	Y	Y	Y	4/4 (High)

Lined Terraces under Vegetable and Flower Cultivation (photo: Prakash Tiwari)

Storage dam used for irrigation of fruit trees (photo: Lance Heath)

Table 37. Feasibility and Impact of Potential Resilience Interventions for the rural system: Rural Livelihoods and Economy

	FEASIBILITY			IMPACT
Potential Resilience Interventions	**Technically**	**Politically**	**Financial**	**Short/medium/long term**
Use new varieties of seeds which use less water	Medium	High	Low	Medium- Long
Reallocation of agricultural land use, revise cropping patterns	High	High	High	Long
Action should be taken to protect crops from wild animals (i.e pigs & monkeys etc)				
Protection of forests to ensure livelihood protection of forest produce users	High	High	High	Long
Develop a sustainable land use policy (Needs to be done at a State level)				
Diversification of livelihoods – bee keeping, fishery, poultry, etc - Alternative sources of employment to prevent out migration	High	Medium	Medium	Long
Create awareness to conserve local ecosystem & to maintain ecosystem services	High	High	High	Long
Sustainability of agricultural business models, assessment and improvement of producer- consumer nexus, e.g. formation of cooperatives, establishing market linkages, food processing units, etc. (Mukteshwar Kisan Producer Company)	High	High	Medium	Long

Table 38. Feasibility and Impact of Potential Resilience Interventions for the rural system: Forestry Resources

Potential Resilience Interventions	Redundancy	Flexibility	Responsiveness	Access to information	Resilience Score
Institutionalization of sustainable forest management & use practices - Strengthen forest panchayats to manage forests sustainably using good practices	Y	Y	Y	Y	4/4 (High)
Sustainable use of forest resources	Y	Y	Y	N	3/4 (Medium)
Wild animals should be protected but consideration should be given to protecting farmer's livelihoods. Efforts to cultivate food in forested areas for wild animals to eat could be considered as a way of ameliorating the consumption of food crops.	Y	Y	Y	N	3/4 (Medium)
Replace firewood with alternative sources such as solar & wind	Y	Y	Y	N	3/4 (Medium)
Create awareness generation of medicinal plants to improve livelihood and economy	Y	Y	Y	Y	4/4 (High)
Delineation and management of fire lines in forests for forest fire management	N	N	Y	Y	2/4 (Average)

Table 39. Feasibility and Impact of Potential Resilience Interventions for the rural system: Forestry Resources

	FEASIBILITY			IMPACT
Potential Resilience Interventions	**Technically**	**Politically**	**Financial**	**Short/medium/long term**
Institutionalization of sustainable forest management & use practices - Strengthen forest panchayats to manage forests sustainably using good practices	High	Low	Medium	Long
Sustainable use of forest resources	High	Medium	Medium	Long
Wild animals should be protected but consideration should be given to protecting farmer's livelihoods. Efforts to cultivate food in forested areas for wild animals to eat could be considered as a way of ameliorating the consumption of food crops.	High	Medium	Medium	Long
Create awareness generation of medicinal plants to improve livelihood and economy	High	High	High	Long
Replace firewood with alternative sources such as solar & wind	High	High	Low	Long
Delineation and management of fire lines in forests for forest fire management	High	High	High	Long

The prioritisation of resilience interventions for the rural system Availability and Supply of Water for Drinking and Irrigation, revealed three potential resilience intervention strategies that scored highly in terms of their resilience. These included 1) water resource management and governance; 2) creating awareness around the issues of afforestation, water conservation and reduction of waste water; and 3) revive traditional sources of water management. Resilience strategies 1 and 2 were high in terms of their technical, political and financial feasibility and were considered long-term in their overall impact. The revival of traditional sources of water management required some financial commitment and was also regarded as having only a short-term impact. The other resilience strategies were deficient in terms of access to available information. The resilience strategy "afforestation with broad leaf species" was high in terms of its feasibility and long-term impact but scored poorly in terms of its redundancy.

Clearly, access to information is probably the main factor impeding the implementation of some resilience intervention strategies. Proper water governance and the creation of greater awareness on water conservation, are key strategies that could assist in the availability and supply of water for drinking. The data gap analysis also identified the need for more research on some hydrological parameters such as spring and stream discharge.

The prioritisation of resilience interventions for the rural system, Road Connectivity, revealed two potential resilience intervention strategies that scored highly in terms of their resilience. These resilience intervention strategies include: 1) geological mapping and survey to identify and reduce risks; and 2) the installation of check dams (first order streams). Although the second strategy is effective, its impact is short-term. Three resilience strategies, namely 1) adequate construction codes for roads and the need to follow engineering plans and guidelines; 2) construct good drainage systems such as culverts; and 3) afforestation beside roads, all received average resilience scores. Their impact, however, was medium-term except for "afforestation besides roads", which was considered long-term in its overall impact. Therefore, a tree planting strategy or program targeted at roadsides could help prevent excessive erosion from landslides. The use of local materials such as wood to repair damaged bridges was a short-term measure or impact but was excellent in terms of its technical, political and financial feasibility. However, access to information on this potential resilience strategy is lacking.

For the rural system Community Health and Wellbeing, there were several resilience interventions that scored highly in terms of their overall resilience. These included: 1) availability of good medical facilities in community health centres; 2) educational and socio-economic empowerment of women to improve hygiene, sanitation, and the health of the entire family; 3) water quality checks of water sources like streams in villages; 4) the promotion of household level purification of water, chlorine tablets, boiling of water, etc; and 5) maintenance of water sources and the conservation and protection of sources from contamination. All resilience strategies had a long-term impact except for the second strategy (water quality checks of water sources like streams in villages).

The provision and availability of good medical facilities in community health centres were regarded as costly options with low political but high technically feasibility. The resilience strategy: "educational and socio-economic empowerment of women to improve hygiene, sanitation, and the health of the entire family", was technically and politically high in terms of its feasibility but would be costly to implement such programs despite their long-term benefits.

All resilience interventions for the rural system, Rural Livelihoods and Economy scored medium to high in terms of their overall resilience. Their long-term impacts were medium to long-term. However, as with the other rural systems, access to information on some resilience strategies such as "using new varieties of seeds which use less water and the reallocation of

agricultural land, revise cropping patterns as well as taking action to protect crops from wild animals (i.e pigs & monkeys etc)" was either deficient or lacking.

For the last rural system, Forestry Resources, six resilience interventions were prioritised in accordance with the IAP scoring system. Two interventions: 1) Institutionalisation of sustainable forest management and use practices - strengthening forest panchayats to manage forests more sustainably using good practices; and 2) create awareness generation of medicinal plants to improve livelihood and economy), were categorised as having high level of resilience. Three interventions scored a medium level of resilience; these were: 1) sustainable use of forest resources; 2) wild animals should be protected but consideration be given to protecting farmer's livelihoods. Efforts to cultivate food in forested areas for wild animals to eat could be considered as a way of ameliorating the consumption of food crops. The erection of fences is another intervention that could considered but was not mentioned at the SLD.

Only one resilience intervention scored average for the rural system Forest Resources and this was the "delineation and management of fire lines in forests for forest fire management". All resilience interventions were considered to have long-term impacts. However, the replacement of firewood with more sustainable energy practices such as renewable energy (wind and solar) scored low in terms of its financial feasibility. The sustainable use of forest resources required extra financial resources and the political willingness in order to be adopted by policy makers.

3.6.1 Integration into Rural Plans

The last step in the IAP is linking resilience interventions to ongoing programs. The Ramgad watershed management authorities already have a comprehensive set of plans, ongoing programs and projects. Wherever possible, climate resilience interventions should be linked with, or built into, existing departmental workplans. Through extensive consultation with planning authorities and the Stakeholder Group, each resilience intervention developed as part of this IAP was then assessed to determine whether it belongs to an existing program or whether it is an ongoing/upcoming or planned intervention. Currently there are several on-going, up-coming or panned programs that are listed beside each resilience intervention.

Linking resilience interventions to ongoing programs for the rural system Availability and Supply of Water for Drinking and Irrigation is shown in Table 40. More than half of the resilience interventions developed from the IAP for this rural system have plans that are currently under the process of implementation. However, no such plans are in place or are planned for the use tankers to transport water or strategies to re-use water. Interventions on awareness relating to water conservation and reduction or revival of traditional sources of water management are lacking and could be implemented.

Table 40. Linking Resilience Interventions to ongoing Programs for the Rural System: Availability and Supply of Water for Drinking and Irrigation

Resilience Interventions	Relevant programs	Ongoing/Upcoming/Planned	Can the program be leveraged (yes/no), if yes how ?
Tanker use	No	No plans	Yes
Afforestation with broad leaf species	Implemented	On going	Yes
Check drains	Implemented	On going	Yes
Infiltration Trenches	Implemented	On going	Yes
Rainfall water harvesting and recharge	Implemented	On going	Yes
Water reuse at the household level	No	No plans	Yes
Revive traditional sources of water management	No	No Plans	Yes
Storing seasonal water in tanks	Yes	On going	Yes
Water resource management & governance	No	No Plan	Yes
Awareness regarding afforestation water conservation & reduction of water wastage	No	No Plan	Yes

Table 41 links the resilience interventions with ongoing programs for the rural system Road Connectivity. Of the seven resilience interventions, five have on-going plans for their implementation with one strategy (installation of check dams) lacking a designated program. There are currently no relevant programs for some resilience intervention strategies such as geological mapping and surveying to identify and reduce risks as well as the use of local materials such as wood to repair damaged bridges. However, there are plans in place to implement the first resilience intervention strategy. Adequate construction codes for roads and the need to follow engineering plans and guidelines required extensive lobbying by community groups in order to secure the funds available.

Table 41. Linking Resilience Interventions to ongoing Programs for the Rural System: Road Connectivity

Resilience Interventions	Relevant programs	Ongoing/Upcoming/ Planned	Can the program be leveraged (yes/no), if yes how ?
Geological mapping and survey to identify and reduce risks	No	Planned	Yes
Adequate construction codes for roads & the need to follow engineering plans and guidelines & retaining walls	Yes	On-going	Yes: Funding is available but need to apply (lobbying) Depends on the type of road required (rural, state national)
Construct good drainage systems such as culverts	Yes	On-going	As above
Afforestation beside roads	Yes	On going	Yes
Use of oxen or horses for transporting goods temporarily	Yes	On-going	Yes: All part of road construction (as above) EIA
Installation of check dams (first order streams)	No	On-going	Yes: Requires proper use of resources in a constructive way. No programs
Temporary accessibility managed by local materials like wooden bridges, wherever possible	No	No plans	No

Linking resilience interventions to ongoing programs for the rural system Community Health and Wellbeing is shown in Table 42. Most of the resilience interventions developed for this rural system have programs or on-going plans for their implementation. Some fall under the national health system such as the provision and availability of good medical facilities in community health centres. The resilience intervention awareness programs on hygiene and sanitation for local people was viewed as policy intervention and not a program as such.

While there has been extensive research into the use of climate resilient varieties of seeds to maintain/increase food production, no such program has been implemented in the watershed. Likewise, there is no program or service available for water quality checks despite efforts to ensure the proper conservation and protection of water supplies from potential sources of contamination. Without adequate and frequent water quality monitoring programs *in-situ*, there is no real measure of the effectiveness of current water conservation and protection measures currently in place.

Table 42. Linking Resilience Interventions to ongoing Programs for the Rural System: Community Health and Wellbeing

Resilience Interventions	Relevant programs	Ongoing/Upcoming/Planned	Can the program be leveraged (yes/no), if yes how ?
Awareness programs on hygiene and sanitation for local people	No	On-going	No: SBM (Mainly Sanitation) (policy level not a program)
Availability of good medical facilities in community health centres (See Footnote)	Yes	On-going	Yes: National Rural Health Mission
Use of climate resilient varieties of seeds to maintain/increase food production	No	No Plan	No: No Plan (Agricultural Department undertakes research) Provide some training on use of improved varieties.
Revise BPL list to improve access to food security	Yes	On-going	Yes: Need to apply for the list from the census through the district govt
Educational and socio-economic empowerment of women to improve hygiene, sanitation, & the health of the entire family	Yes	On-going	Yes: ICDS (Integrated Child Development Scheme) (Uttarakhand Womens Integrated Development Scheme)
Water quality checks of water sources like streams in villages	No	Not Planned	No: No specific program available. Cost is a problem
Promote Household level purification of water, chlorine tablets, boiling of water, etc	Yes	On going	Yes: part of primary health care centres
Maintenance of water sources, conservation and protection of sources from contamination	Yes	On going	Yes

Linking resilience interventions to ongoing programs for the rural system Rural Livelihoods and Economy is shown in Table 43. As with the use of climate resilient varieties of seeds to maintain/increase food production (previous rural system), the use of new varieties of seeds that use less water has no dedicated program. The resilience intervention on the reallocation of agricultural land use and the revision of cropping patterns, also lacks a dedicated program. Furthermore, the development of a sustainable land use policy is a resilience intervention program that goes beyond the jurisdiction of the Ramgad watershed.

The need for the development of sustainable agricultural business models and the improvement of the producer-consumer nexus, requires further investigation, particularly around the formation of cooperatives, establishing market linkages and food processing units.

The resilience intervention on the diversification of livelihoods such as bee keeping, fisheries, and poultry to help stem the continued problem of out migration is currently implemented by a number of organisations and programs. For example, the Mahatma Gandhi National Rural Employment Guarantee Act (MNREGA) provides employment opportunities for 100 days for everyone and the Uttarakhand State Rural Livelihood Mission (USRLM) provides opportunities mainly in construction work. The organisation Krishi Vigyan Kendra provides training on fisheries, poultry farming etc.

Table 43. Linking Resilience Interventions to ongoing Programs for the Rural System: Rural Livelihoods and Economy

Resilience Interventions	Relevant programs	Ongoing/Upcoming/Planned	Can the program be leveraged (yes/no), if yes how ?
Use new varieties of seeds which use less water	No	No Plans	No: No specific programs for these interventions
Reallocation of agricultural land use, revise cropping patterns	No (cannot secure programs)	No Plans	As Above
Action should be taken to protect crops from wild animals (i.e pigs & monkeys etc)	No	No Plans	As Above
Protection of forests to ensure livelihood protection of forest produce users	Yes	On-going	No: As above Forest Department undertakes
Develop a sustainable land use policy (Needs to be done at a State level) Footnote			No: Beyond the jurisdiction of the watershed

Resilience Interventions	Relevant programs	Ongoing/Upcoming/Planned	Can the program be leveraged (yes/no), if yes how ?
Diversification of livelihoods – bee keeping, fishery, poultry, etc - Alternative sources of employment to prevent out migration	Yes	On-going	Yes; Via the Uttarahkhand State Rural Livelihood Mission (USRLM). Krishi Vigyan Kendra (Training to fisheries, poultry farms).
Create awareness to conserve local ecosystem & to maintain ecosystem services	No	No plans	No Plans
Sustainability of agricultural business models, assessment and improvement of producer consumer nexus, e.g. formation of cooperatives, establishing market linkages, food processing units, etc. (Mukteshwar Kisan Producer Company)	No	No plans	No Plan

The last rural system linking resilience interventions to ongoing programs is Forest Resources (Table 44). Five out of the six resilience intervention strategies have relevant programs in place that are also on-going. For example, the resilience intervention on replacing firewood with alternative energy sources such as solar and wind could be implemented through the National Solar Initiative Rooftop Solar Power Scheme. The agency responsible for this strategy is the Uttarakhand Renewable Energy Development Agency. The major drawback to the implementation of such programs is their cost as revealed in the analysis on the prioritisation of intervention programs.

The institutionalisation of sustainable forest management practices through strengthening forest panchayats to manage forests sustainably was viewed as an important intervention strategy by stakeholders but requires a more comprehensive program that will bring together all disciplines (natural, economic and social aspects) into the one program. Furthermore, there is also a need for the delineation and management of fire lines in forests for sustainable forest fire management.

Lastly, wild native animals were viewed as troublesome by many farmers because of their tendency to consume food crops. A potential resilience intervention strategy would be to ensure an adequate food supply is available in forests to prevent animals from moving to farm land in search of food.

Table 44. Linking Resilience Interventions to ongoing Programs for the Rural System: Forest Resources

Resilience Interventions	Relevant programs	Ongoing/Upcoming/Planned	Can the program be leveraged (yes/no), if yes how ?
Institutionalization of sustainable forest management & use practices - Strengthen forest panchayats to manage forests sustainably using good practices	Yes	On-going	Yes: Integrated watershed management program. Comprehensive program bringing together all disciplines (natural, economic and social aspects)
Sustainable use of forest resources	Yes	On-going	As above
Wild animals should be protected but consideration should be given to protecting farmer's livelihoods. Efforts to cultivate food in forested areas for wild animals to eat could be considered as a way of ameliorating the consumption of food crops.	Yes	On-going	Yes
Create awareness generation of medicinal plants to improve livelihood and economy	Yes	On-going	Yes: Integrated watershed management program. Comprehensive program bringing together all disciplines (natural, economic and social aspects) National AYUSH Mission
Replace firewood with alternative sources such as solar & wind Awareness generation of medicinal plants – will improve livelihood and economy	Yes	On-going	Yes: Via Forest Department National Solar Initiative Rooftop Solar Power Scheme Uttarakhand Renewable Energy Development Agency
Delineation and management of fire lines in forests for forest fire management	Yes	No Plans at this stage	No Plans at this stage

4. Conclusions

The Ramgad watershed is experiencing dramatic social, economic and environmental pressures. The application of the IAP highlighted some key vulnerabilities to the impacts of climate change as well as some practical adaptive measures that can be implemented to strengthen community resilience in light of the impending challenges that lie ahead.

The climate change projections for the Ramgad watershed indicate that there will be an overall increase in temperature together with changes in seasonality. The wet season will become wetter with an increased incidence of extreme weather events, resulting in more flash flooding and cloud bursts. Such extreme weather events will result in more landslides, slope failures, and increased erosion. Conversely, the dry season will become drier with more severe droughts. The historical climate data revealed that minimum and maximum temperatures have increased over the last 30 years with night time temperature rising more than day time temperature. There is also a marked increase in the rainfall during the monsoon season and less rainfall during the dry season. For the drier months of December, January and February there has been a sharp decline in the amount of rainfall, which is consistent with the overall trend experienced across the Himalaya. Furthermore, the snow cover and snow fall frequency from year to year are also in decline. The historical climate data records were confirmed in the IAP Shared Learning Dialogues.

Based on the results obtained from the IAP for the Ramgad watershed, there are five rural systems that require immediate attention to help improve overall resilience to the impacts of climate change. These systems include: 1) Availability and Supply of Water for Drinking and Irrigation; 2) Road Connectivity; 3) Community Human Health and Wellbeing; 4) Rural Livelihoods and Economy; and 5) Forest Resources.

The communities of the Ramgad watershed are highly reliant on agriculture, tourism and forestry for their livelihoods. Climate change is without doubt having a major impact on the economic, social, health and wellbeing of communities within the watershed. A shortage of water and its supply for both dinking and irrigation purposes is leading to long-term health effects and food shortages. An increase in extreme weather events is having an impact on maintaining road connectivity between different watershed communities and to major food and produce distribution centres outside the watershed catchment. Residents living within the watershed feel that these impacts are leading to an increased fear of long-term isolation and economic hardship.

A series of intervention strategies were developed for each rural system and these were prioritised according to their redundancy, flexibility, responsiveness, access to information and overall impact. Some of the intervention strategies are cost effective and could be implemented immediately, while others require a considerable injection of funds and the political willingness of policy makers to turn such interventions into a reality. Over 40 resilience interventions were developed for the Ramgad watershed.

Greater awareness of water conservation, as well as the revival of some traditional water management strategies, were viewed as a way of ameliorating some of negative impacts on

the availability and supply of water for drinking and irrigation purposes. Some simple and cost-effective measures, such as the transportation of water by tankers and the development of water reuse strategies, could assist communities in the short-term. Programs that focus on geological mapping and water quality monitoring to help reduce the incident of water-borne diseases could be implemented immediately. While there are conservation and protection measures in place for water supplies within the Ramgad watershed, the lack of water quality monitoring has made it difficult to assess the effectiveness of such measures.

Although there has been extensive research into the use of climate resilient varieties of seeds to maintain or increase food production and conserve water, there is a need to implement a long-term program to improve food security and conserve water resources. Maintaining road connectivity was viewed by stakeholders as an important issue to prevent long-term isolation and economic loss through the inability to transport produce to markets and distribution centres. Local materials such as wood could be used to repair bridges damaged as result of extreme weather events and flash flooding. The installation of check dams (first order streams) to prevent excessive erosion, would help to ameliorate some of the consequences (slope failures, landslides, debris and mud flow) resulting from intense rainfall events.

The institutionalisation of sustainable forest management practices to enable forest panchayats to manage forests more sustainably was viewed as an important intervention strategy by the Stakeholder Group, but requires a more comprehensive program that will integrate all disciplines (natural, economic and social aspects) into the one program. Furthermore, there is also a need for the delineation and management of fire lines in forests to ensure a more sustainable forest fire management regime. The farming community viewed wild native animals as a major problem because of their tendency to consume food crops. A potential resilience intervention strategy would be to ensure an adequate food supply is available in forests to prevent animals from moving to farm land in search of food. Clearly, this would require a strong focus on maintaining and protecting ecosystem services. Unfortunately, ecosystem services were not highlighted as a rural system in this IAP but should form the basis of future work.

Finally, access to information was an impediment for nearly all the rural systems that were reviewed under the IAP. The development of a Knowledge Management Framework for the Ramgad watershed to support decision making processes is urgently required.

5. Future Directions

This is the first time the IAP has been used in India in a rural context. The IAP was designed for use in cities and urban environments such as the city of Nainital. Through the Shared Learning Dialogue (SLD) workshops, participants discovered after conducting the IAP exercises, that the sensitivity relating to the scoring system could be improved to truly reflect the rural environment. The reasons for these observations are probably varied but one reason for this difference is to do with the nature of rural system and the fact that they typically have less resources to measure threats and their associated impacts. This is also compounded by the physical distances between cities that have better infrastructure and resources at their disposal (i.e better hospitals and equipment, human resources etc) and rural environments that quite often lack basic amenities, infrastructure as well as the ability to mobilise human resources *en masse*. Therefore, the IAP system of scoring may not be suitable for assessing

the adaptive capacity of actors to respond to shocks and disruptions. An alternative ranking scale is required to reflect a more realistic level of adaptive capacity for each actor. This area of research should be explored and tested in more detail in future IAP studies that examine the adaptive capacity of rural environments.

Reliable climate information is essential to the quantitative assessment of climate impacts in mountain regions and for improving regional resilience and adaptive capacity to such impacts. Mountain regions have various regional climate characteristics for example terrain-oriented rainfall patterns. Typically, mountainous regions of the Himalaya lack weather stations due to the steep and rugged terrain. Many areas are simply too difficult to access. This is the case for the Ramgad watershed in which there is only one weather station available at Mukteshwar. Therefore, the Ramgad watershed can be defined as a hydro-meteorological data deficit region. However, attempts have been made to address this data deficiency through the installation of five community based weather monitoring stations installed in five villages in the Ramgard watershed. This new initiative is taking place under the auspices of a collaborative project between Newcastle University, in the United Kingdom and Kumaun University in Nainital. This project is supported by the UK Royal Society (Figure 19).

Figure 19. Five community based weather monitoring stations have been installed in five villages in the Ramgad watershed (photo: Prakash Tiwari).

With a deficiency in weather stations and available climate data, it is almost impossible to create a spatial representation of rainfall and temperature across the entire watershed. Software programs such as ANUSPLIN and ANUCLIM (Hutchinson, 1991,1995 & 2004) uses an elevation-dependent algorithm to create spatial representations of rainfall and temperature in mountainous regions. The more weather stations there are in the watershed, and hence the more climate data that is available, the better the spatial representation.

The climate surface maps generated from these software packages can be used to model rainfall/runoff in agricultural catchments by using a suite of hydrological software. The results from this analysis can inform policymakers on a range of watershed management issues including the optimisation of rainfall capture and storage. The ANUCLIM software can also be used to predict the bioclimatic distribution of organisms in response to a changing climate (Xu and Hutchinson, 2013). It is highly recommended that future work should focus on the application of these software packages to build a reliable account of the spatial distribution of rainfall and temperature across the Ramgad watershed. Consequently, it will provide a greater understanding and knowledge of the hydrological and bioclimatic processes within the Ramgad watershed environment. The data gap analysis also identified the need for more research on some hydrological parameters such as spring and stream discharge.

A lack of information on how climate change is affecting the region and how to respond to it was found to be a major barrier to adaptation. The IAP revealed a major deficiency in the accessibility and flow of information to those most in need. The development of a Knowledge Management Framework can help improve the follow and accessibility of information to farmers, tourist operators, forest managers, community leaders and policymakers. This is achieved through the development of a Knowledge Management Platform to encourage the collection and sharing of critical information and knowledge at multiple levels. Therefore, efforts should be made to initiate planning for the establishment of Knowledge Management Framework Platform.

Lastly, ICLEI with support from the Rockefeller Foundation, has finalised the IAP for the City of Nainital, which is approximately 40 km from the Ramgad watershed in the state of Uttarakhand, India. Because of the proximity of these two IAP study regions, future work should identify and examine crucial climate change adaptation linkages between the urban and rural sectors, and could form the basis for a new research endeavour.

6. References

Aase, T. H., Chapagain, P. and Tiwari, P. C. (2013) Innovation as an expression of adaptive capacity to change in Himalayan Farming. Mountain Research and Development 33(1), 4–10. (E)

Allen Consulting Group. (2005) Climate change risk and vulnerability: Promoting an efficient adaptation response in Australia, Australian Greenhouse Office.

Australian National University. (2009) Implications of climate change for Australia's World Heritage properties: A preliminary assessment. A report to the Department of Climate Change and the Department of the Environment, Water, Heritage and the Arts by the Fenner School of Environment and Society, the Australian National University.

Government of Uttarakhand. (2011) Slope Instability and Geo-environmental Issues of the Area around Nainital, Disaster Management and Mitigation Centre, Government of Uttarakhand, Report, Disaster Management and Mitigation Centre, Government of Uttarakhand, Dehradun

Heath, L., Salinger, M.J., Falkland, T., Hansen, J., Jiang, K., Kameyama, Y., Kishi, M., Lebel, L., Meinke, M., Morton, K., Nikitina, E., Shukla, P.R and White, I. (2014) Climate and Security in Asia and the Pacific (Food, Water and Energy) in Michael J. Manton and Linda Anne Stevenson (ed.). Climate in Asia and the Pacific: Security, Society and Sustainability, Springer, Dordrecht, Heidelberg, New York, London, pp. 129-198.ISBN 978-94-007-7337-0

Hutchinson, M.F. (1991) The Application of thin plate smoothing splines to continent- wide data assimilation. In: Data Assimilation Systems, J.D.Jasper (ed), Bureau of Meteorology Res. Rep. No. 27, Bureau of Meteorology, Melbourne, pp. 104-113.

Hutchinson, M.F. (1995) Interpolating mean rainfall using thin plate smoothing splines. International Journal of GIS 9: 385-403.

Hutchinson, M.F. (2004) ANUSPLIN Version 4.3. Fenner School of Environment and Society, Australian National University, Canberra.

ICLEI. (2014) ICLEI South Asia First Edition, December 2014. ICLEI - Local Governments for Sustainability, South Asia.

IPCC. (2001) Climatic changes 2001: Intergovernmental Panel on Climate Change. The scientific basis, Technical summary from Working Group I, IPCC, Geneva.

IPCC. (2007a) Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the IPCC. - http://www.ipcc.ch/ipccreports/ar4-wg1.htm.

IPCC. (2007b) Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Annex I., M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK.

IPCC. (2007c) Climate Change 2007: Mitigation of Climate Change. Contribution of Working Group III to the Fourth Assessment Report of the IPCC. – http://www.ipcc.ch/ipccreports/ar4-wg3.htm.

IPCC. (2014) Climate Change 2014: Impacts, Adaptation, and Vulnerability is the second volume of the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC)

Rawat, J.S. (2009) Saving Himalayan Rivers: developing spring sanctuaries in headwater regions. In: Shah, B.L.(ed.) Natural Resource Conservation in Uttarakhand, Ankit Prakshan, Haldwani, pp. 41–69.

Tiwari, P. C and Joshi B. (2012a) Environmental changes and sustainable development of water resources in the Himalayan headwaters of India, International Journal of Water Resource Management, 26 (4), pp. 883–907, DOI 10.1007/ s11269-011-9825-y.

Tiwari, P. C and Joshi, B. (2012b), Natural and socio-economic factors affecting food security in the Himalayas, Journal of Food Security, 4 (2), pp. 195–207, DOI 10.1007/s12571-012-0178-z.

Tiwari, P.C. and Joshi, B. (2013) Rainfall Variability and its Impact on Water Resources and Rural Health in Kumaon Himalaya, India, in Velma Grover (ed) Impact of Climate Change on Water and Health, CRC Press, Taylor and Francis Group, pp.286-307

Tiwari, P.C and Joshi, B. (2014) Environmental Changes and their Impact on Rural Water, Food, Livelihood, and Health Security in Kumaon Himalaya. International Journal of Urban and Regional Studies, Tiwaris, Hiroshima University, 1(1): 1–12 (2014)

Tiwari, P.C and Joshi, B. (2015) Climate Change and Rural Out-migration in Himalaya. Change and Adaptation in Socio-Ecological Systems Climate Change, Social Changes, Technological Development. De Gruyter (Open). 2: 8-25

Valdiya, K.S. and Bartarya, S.K. (1991) Hydrological studies of springs in the catchment of Gaula River, Kumaun Lesser Himalaya, India. Mountain Research and Development 11, 17–25.

Xu, T. and Hutchinson, M.F. (2013). New developments and applications in the ANUCLIM spatial climatic and bioclimatic modelling package. Environmental Modelling and Software, 40: 267-279 [40, 52].

7. Appendix Conferences/Symposia/Workshops

Core Climate Team

S. No.	Member Name	Position	Affiliation	Contact Details
1	Prof. P. C. Tiwari	Professor	Kumaun University, Nainital, Uttarakhand	Cell: 91-9410941117 Email: pctiwari@yahoo.com
2	Dr. Nathan Forsythe	Post Doctoral Fellow	New Newcastle University, New Newcastle, UK	Email:nathan.forsythe@newcastle.ac.uk
3	Dr. Bhagwati Joshi	Assistant Professor	Government Post Graduate College Rudrapur, Uttarakhand	Cell: 91-9411538139 Email: bhawanatiwari@yahoo.com
4	Prof. R.C. Joshi	Professor	Kumaun University, Nainital Uttarakhand	Cell: 91-9410938847 Email: rcjoshi007@gmail.com
5	Mrs. Pushpa Negi	Head Rangarh Development Block	Nathuwakhan, Ramgarh, Nainital, Uttarakhand	Cell: 91-9458338856
6	Mr. D.N. Bisht	Assistant Engineer	Drinking Water Department, Ramgarh, Nainital, Uttarakhand	Cell: 91-9412161877/7055012603
7	Mr. B. C. Pant	Assistant Engineer	Irrigation Department Ramgarh	Cell: 91-9411328841
8	Mr. Surendra Negi	Project Manager	Central Himalayan Rural Action Group (CHIRAG) Mukteshwer, Nainital, Uttarakhand	Cell: 91-9690565464
9	Mr. Bhupal Singh Khati	Block Development Officer, Ramgarh Development Block, Nainital, Uttarakhand	Block Development Officer Ramgarh, Nainital, Uttarakhand	Cell: 91-9457647929
10	Mr. Himanshu Panday	Assistant Review Officer	Uttarakhand High Court, Nainital, Uttarakhand	Cell: 91-9458940260

Stakeholder Engagement Workshop, Manu Maharani Hotel (Workshop 1)

Participants who attended the Stakeholder engagement workshop in Nainital

Workshop Participants

S. No.	Name	Affiliation/Occupation	Email	Telephone
1	Mr. Yashpal Arya	Chairman Village Council Naikana	NA	91-7409462984
2	Mr. Yashwant Bisht	Block Development Committee Member, Rangarh	NA	91-9411303981
3	Mr. Krishna Chandra	Chairman Village Council Nathuwakhan	NA	91-9012239631
4	Mr. Ganga Singh Gaur	Head Forest Council, Stabunga	NA	91-9410514701
5	Mrs. Pushpa Negi	Head Ramgarh Development Block	NA	91-9458338856
6	Sri. D.N. Bisht	Assistant Engineer Drinking Water	NA	91-9412161877
7	Sri. B. C. Pant	Assistant Engineer, Drinking Water	NA	91-9411328841
8	Mr. Surendra Negi	Central Himalayan Rural Action Group	NA	91-9690565464
9	Bhupal Singh Khati	Block Development Officer, Ramgarh Development Block, Nainital, Uttarakhand	NA	91-9457647929
10	Mr. Yashpal Arya	Chairman Village Council, Naikana	NA	91-7409462984

11	Mr. M.S. Sammul	Researcher	mohansummal@gmail.com	91-8126217227
12	Mr. Dhiraj Pant	Researcher	dhirajpant@gmail.com	91-9997884525
13	Ms. Ritika Vishnoi	Researcher	ritika.vishnoi88@gmail.com	91-8392887353
14	Ms. Priyanka Suyal	Student	NA	91-9536979529
15	Mr. Gyanendra Kumar	Researcher	gk8047@gmail.com	91-9758960307
16	Dr. Sunandan Tiwari	ICLEI, South Asia, New Delhi	sunandan.tiwari@iclei.org	91-9891456157
17	Dr. Nathan Forsythe	New Newcastle University, New Newcastle, UK	nathan.forsythe@newcastle.ac.uk	NA
18	Mrs. Pooja Mehra	Village Development Officer, Naikana	NA	91-9458940075
19	Mrs. Renu Arya	Village Development Committee Member	NA	91-9411322917
20	Prof. Lance Heath	ANU/SUSTINEO, Australia	Lance.heath@anu.edu.au	61-419018777
21	Mr. Jaswant Singh	Uttarakhand Water Department	NA	91-7055019413
22	Mr. Himanshu Pande	Uttarakhand High Court	NA	91-9458940260
23	Mrs. Kamla Jangpangi	Block Education officer, Ramgarh	NA	91-1910764831
24	Mr. Umesh C. Joshi	Teacher, Ramgarh	NA	91-9411323177
25	Mrs. Hanshi Suyal	Village Panchayat Member	NA	NA
26	Mrs. Renu Arya	Farmer, Bhorakote	NA	91-9727484917
27	Mr. N. K. Joshi	Horticulture Department	NA	91-9411790734
28	Ms. Mamta	Teacher	NA	91-9627433093
29	Mr. Sundar Lal	Village Council Member, Stabunga	NA	91-9411947744
30	Mr. Sonu Suyal	Teacher	NA	91-9675584608
31	Mrs. Kamla Negi	Central Himalayan Rural Action Group	NA	91-9759778399
32	Mr. K. C. Joshi	Farmer	NA	91-9536118491
33	Mrs. Shoba Daramwal	Head Village Council, Bohrakote	NA	91-9536117276
34	Prof. P. C. Tiwari	Professor	pctiwari@yahoo.com	91-9410941117
35	Dr. Bhagwati Joshi	Assistant Professor	bhawanatiwari@yahoo.com	91.9411538139
36	Mrs. Janki Daramwal	Deputy Head Village Council, Bohrakote	NA	91-8449241789
37	Mr. S. C. Arya	Head Village Council	NA	91-8449238957
38	Mr. Ayush Tiwari	Student	tiwariayush97@yahoo.com	91-8755063564
39	Mr. Abhinav Tiwari	Student	toabhinavtiwari@gmail.com	91-9479818374
40	Mr. Bhupal Singh Khati	Block Development Officer, Ramgarh, Nainital	NA	91-9457647929

Agenda Stakeholder Engagement Workshop

Wednesday 4th Nov 2015 Venue: Manu Maharani Hotel

9:00am-9:30am	Tea and Coffee Upon Arrival
9:30am-10:15pm	Session 1: Welcome, Introductions & Aim of Workshop
9:30am-9:45am	Welcome & Self Introductions Chair Professor Prakash Tiwari, Kumaun University
9:45am-10:15am	Aim of Workshop & Summary of Activities Professor Prakash Tiwari, Kumaun University
10:15am-11:00am	Session 2: Forming a Climate Core Team & Stakeholder group
10:15am -10:30am	Forming a Climate Core Team (positions & responsibilities)
10:30am-11:00am	Forming a Stakeholder Group
11:00am-11:15am	Group Photo & Tea and Coffee Break
11:15am-12:30pm	Session 2: Baseline Questionnaire
11:15am-11:30am	Impacts & responses to climate change
11:30am-11:45am	Overview of Sectoral Impacts of Climate Change
11:45am-12:00noon	Overview of Responses to Climate Change
12:00noon-12:15pm	Existing Climate Data/Mapping
12:15pm-12:30pm	Availability of Data
12:30pm-1:00pm	Session 3: Next Steps
12:30pm-1:00pm	Summary and Discussion on Next Steps

1:00 pm – 2:00pm		**Lunch**
2:00pm-6:00pm		**Field Trip**
		Field Trip to Ramgad Watershed

Vulnerabilities and Risk Assessment Workshop Rmagad Watershed (Aamari Resort) (Workshop 2)

Workshop Participants

Name	Affiliation/Occupation	Email	Telephone
Mr. Yashpal Arya	Chairman Village Council Naikana	NA	91-7409462984
Mr. Parmod Shahi	Flower Cultivator	shahipramod@yahoo.com	91-8191044518
Mr. Ramu Negi	Social Worker	NA	91-9719418818
Mr. Yashwant Bisht	Block Development Committee Member, Ramgarh	NA	91-9411303981
Mr. Jagat Singh Gaur	Farmer	NA	91-8449238957
Mr. Krishna Chandra	Chairman Village Council Nathuwakhan	NA	91-9012239631
Mr. Ganga Singh Gaur	Head Forest Council, Stabunga	NA	91-9410514701
Mr. N. Singh	Village Council Member, Stabunga	NA	91-3958941745
Mr. Bhupendra Chandra	Teacher	NA	91-9719656298
Mrs. Saroj Devi	Member Self Help Group, Bohrakote	NA	91-9927152968
Mrs. Hira Devi	Member Self Help Group, Bohrakote	NA	91-9012351036
Mr. Bachi Ram	Block Development Committee Member, Ramgarh Development Block	NA	91-9690458627
Mr. M.S. Sammul	Researcher	mohansummal@gmail.com	91-8126217227

Mr. Dhiraj Pant	Researcher	dhirajpant@gmail.com	91-9997884525
Mr. Vashim Ahmad	Researcher	ahmad@gmial.com	91-90122697183
Mr. Gyanendra Kumar	Researcher	Gk8047@gmail.com	91-9758960307
Mrs. Shruti Sadhukhan	ICLEI, South Asia, New Delhi	shrutisadhukhan@iclei.org	91-9910294934
Prof. Zian Zhong Yan	Southwest University, China	yanjzswu@126.com	NA
Ms. Emmapankhurst	ANU/SUSTINEO, Australia	e.pankhurst@gmail.com	61-431141727
Prof. Lance Heath	ANU/SUSTINEO, Australia	Lance.heath@anu.edu.au	61-419018777
Mr. Jaswant Singh	Uttarakhand Water Department	NA	91-7055019413
Mr. Revendra Singh	Social Worker	NA	91-9411376373
Mr. K. S. Mehra	Hotel Manager	NA	91-9627801112
Mrs. Ricky Surie	Migrated Local Resident	rickysurie@yahoo.com	91-9899400816
Mr. Mahesh Lal	Farmer, Bohrakote	NA	91-9411322917
Mr. S. C. Tewari	Irrigation Department	NA	91-9012035826
Mr. J. S. Harnawal	Farmer, Bohrakote	NA	91-9411378253
Mrs. Renu Arya	Farmer, Bhorakote	NA	91-9727484917
Mrs. Leela Dalakoti	Deputy Head Ramgarh Development Block	NA	91-8938003435
Mr. N. K. Joshi	Horticulture Department	NA	91-9411790734
Ms. Mamta	Teacher	NA	91-9627433093
Mr. Sundar Lal	Village Council Member, Stabunga	NA	91-9411947744
Mr. Sonu Suyal	Teacher	NA	91-9675584608
Mr. Rajeev Joshi	Deputy Head Village Council, Umagarh	NA	91-9411346664
Mr. K. C. Joshi	Farmer	NA	91-9536118491
Mrs. Shoba Daramwal	Head Village Council, Bohrakote	NA	91-9536117276
Prof. P. C. Tiwari	Professor	pctiwari@yahoo.com	91-9410941117
Dr. Bhagwati Joshi	Assistant Professor	bhawanatiwari@yahoo.com	91.9411538139
Mrs. Janki Daramwal	Deputy Head Village Council, Bohrakote	NA	91-8449241789
Mr. Hement Daramwal	Farmer	NA	91-8758020422
Mr. N. K. Joshi	Horticulture Department	NA	91-9411790734

Mr. S. C. Arya	Head Village Council	NA	91-8449238957
Mr. Govind Ballabh	Farmer	NA	91-8475045501
Mr. Narendra Singh	Forest Department	NA	91-8474935148
Mr. Vishamber Dayal	Framer	NA	91-9837284463
Mr. Om Prakash	Farmer	NA	91-9627593405
Mr. J. S. Gaur	Farmer	NA	91-8449842598
Mr. Ayush Tiwari	Student	tiwariayush97@yahoo.com	91-8755063564
Mr. Abhinav Tiwari	Student	toabhinavtiwari@gmail.com	91-9479818374
Mr. Madan Singh	Farmer	NA	91-8859131491
Mr. Bhupal Singh Khati	Block Development Officer, Ramgarh, Nainital	NA	91-9457647929
Mr. Manoj Bisht	Farmer	NA	91-9690111562

Agenda: Vulnerabilities and Risk Assessment Workshop

Sunday 27th March 2016 Venue: Aamari Resort Ramgad Basin

3:00pm-4:00pm	**Delegates from Delhi arrive at Aamari**
6:30pm-7:00pm	**Pre-Dinner Workshop meeting**
7:00pm-9:00pm	**Working Dinner to Discuss Workshop**

Monday 28th March 2016 Venue: Aamari Resort Hotel

8:30am-9:00am	**Tea and Coffee Upon Arrival**
9:00am-10:15pm	**Session 1: Welcome, Introductions & Aim of Workshop**
9:30am-9:45am	**Welcome & Self Introductions**
9:45am-10:00am	**Outline of Workshop Agenda**
10:00am-11:00am	**Session2: Overview of Phase 1**

10:00am -10:15am		Overview of Climate Core Team and their Engagement
10:15am-10:30am		Overview of Stakeholder Members
10:30am-11:00am		Baseline Questionnaire Assessment (understanding data availability)
11:00am-11:30am		Climate Ready Review Assessment (establishing the policy & program scenario)
11:00am-11:30am		Group Photo & Tea and Coffee Break
11:30am-12:30pm		Session 3: Climate Impacts Assessment
11:30am-11:50am		Analysis of Past Weather Events in the Ramgarh • Scientific assessment • Stakeholders perceptions
11:50am-12:10am		Analysis of Climate Projections • Scientific assessment • Stakeholder perceptions
11:10am-12:30pm		Consensus on Potential Climate Change Impacts in the Ramgarh
12:30pm-1:30pm		Lunch
1:30pm-2:30pm		Session 4: Assessment of Fragile Systems in the Ramgarh Watershed
1:30pm-2:00pm		Identification of Fragile Systems
3:00pm-3:30pm		Identify Reasons for their Fragility
3:30pm-4:00pm		Tea and Coffee Break
4:00pm-5:00pm		Session 5: Assessment of Anticipated Climate Change Impacts on Fragile Systems
4:00pm-4:30pm		Identify how the Fragile Systems will be Impacted

4:30pm-5:00pm		Formulation of the Climate Fragility Statement
5:00pm-5:10pm		Summary & Wrap up

Tuesday 29th March 2016 Venue: Aamari Resort Hotel

8:30am-9:00am		Tea & Coffee Upon Arrival
9:00am-10:00pm		Session 6: Overview of Day1 and Outline of Day 2
9:00am-9:15am		Summary of day 1
9:15am-9:30am		Outline of Workshop Agenda for Day 2
9:30am-11:00pm		Session 7: Risk Assessment Exercise
9:30am-9:45am		Explanation of Task and Break Out Groups
9:45am-10:30am		Group Work (Assessing risk status of the Climate Fragility Statements)
10:30am-11:00am		Groups report back (Discussions: workshop team documents scores collated)
11:00am-11:30am		Tea and Coffee Break
11:30am-11:45am		Groups' Presentation of Risk Assessment Results
11:30am-12:30pm		Session 8 Vulnerability Assessment (Part 1)
11:30am-11:45am		Explanation of Task and Break Out Groups
11:45am-12:30am		Mapping Areas of Vulnerability (Extreme to High Risk)
12:30pm-1:30pm		Lunch
1:30pm-3:00pm		Session 8: Vulnerabilities Assessment (Part 2)

12:30pm-1:00pm		Mapping Areas of Vulnerability (Extreme to High Risk)
1:00pm-1:30pm		Groups Report back on Vulnerability Mapping Exercise
1:30pm-2:20pm		Actor Analysis Exercise • Explanation of Task • Actor analysis
2:20pm-2:45pm		Groups Report back on Actor Analysis Exercise
2:45pm-3:00pm		Wrap up and next steps

Adaptive Capacity and Impacts Assessment Workshop

Radisson Blu Plaza Hotel New Delhi 2017 (Workshop 3)

Workshop Participants New Delhi 2017 (Photo: Xiaojun Deng, APN Secretariat)

Workshop Participants

Name	Affiliation/Occupation	Email	Telephone
Bedoshruiti Sadhukhan, ,	ICLEI, INDIA	shruti.sadhukhan@iclei.org	91-9910294934
Prof. P. C. Tiwari	Professor Kumaun University	pctiwari@yahoo.com	91-9410941117
Ms Eleanor Robson	ANU/SUSTINEO, Australia	eleanor.robson@sustineo.com.au	61448 780 651
Dr Lance Heath	ANU/SUSTINEO, Australia	Lance.heath@anu.edu.au	61-419018777
Dr. Bhagwati Joshi	Assistant Professor	bhawanatiwari@yahoo.com	91.94115381
Assoc ProfPrem Chapagain	Trihuvan Univerity	ps.chapagain@gmail.com	
Dr Baijayanti Mala Pokhrel	Trihuvan Univerity	bmp.pokhrel@gmail.com	
Ayush Tiwari	Student	tiwariayush97@yahoo.com	91-8755063564
Abhinav Tiwari	Student	tiwariayush97@yahoo.com	91-8755063564
Ms Pooja Nainwal	Kumaun University	pujinwl@gmail.com	
Mr. Dheeraj Pant	Kumaun University	Dheerajpant18@gmail.com	91-7078581242
Mr. Kevala N		kevalpandey1990@yahoo.in	91-8057741211

Agenda: Adaptive Capacity and Impacts Assessment Workshop (Workshop 3)

Wednesday 26 April Venue: Radisson Blu Plaza Delhi.

Delegates arrive at Radisson Blu Plaza Hotel Delhi

Thursday 27 April 2017 Venue: Crystal Room 3

Radisson Blu Plaza Delhi.

9:00 m - 9:30 a m	**Tea and Coffee Upon Arrival**
9:30 a m - 10:00 p m	**Session 1: Welcome, Introductions & Aim of Workshop**
10:00 a m - 10:30 a m	**Welcome & Self Introductions**
10:30 a m - 11:00 a m	**Outline of Workshop Agenda**

11:00am-11:30am		Group Photo & Tea and Coffee Break
10:00am-11:00am		Session 2: Overview of Phase 1 & 2
11:00am-12:00 noon		Summary of Baseline Questionnaire & Climate ready review. Presentation of results of last workshop: • Climate Exposure: Climate projections • Rural system analysis (identification of fragile systems & climate fragility statement) • Risk Assessment
12:00noon-1:30pm		Lunch
1:30pm-3:00pm		Session 3: Phase 3 Vulnerabilities Assessment
1:30pm-1:45pm		Vulnerable People & Places (overview)
1:45pm-2:30pm		Mapping of Existing Vulnerable Areas (Kumaun University (KU) Students)
2:30pm-3:00pm		Analysis of Adaptive Capacity of Rural Actors (Exercise)
3:00pm-3:30pm		Tea and Coffee Break
3:30pm-4:00pm		Assessing the Adaptive Capacity or Rural Systems & Data Gap Analysis) (KU to provide)
4:00pmm-5:00pm		Discussion & Analysis of Vulnerability Assessment
4:30pm-5:00pm		Summary & Wrap up
5:00pm-6:00pm		Free Time
7:00pm-9:00pm		Dinner

Friday 28 April 2017 Venue: Radisson Blu Plaza Delhi.

8:30 am - 9:00 am	Tea & Coffee Upon Arrival
9:00 am - 10:00 pm	Session 4: Overview of Day1 and Outline of Day 2
9:00 am - 9:15 am	Summary of day 1
9:15 am - 9:30 am	Outline of Workshop Agenda for Day 2
9:30 am - 11:00 pm	Session 5: Phase 4 Rural Resilience Strategy
9:30 am - 10:30 am	Developing Climate Resilience Interventions (Analysis of case studies from Nepal: Lessons learnt from Panchkhal) (Tribhuvan Uinversity)
10:30 am - 11:00 am	Intervention Mapping process
11:00 am - 11:30 am	Tea and Coffee Break
11:30 am - 12:00 pm	Discussion of Resilience Interventions
12:00 pm - 1:00 pm	Lunch
1:00 pm - 3:00 pm	Session 6: Prioritisation of Rural Interventions
12:30 pm - 1:30 pm	Prioritising Rural Interventions Assessment
1:30 pm - 2:30 pm	Feasibility & Impact Assessment
3:00 pm - 3:30 pm	Tea and Coffee Break
3:30 pm - 4:30 pm	Session 7: Integration into Rural Plans
3:30 pm - 4:00 pm	Linking Interventions to ongoing programs
4:00 pm - 4:30 pm	Summarising Recommended Resilience Interventions

4:30pm-5:00pm		Rural Resilience Strategy for Ramgarh
5:00pm-5:15pm		Wrap up
5:15pm-9:00pm		Free Time

Saturday 29 April 2017 Venue: Radisson Blu Plaza Delhi.

Delegates depart Radisson Blu Plaza Hotel Delhi

Resilience Workshop (Workshop 4)

Welcome Hotel New Delhi (October 2017)

Workshop participants in New Delhi October 2017(Workshop 4) (Photo: Laura Heath)

Workshop Participants

Name	Affiliation/Occupation	Email	Telephone
Bedoshruiti Sadhukhan, ,	ICLEI, INDIA	shruti.sadhukhan@iclei.org	91-9910294934
Prof. P. C. Tiwari	Professor	pctiwari@yahoo.com	91-9410941117
Dr. Bhagwati Joshi	Assistant Professor	bhawanatiwari@yahoo.com	91.94115381
Dr Baijayanti Mala Pokhrel	Trihuvan Univerity, Nepal	bmp.pokhrel@gmail.com.	

Assoc Prof Prem Chapagain	Trihuvan Univerity	ps.chapagain@gmail.com	
Ms Victoria Pilbeam	ANU/SUSTINEO, Australia	Victoria.pilbeam@sustineo.com.au	+61 0432122528
Dr. Zian Zhong Yan	Southwest University, China	yanjzswu@126.com	NA
Ms Dianne Manning	ANU/SUSTINEO, Australia	Dmanning-heath@grapevine.com.au	+61 417250637
Dr Lance Heath	ANU/SUSTINEO, Australia	Lance.heath@anu.edu.au	+61419018777
Prof Jianzhong Yan	South West University, China	yanjzswu@126.com	
Mr. Ayush Tiwari	Student	tiwariayush97@yahoo.com	91-8755063564
Mr. Abhinav Tiwari	Student	toabhinavtiwari@gmail.com	91-9479818374
Mr. Madan Singh	Farmer	NA	91-8859131491
Mr. Bhupal Singh Khati	Block Development Officer, Ramgarh, Nainital	NA	91-9457647929
Mr. Manoj Bisht	Farmer	NA	91-9690111562
Ramesh Singh Mer	Farmer	NA	91-8476086486
Khushal Singh	Farmer	NA	91-7409926296
Kevla Nand	Student	kevalpandey1990@yahoo.in	91-8979709220
Prabhat Suyal	Farmer	NA	91-7500899342
Ayush Tiwari	Student	tiwariayush97@yahoo.com	91-8755063564
Laura Heath	Student Canberra Girls Grammar School	laura.heath@iinet.net.au	

Agenda: Resilience Workshop (Workshop 4)

Monday 2 October (Public Holiday) Venue: WelcomHotel, Dwarka, New Delhi.

Delegates arrive at WelcomHotel, Dwarka New Delhi

Tuesday 3 October Venue: WelcomHotel Dwarka, New Delhi.

9:00m-9:30am	**Tea and Coffee Upon Arrival**
9:30am-9:45pm	**Session 1: Welcome, Introductions & Aim of Workshop**
9:45am-10:00am	**Welcome & Self Introductions**

10:00am-10:10am		Outline of Workshop Agenda
10:10am-10:30am		Group Photo & Tea and Coffee Break
10:30am-11:00noon		Session 2: Overview of Phase 2,3 & 4
10:30am-11:00 am		• Climate ready review • Overview of risk Assessment • Vulnerabilities Assessment • Overview of Analysis of Adaptive Capacity of Rural Actors
11:00am-12:30pm		Session 3: Phase 4: Rural Resilience Strategy Resilience Interventions
11:00am-11:15am		Assessing Adaptive Capacity of Ramgad Rural System & Potential Resilience Interventions
11:15am -12:30pm		Discussion and feedback from Ramgad Community members on Resilience Interventions
12:30pm-1:30pm		Lunch
1:30pm-2:30pm		Linking Resilience Interventions to Ongoing Programs
2:30pm-3:00pm		Session 4: Synopsis of Nainital Resilience Strategy
2:30pm-3:00pm		Demonstration of the Nainital IAP Work
3:00pm-3:30pm		Tea & Coffee Break
3:30pm -3:45pm		Discussion of next steps & Future
3:45pm-4:00pm		Summary & Wrap up
4:00pm-6:00pm		Free Time

Wednesday 4 October 2017 Venue: WelcomHotel, Dwarka, New Delhi.

8:00 a m - 6:00 p m	Field Trip or Free Time
	Field Trip
7:00 p m - 9:00 p m	Banquet (Working) Dinner (Hotel)

Thursday 5 October 2017

Delegates depart WelcomHotel, Dwarka, New Delhi

Annexure A: Climate Change Projections

Duration	Seasonal mean of surface air temperature					Seasonal mean of precipitation				
	DJF	MAM	JJA	SON	Annual	DJF	MAM	JJA	SON	Annual
1981-2000	5. 32	15. 49	20. 57	13. 51	13. 72	2. 54	2. 34	5. 60	2. 99	3. 36
2041-2060	7. 92	18. 10	22. 34	15. 32	15. 93	2. 16	2. 33	6. 21	2. 78	3. 37
	Change in surface air temperature with 1981-2000					Change in precipitation with 1981-2000				
	DJF	MAM	JJA	SON	Annual	DJF	MAM	JJA	SON	Annual
2041-2060	2. 60	2. 612	1. 77	1. 81	2. 21	−0. 375	−0. 01	0. 61	−0. 21	0. 01
						−14. 68%	−0. 33%	10. 85%	−6. 96%	0. 14%

Seasonal mean (upper table) and future change (lower table) in surface temperature (°C) and precipitation (mm/d) from multi-models under A1B emission scenarios for the Nainital/Ramgad region.

Duration	Seasonal mean of Max-temperature					Seasonal mean of Min-temperature				
	DJF	MAM	JJA	SON	Annual	DJF	MAM	JJA	SON	Annual
1981-2000	9. 59	19. 65	23. 65	17. 92	17. 69	0. 13	9. 29	15. 73	8. 94	8. 52
2041-2060	11. 12	19. 75	22. 65	17. 64	17. 80	2. 40	10. 22	15. 34	9. 45	9. 36
	Change in Max-temperature with 1981-2000					Change in Min-temperature with 1981-2000				
	DJF	MAM	JJA	SON	Annual	DJF	MAM	JJA	SON	Annual
2041-2060	1. 53	0. 09	−1. 00	−0. 28	0. 11	2. 26	0. 93	−0. 39	0. 51	0. 84

Seasonal mean (upper table) and future change (lower table) in minimum, maximum temperature (°C) from multi-models mean under scenarios A1B for the Nainital/Ramgad region.

Annexure B: Risk Assessment of Climate Fragility Statements

Rural System	*Climate Risk (Impacts of Climate Change)*	*Likelihood*	*Consequence*	*Risk Ranking*	*Risk Status*
Availability and Supply of Water for Drinking and Irrigation	A decrease in winter rainfall and an increase in temperature during winter will increase the gap in the demand and supply of water.	5	5	25	Extreme
	An increase in rainfall and a decrease in summer temperatures will lead to high intensity rainfall and a change in groundwater dynamics (high intensity rainfall may lead to greater runoff and less infiltration).	4	3	12	High
	Incidences of high intensity rainfall will disrupt and damage water infrastructure and distribution system.	4	3	12	High
	Water sources may become dry due to prolonged droughts affecting water availability.	5	5	25	Extreme
Road Connectivity	Incidences of high intensity rainfall will disrupt roads and bridges which will in turn affect the rural economy, livelihood and community health.	3	4	12	High
Community Human Health and Wellbeing	Reduced availability of water will impact the rural food system, hygiene, sanitation and community health.	5	5	25	Extreme
Rural Livelihoods and Economy	A decrease in rainfall, frequent droughts and increasing incidences of high intensity rainfall will affect crop-rotation, agricultural productivity, livelihood, tourism and the rural economy.	5	5	25	Extreme
Forest Resources	Increase in temperature and a decrease in rainfall will increase the incidence of forest fire, loss of biodiversity, depletion of medicinal plants and a reduction in the availability of fuel-wood and fodder.	5	5	25	Extreme

Funding sources outside the APN

Support Leveraged from sources other than APN:		In-Kind (US$)	Cash (US$)
Budget Secured from Other Sources (Cash and In-kind Contribution)			
Activity	**Organisation**		
Assessment Tool Development and Road Map	Department of Foreign Affairs and Trade (PSLP) (Australian National University Climate Change Institute) (Support for ICLEI, Catering, Software & workshop in Kathmandu)		5,000
Knowledge Management	Monash Sustainability Institute, Monash University	10,000	
Administration & Personnel Support	Australian National University Climate Change Institute	30,000	
Personnel support	Monsoon Asia Integrated Regional Study	30,000	
Total		**70,000**	**5,000**

List of Young Scientists

1. Mr. Kevla Nand (Kumaun University, Email: kevalpandey1990@yahoo.in)

2. Ayush Tiwari (Graphic Era Hill University, Bhimtal, Nainital, Email:astroiostiwa@gmail.com)

3. Abhinav Tiwari (National Institute of Technology, Bhopal, Email: tiwariayush97@yahoo.com)

4. Pooja Nainwal (Kumaun University, Nainital, Email: pujinwl@gmail.co

"This has been a great opportunity for us having involved and worked in this prestigious international project by APN. The project provided us with the chance of working with poor and marginalized rural communities in the Himalayan mountains where the impacts of climate change and very complex and severe affecting the water availability, food security, livelihood and health of large proportion of rural population, particularly poor, weaker sections of society and women. We learn various field techniques of data collection, analysis and interpretation; working with community and getting them involved in climate change adaptation programme and activities. We were also exposed to community based techniques of analyzing climate change impacts on different rural sectors, assessment of vulnerability of people and rural systems and mapping of community adaptive capacity to climate change in rural environment. The project-workshops provided us with great opportunity of interacting with experts from different institutions and countries, government agencies and local institutions".

Mohan Singh, Ayush Tiwari, Kevala Nand, Dheeraj Pant, Kailash Chandra Tewari, Vaseem, Rahul Kumar).

Glossary of Terms

ACCCRN: Asian Cities Climate Change Resilience Network
ANU: Australian National University
APN: Asia Pacific Network for Global Change Research
IAP: ICLEI/Asian Cities Climate Change Resilience Network (ACCCRN) Process
ICLEI: International Council for Local Environment Initiatives
IPCC: Intergovernmental Panel on Climate Change
KMF: Knowledge Management Framework
NGOs: Non-Government Organisations
PWD: Public Works Department
SLD: Shared Learning Dialogue