



Resilient India: Disaster Free India



JANUARY 2019

CLIMATE RESILIENT DISASTER RISK MANAGEMENT

Best Practices Case Studies
Compendium



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Compendium**



ACKNOWLEDGEMENT

This publication is produced by the Department of Relief and Rehabilitation, Government of Maharashtra (GoM), with technical support from Climate Change Innovation Programme - Action on Climate Today¹, to integrate climate change actions into policies and programmes and implement the State Action Plan on Climate Change. This work was spearheaded by the Additional Chief Secretary and the Director, Department of Relief and Rehabilitation, with inputs from faculty at National Institute of Disaster Management, Government of India.

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¹ The Climate Change Innovation Programme (CCIP) is funded by the UK Department for International Development (DFID) and managed by Oxford Policy Management. Together with the Climate Proofing Growth and Development (CPGD) Programme, the CCIP contributes to the Action on Climate Today (ACT) initiative to combat climate change in South Asia.

MESSAGE

India is signatory to the global treaty on climate change under the United Nations Framework Convention on Climate Change. As part of this treaty, Government of India formulated the National Action Plan on Climate Change in 2008 and subsequently we formulated the State Action Plan on Climate Change (SAPCC). Maharashtra's SAPCC identified the vulnerabilities due to the impacts of increased temperatures and changes in rainfall patterns. Maharashtra has also recently enacted the Climate Change Policy for effective implementation of the actions suggested in the SAPCC and the Sectoral Climate Action Plans.



The State Action Plan on Climate Change and the Climate Change Policy strive to integrate climate change concerns and priorities in the overall development strategy of the state in order to minimize the adverse impacts of climate change on natural resources, dependent economic activities, critical infrastructure and the well-being of people.

In its pursuit of excellence, the Govt of Maharashtra endeavours to emulate and even improve upon the best practices in various types of resilience building measures to disaster risk reduction and climate change impacts. The knowledge of best practices provides a competitive advantage for organizations and departments who want to aspire to the benchmarks set to the best standards or practices.

I am pleased to release this compendium that is a documentation of the best practices in some of the climate resilience building measures being practices in India and elsewhere. I hope that the knowledge gained from this compilation will be used to adapt and innovate on the best practices and thus introduce methods and actions for resilience building in Maharashtra that are even better.

Devendra Fadnavis

Chief Minister, Maharashtra

MESSAGE

I am happy to present this Compendium-a compilation of successful case studies from India and world on climate change adaptation (CCA) and disaster risk reduction (DRR) that is very much relevant in the context of Maharashtra. I am convinced that contents of this compendium will facilitate the departments of the Maharashtra Government to devise action plans towards ameliorating the vulnerabilities due to climate induced disaster risks in different geo-climatic regions of Maharashtra.



It is envisaged that the lessons and actions specified in this compendium will be well taken and implemented through concerted efforts of the departments identified to take the lead, involving appropriate levels of governance and a set of institutions with required expertise functioning in the public as well as in the private sector domain. I look forward to the successful implementation of the actions prioritised in the Compendium and on behalf of the Government would be happy to facilitate the implementation of the same by providing necessary guidance's through the high level committee formed to steer the State's actions on disaster risk reduction (DRR) and climate change adaptation (CCA).

The technical support provided by the programme - Action on Climate Today, an initiative supported by the UK Department for International Development (DFID) and YASHDA, Government of Maharashtra in bringing out this very important publication is highly appreciated.

Chandrakant (Dada) Bachchu Patil

Minister, Revenue, Relief and Rehabilitation, Maharashtra

FOREWORD

Implications of climate change on disaster risk and vulnerability – especially those related with water and weather system, extreme events, ecosystems, forests, biodiversity, coastal hazards, associated disease & epidemics, etc. are well recognized scientifically and socially. The recent report of IPCC cautions about more complex and challenging consequences of Global Warming. The report also calls for significant improvement in human behaviour, in terms of consumption patterns, managing our natural resources in a much more prudent and effective manner to meet the demands of sustainability. 'Resilience' is the 'Mantra' for adaptive development benefits, for which disaster risk reduction should necessarily be woven across developmental planning and implementation processes. The various aspects of creating climate resilience, thus, are key to disaster risk reduction, for attaining sustainable development.



While there is significant scope and opportunities from technological advances, local and traditional knowledge and innovations of simpler but effective roles in climate and disaster resilience of communities exist in almost all parts of India. Such endeavours and lessons need to be documented as case studies to support policy process and capacity building process. On this apt and excellent initiative of the Government of Maharashtra, the National Institute of Disaster Management has been pleased to extend its technical and research support which is of strategic importance to the large mandate of disaster risk reduction capacity building.

The compendium covering the aspects of hazard-risk-vulnerability and key context of climate related disasters has been designed to bring in a comprehensive package of examples and illustrations. I am of the opinion that it would serve its purpose and would be found useful, to all practitioners of Climate Change Resilience.

B H Anil Kumar

Executive Director, National Institute of Disaster Management, New Delhi

FOREWORD

The Department of Disaster Management is pleased to release “Building Resilience in Maharashtra: Best Practices Case Study Compendium”. Climate induced disasters are very frequent in the state and the major disasters being faced by the state are floods, droughts, cyclones and landslides. The Compendium comprehensively brings forth case studies related to climate change induced hazards and disasters that have plagued different regions, cities, rural areas in India and around the world. The case studies on the impacts and resilience building have been selected based upon the specific hazards from climate change that are most relevant to the state of Maharashtra and can be replicated in the context of different geo-climatic conditions.



The Handbook has been prepared in technical collaboration with Action on Climate Today – a programme of the UK-India bilateral collaboration and managed by Oxford Policy Management in India. National Institute of Disaster Management, Govt of India provided the technical support and review of the best practices documented in this compendium. It is envisaged that the wide dissemination of this compendium will generate awareness about the disaster risk reduction (DRR) and climate change adaptation (CCA) challenges across the districts of Maharashtra. We look at different systems and institutions that need to be strengthened to build resilience towards climate change induced disasters for sustainable development of people and regions.

The link between climate variability and natural disasters are well established and if not addressed at present can undermine the very objectives of Sustainable Development Goals (SDGs), Paris Climate Agreement as well as Sendai Framework for Disaster Risk Reduction (SFDRR) to which India is party. The Department is committed to build resilience of different stakeholders through training and capacity building in the field of disaster management and climate change.

Medha Gadgil

Additional Chief Secretary, Relief and Rehabilitation

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SECTION 1

INTRODUCTION

India is a country highly vulnerable to impacts of natural hazards mostly turning into disasters of severe intensities. Whether a flood, a regional drought or devastating earthquakes, millions of Indians are affected each time a disaster occurs. In addition to large-scale displacement and the loss of life, these events result in the loss of property and agricultural crops worth millions of rupees annually. Increasing intensities of climate induced disasters and related impacts of climatic variability pose additional challenges to development and overall wellbeing of communities (Gupta et al., 2017). High multi hazard vulnerability poses a great challenge before the National, State and District governments to mitigate and prevent the impact of disasters through an integrated approach. The link between climate variability and natural disasters are well established and if not addressed at present can undermine the very objectives of Sustainable Development Goals (SDGs), Paris Climate Agreement as well as Sendai Framework for Disaster Risk Reduction (SFDRR) to which India is party.

Maharashtra state is located in the Western region of India and spread across central part as well. It is the second most populous and third largest state in terms of area. It has a long coastline stretching nearly 720 km along the Arabian Sea. Climate induced disasters are very frequent in the state and the major disasters being faced by the state are floods, droughts, cyclones and landslides. The table below elaborates the major climate related disasters of the State.

TABLE 1.1: VULNERABLE AREAS IN THE STATE TO VARIOUS DISASTERS

Disasters	Vulnerable area
Floods	All districts (e.g. Mumbai 2005 flood)
Cyclones	Districts in Konkan region, Pune division (e.g. Cyclone Phyan in 2009)
Hailstorms	Some parts in the State, Specially Marathwada and Vidarbha.
Drought	Marathwada and parts of Vidarbha
Heat wave	Marathwada, Vidarbha and Nashik Divisions
Landslides/mud flow	Ratnagiri, Raigad, Satara, Thane, Nashik, Mumbai, Sindhudurg, Pune
Sea erosion	Districts in Konkan region

SCOPE OF THE DOCUMENT

This document is an effort to analyze case studies related to climate change induced hazards and disasters that have plagued different regions, cities, rural areas in India and around the world. We look at different systems and institutions that need to be strengthened to build resilience towards climate change induced disasters for sustainable development of people and regions.

The case studies on the impacts and resilience building have been selected based upon the specific hazards from climate change that are most relevant to the state of Maharashtra. To analyze the possible climate induced hazards in Maharashtra, the geo-climatic division of state as given in the State Action Plan on Climate Change are used. The state of Maharashtra is divided into five major regions locally referred as Konkan, Khandesh, Western Maharashtra, Marathwada and Vidarbha. These regions have distinctive features due to their physical and geo-climatic conditions that are largely responsible for the biodiversity in the respective regions.

The second section is an analysis of the five geo-climatic regions for the climate hazards, risks and vulnerabilities. A listing of action points or resilience building measures necessary to combat these risks is also included for each region. The third section comprises cases studies related to the above actions points, each having lessons learnt and/ or best practice for building resilience to a particular hazard and risk for specific sector (like agriculture, water/sanitation) or area (like urban agglomerations). The fourth section or the conclusion section presents ways forward and opportunities to build climate resilience in the state of Maharashtra.

Action on Climate Today (ACT), a programme being implemented by UK Department for International Development (DfID) combines Climate Proofing Growth and Development (CPGD) and Climate Change Innovation Programme (CCIP). While CPGD works in partnership with governments of Afghanistan, Bangladesh, Nepal and Pakistan, the CCIP focuses on India. ACT aims to integrate climate change in policies, plans and budgets, while also contributing to capacity of countries to attract and leverage climate change investment. Maharashtra is one of the project states of CCIP.





SECTION 2

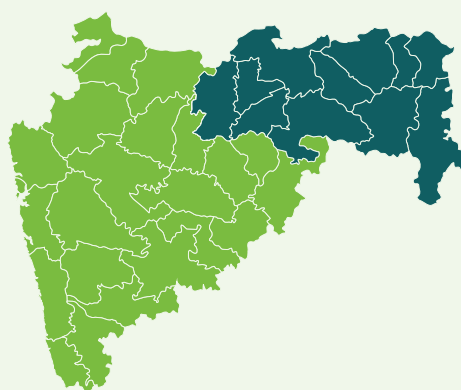
**HRVA OF 5
GEO-CLIMATIC
REGIONS
IN MAHARASHTRA**

1. VIDHARBHA

TABLE 2.1. GENERAL INFORMATION

Region	Vidarbha (Nagpur and Amravati Division)
Headquarters	Nagpur and Amravati
Districts (Nagpur division)	Bhandara, Chandrapur, Gadchiroli, Gondia, Nagpur, Wardha
Districts (Amravati Division)	Akola, Amravati, Buldana, Yavatmal, Washim
Total area	97,321 square kilometer
Rainfall	161 mm to 848 mm
Temperature	Maximum 43°C, Minimum 13°C
Population	23 million
General Profile	<ul style="list-style-type: none"> • Vidarbhas' economy is primarily agrarian with cotton, jowar, soyabean and pulses being its main farm outputs. • Less economically prosperous, plagued by poverty and malnourishment • The largest city Nagpur is the central hub for business. • The region is rich in forest and mineral wealth. • Large number of farmer suicides cases mostly by cotton farmers reported

Map



**FIGURE 1:
MAP SHOWING
VIDARBHA REGION**

HAZARD AND VULNERABILITY PROFILE OF THE REGION

- Vidarbha is home for approximately 3.4 million cotton farmers and 95% of these are struggling with the massive debt.
- Vidarbha is basically a low rainfall area, and farmers rely more on dry farming.
- Most parts of Vidharbha have experienced severe droughts between 2001-2013.
- This region lacks basic last mile services and social infrastructure such as all-weather roads, drinking water, regular electricity, primary health care, and basic education.
- The eastern districts of Gondia, Bhandara, Gadchiroli and Nagpur fall in Earthquake Zone I, while other districts fall in Zone 2 which are otherwise considered relatively safe from the impacts of earthquake hazards, yet, need to have adequate preparedness measures integrated (BMTPC, 2006).
- Past history of the State indicate suffering from flood for most parts of Vidharbha region along with occasional hail storm vulnerabilities in parts of this region.

TABLE 2.2: CLIMATE CHANGE CHALLENGES AND ITS IMPACT IN THE VIDARBHA REGION

Climate change Challenges	Impact	Districts affected
Change in rainfall pattern	Increase in monsoon rainfall by 2030s and 2050s ranging between 18-30% for most districts. However, total annual mean rainfall shows decreasing trends – indicating more rainfall in shorter durations	Wardha, Buldana, Amravati, Akola, and Yavatmal
Change in temperature	<ul style="list-style-type: none"> • Temperature and rainfall are projected to increase all across the region though there are variations. • Increase in heat wave spell across the region especially Nagpur division by 2030s and make the entire Vidharbha region vulnerable to the impact of such extreme events • Amravati district may experience a greater rise in annual mean temperature than other parts of the State. • Projected increase in minimum temperature would be between 48-63% for the districts of this region. • Increase in the number of dry days for most of the Vidharbha region is expected between 5-7%. 	All districts

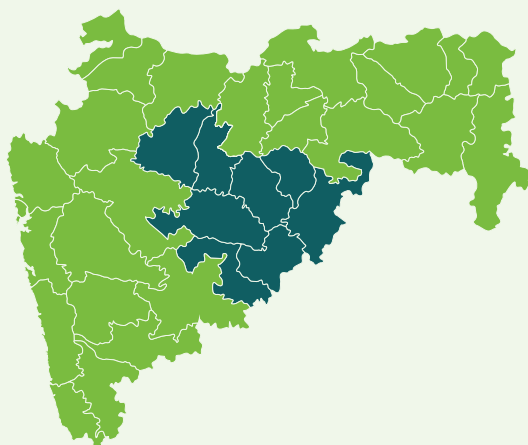
Source: MSAPCC, MSDMP

2. MARATHWADA

TABLE 2.3: GENERAL INFORMATION

Region	Marathwada (Aurangabad Division)
Headquarter	Aurangabad
Districts	Aurangabad, Beed, Jalna, Osmanabad, Latur, Nanded, Parbhani, Hingoli
Total area	64,590 square kilometer
Rainfall	26mm to 682 mm.
Temperature	Maximum 42°C and minimum 16°C
Population	18.7 million
General Profile	<ul style="list-style-type: none"> • Marathwada possess vast natural land resource including, mountains, perennial rivers, cultivable wasteland etc. but these remained relatively unutilized. • The Hydropower potential of the region has been harnessed only up to 25 per cent. • It is the second most underdeveloped area in the state, after Vidarbha. • All eight districts in the region figure in the list of the 100 poorest districts in the country.

Map



**FIGURE 2:
MAP SHOWING
MARATHWADA REGION**

HAZARD AND VULNERABILITY PROFILE OF THE REGION

- The Marathwada region is by now known to be struggling with its consecutive and intense drought seasons, almost since 2011.
- All of its eight districts are severely affected by water scarcity resulting in reduced productivity from agriculture.
- The 2005 and 2006 floods indicate that flooding is also a concern with some of the districts of this region.
- Marthawada region also experience occasional hail storms.

TABLE 2.4: CLIMATE CHANGE CHALLENGES AND ITS IMPACT IN THE MARATHWADA REGION

Climate change Challenges	Impact	Districts affected
Change in rainfall pattern	<ul style="list-style-type: none"> • Increase in extreme rainfall in the 2030s relative to baseline by 18-26%. • As the heat spell is bound to increase, the warmer atmosphere will have more capacity to hold water. • This may produce more intense rainfall events but, with longer dry or low rainfall spells between these events. • Number of low rainfall days is projected to increase between 6-9% for all districts of this region. • A projected increase in precipitation can help yield rain fed crops with improvements in water resources 	Aurangabad, Latur, Beed and Parbhani
Change in temperature	<ul style="list-style-type: none"> • It invariably makes the region vulnerable to the impacts of heat waves in the future • The rise in minimum temperatures will have relative less impact in this region in 2030s ranging between 58-68 % more. • Increase in temperatures will lead to decrease in yields for some crops. • This will increase aridity and reduce fodder supply for this region. • Higher temperatures would mean, faster rate of parasite development, increase in water borne diseases by 2050s and have detrimental health impacts. 	Beed, Latur, Parbhani and Hingoli

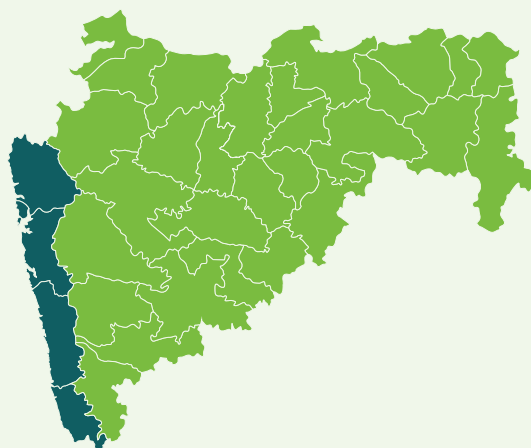
Source: MSAPCC, MSDMP

3. KONKAN

TABLE 2.5: GENERAL INFORMATION

Region	Konkan (Konkan Division)
Headquarter	Mumbai
Districts	Mumbai city, Mumbai suburban, Thane, Palghar, Raigad, Ratnagiri, Sindhudurg
Total area	30,746 square kilometer
Geographical extend	15°6' N to 20°22' N latitude and 72°39' E to 73°48' E longitudes
Rainfall	2500 mm to 4500 mm.
Temperature	Maximum 37°C and minimum 15°C
Population	28.6 million
General Profile	<ul style="list-style-type: none"> Administrative division in the coastal region of Maharashtra. Immense potential in terms of industrial out springs, tourism, horticulture, minerals and fisheries etc. Vast western coastline making it a strategic location for global trade. The economy stands fourth amongst all States and accounts for 41% of the Maharashtra's GDP. Mumbai – home to India's financial, banking and entertainment industries.

Map



**FIGURE 3:
MAP SHOWING KONKAN
REGION**

HAZARD AND VULNERABILITY PROFILE OF THE REGION

- The region is prone to heavy rain, cloud bursts, flash floods and urban flooding especially affecting the city of Mumbai which from a commercial angle keeps utmost importance.
- Mumbai metropolitan region shall become more prone to flooding when exposed to heavy rainfall events and can get flooded even at an augmented drainage capacity of 50 mm/hour if an extreme rainfall event like that of July 2005 to recur in the future.
- Five coastal districts namely Thane, Ratnagiri, Raigad including Mumbai and its suburb are prone to the impact of cyclones/ heavy winds (BMTPC, 2006).
- The earthquake hazard map of the BMTPC indicate high intensity risk zone for Ratnagiri, Raigad and Thane.
- Parts of Ratnagiri, Raigad, Thane, Mumbai and Sindhudurg are also prone to landslides of varying impacts.

TABLE 2.6: CLIMATE CHANGE CHALLENGES AND ITS IMPACT IN THE KONKAN REGION

Climate change Challenges	Impact	Districts affected
Change in rainfall pattern	<ul style="list-style-type: none">• It has been projected that extreme rainfall will range between 10-14% more by 2030.• Increase in extreme weather events like floods• Crop damage and reduce agriculture production.• Increase in food insecurity at household level• Increase in vector borne diseases	Thane, Mumbai, Ratnagiri and Sindhudurg
Change in temperature	<ul style="list-style-type: none">• Increase in minimum temperature ranging between 68-78% by 2030.• Crops sensitive to high night temperatures in the reproductive phase will be impacted more• Aggravate heat waves, deadly, health consequences, including heat stress and heat stroke• Increase the energy demand for cooling in urban areas which will greatly impact the Urban Heat Island (UHI) effect• Increase in number of dry days, impacting the crop productivity	Sindhudurg, Raigad, Ratnagiri, Thane, Mumbai
Sea level rise	<ul style="list-style-type: none">• Sea level rise analysis for Maharashtra coastline shows a sea level rise of 0.13-2 cm.• Salt water intrusion into ground water aquifers especially near the coast.	All districts

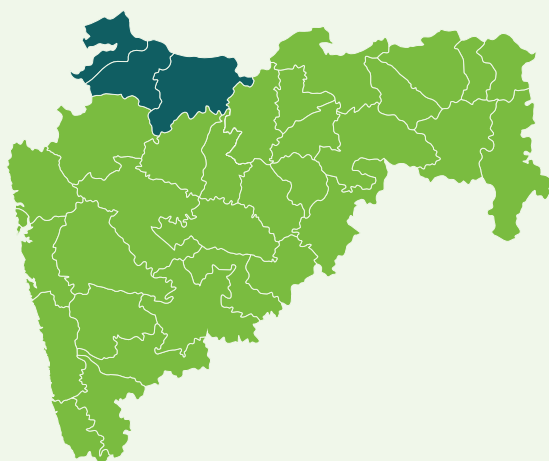
Source: MSAPCC, MSDMP

4. KHANDESH AND NORTHERN MAHARASHTRA

TABLE 2.7: GENERAL INFORMATION

Region	Khandesh and Northern Maharashtra (Nashik Division)
Headquarter	Nashik
Districts	Ahmednagar, Dhule, Jalgaon, Nandurbar, Nashik
Total area	57,806 sq.km
Rainfall	812 mm
Temperature	12.5°C to 36°C
Population	18.5 million
General Profile	<ul style="list-style-type: none"> Nashik region occupies the third position in terms of its largeness after Mumbai and Pune. The region is known for its agro-processing industries and especially wine. Of the total 46 wineries in India, 43 are housed in Maharashtra, of which 22 are in Nashik city itself. 20% of the area in this region is covered by the forest which is located in the hilly region

Map



**FIGURE 4:
MAP SHOWING
KHANDESH REGION**

HAZARD AND VULNERABILITY PROFILE OF THE REGION

- Nashik lies on the western edge of the Deccan Plateau which is a volcanic formation thereby always being associated with some percentage of associated risk
- Past historical records reflect that all the districts are vulnerable to flooding.
- Heat wave is again a concern for this region as well.
- Considering the State has few hilly terrains, coupled with past record of landslides and mud flows, this makes Nashik and nearby areas prone to such hazards and their detrimental impacts as well.
- Nashik hosts one of the largest religious gatherings in the world known as "Maha Kumbh" which is celebrated every twelve years at four places in Allahabad, Haridwar, Ujjain, and Nashik, thus, making it an ideal ground for risks associated with stampedes and related secondary hazards and disasters.

TABLE 2.8: CLIMATE CHANGE CHALLENGES AND ITS IMPACT IN THE KHANDESH REGION

Climate change Challenges	Impact	Districts affected
Change in rainfall pattern	<ul style="list-style-type: none"> The rise in monsoon rainfall by 2030s would be relatively more for the Nashik region. Northern part of Nashik region will experience an increase in rainfall with a projected increase in extreme rainfall by 2030s ranging from 22 % and extending beyond 30 %. Extremely low rainfall days especially during monsoons between 6-8%. Increase in temperature have an impact on the agricultural production and put water resources under tremendous stress 	Jalgaon, Nashik and Dhule Ahmednagar, Nashik
Change in temperature	<ul style="list-style-type: none"> The rise in minimum (between 63-68% for all the five districts) as compared to rise in maximum temperature for Nashik region by 2030s Adverse impact on crops sensitive to high night temperatures for their growth and productivity. Increase the energy demand for cooling in urban areas which will greatly impact the Urban Heat Island (UHI) effect. 	All districts

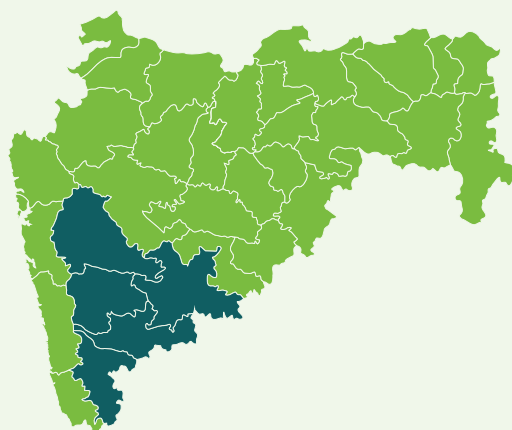
Source: MSAPCC, MSDMP

5. PASCHIM MAHARASHTRA

TABLE 2.9: GENERAL INFORMATION

Region	Paschim Maharashtra (Pune Division)
Headquarter	Pune
Districts	Kolhapur, Pune, Sangli, Satara, Solapur
Total area	15,642 square Kms
Rainfall	3000 mm to 4000 mm
Temperature	22°C to 28°C
Population	23.4 million
General Profile	<ul style="list-style-type: none"> The region is known as the sugar belt of Maharashtra; it is the second-largest producer of sugarcane in India and hosts the country's second-largest sugar-processing capacity. Pune is known as "Oxford of the East" due to the presence of several well-known educational institutions in the city. Pune is the second largest city of Maharashtra after Mumbai and the seventh most populous city in the country and accounts for 22.4% of GSDP of Maharashtra.

Map



**FIGURE 4:
MAP SHOWING
PASCHIM
MAHARASHTRA
REGION**

HAZARD AND VULNERABILITY PROFILE OF THE REGION

- Pune region is experiencing a temperature variation from 6.8 degree centigrade as minimum to 40 degrees centigrade maximum making it prone to impact of heat waves.
- The average rainfall is about 3000 to 4000 mm thus, making all districts of this region prone to flooding particularly urban flooding in Pune district.
- Previous earthquakes and moderate landslide which affected Maharashtra make the district of Satara vulnerable to earthquake and landslide hazards as well.

TABLE 2.10: CLIMATE CHANGE CHALLENGES AND IMPACTS IN THE PASCHIM MAHARASHTRA REGION

Climate change Challenges	Impact	Districts affected
Change in rainfall pattern	<ul style="list-style-type: none"> • Projected increase in extreme rainfall by 2030s • Extremely low rainfall days in the June-August monsoon months by 2030s • Increased dry spells in this region 	All five districts
Change in temperature	<ul style="list-style-type: none"> • Minimum temperature projections to increase particularly in Pune division in the 2030s • Crops sensitive to high night temperatures in the reproductive phase will be impacted more • Aggravate heat waves, deadly, health consequences, including heat stress and heat stroke • Increase the energy demand for cooling in urban areas which will greatly impact the Urban Heat Island (UHI) effect • Increase in number of dry days 	All five districts

Source: MSAPCC, MSDMP

COMPREHENSIVE LISTING OF RESILIENCE BUILDING MEASURES IN MAHARASHTRA

Based on the intervention areas listed above for each of the five regions, a comprehensive list of interventions has been collated that is used for presenting best practices on resilience building as case studies.

Sector	Interventions	Case study reference	Regions applicable				
			Vidarbha	Marathwada	Konkan	Khandesh	Paschim Maharashtra
Agriculture and Rural Development	Peri-urban agriculture and ecosystems	Gorakhhpur, UP	✓	✓		✓	✓
	Participatory watershed management	Ralegaon Siddhi, Maharashtra	✓	✓	✓		
	Diversification of livelihood to non-farm sector	Dholpur, Rajasthan	✓	✓	✓	✓	✓
	Ecosystem based adaptation for mainstreaming biodiversity in watershed management	WOTR, Maharashtra		✓	✓	✓	✓
	System for Rice Intensification	PRADAN, Rajasthan	✓	✓	✓	✓	✓
Forestry & Biodiversity	Joint Forest Management	Buldhana experience, Maharashtra	✓		✓		
	Tapping Indegenous knowledge for conserving bio-diversity	Mompa Tribe, Arunachal Pradesh		✓		✓	
WATSAN/ Irrigation	Diversion based traditional irrigation system to mitigate risk of crop failure in drought prone area.	Phad irrigation system, Yavatmal	✓	✓			✓
	Collective management of groundwater and surface water	ACWADAM (Pani Panchayat), Maharashtra	✓	✓		✓	✓
	Provision for drinking water: Conjunctive use of water	Indore City, Madhya Pradesh	✓		✓	✓	✓
Urban Development	Infrastructure development and planning to manage urban floods	Chennai, Tamil Nadu	✓		✓	✓	✓
	Eco-system based approach for urban flood resilience	Gorakhpur, Uttar Pradesh	✓		✓	✓	✓
	End-to-end early warning system for flood resilience	Surat, Gujarat			✓		✓
	Urban Health Surveillance system	Surat, Gujarat	✓	✓	✓	✓	✓
	Urban heat island impacts: Heat Action PAn	Ahmedabad, Gujarat	✓	✓	✓	✓	✓
	Waste Management in Urban areas	Yokohoma, Japan	✓	✓	✓	✓	✓
	Coastal urban resilience	Panaji, Goa			✓		
Disaster management	End to end early warning system to address floods/cyclones	Phailin, Odisha			✓		
	Tapping indigenous knowledge of early warning	Majuli Island of Assam for flood forecasting	✓		✓		
	Weather forecasting for climate smart agriculture	Indo-Gangetic plains of eastern Uttar Pradesh	✓	✓	✓	✓	✓



SECTION 3

**CASE STUDIES
-BEST PRACTICES
ON RESILIENCE
BUILDING**

It is not that floods did not happen earlier but the risks, exposure and impacts of these events is being felt more as the pace of urbanization picks up – more so in Asian sub-continent. As is true in many countries of the sub-continent, most of the urban clusters in India, follow a largely unplanned growth. Though the root cause of urban floods are heavy/unprecedented rainfall, high floods in rivers, high tides, etc., its impacts are being felt more due to human factors such as blockages in drainage channels, improper land use, deforestation in headwater regions, etc.

The best practices to building urban flood resilience have been analysed in the case studies from Gorakhpur and Surat.



CASE STUDY UFR-1

ECO-SYSTEM BASED APPROACH FOR FLOOD RESILIENCE IN GORAKHPUR

Almost all cities and urban agglomerations grow by expanding into the adjacent areas that are largely agricultural lands. Many times these expansions do not follow the development plans prepared by urban development agencies. Unregulated urban planning and unauthorized/improper constructions, including encroachments of low lying and natural wetland areas increase the exposure and impacts (examples Chennai, Bangkok). Many a times it is the public sector or the Government buildings that are first to build on such exposed areas (e.g. the international airport near Bangkok is built on marshlands), which then, is followed by others, obstructing paths for natural drainage. Such is the case with Gorakhpur, a tier II city located in eastern Uttar Pradesh at the confluence of rivers Rapti and Rohin, that has grown rapidly into an economic, medical and institutional hub in the region. In case of Gorakhpur, the resilience building efforts include preserving eco-systems in and around the city like water-bodies and peri-urban agricultural lands.

Climate: Climate projections have indicated that the intensity of extreme rainfall events in Gorakhpur is likely to increase 10 to 20% in the coming years causing significant flooding in the city.

Hazards and impacts: Flooding and water-logging are a constant phenomenon within Gorakhpur City. Low lying areas in Gorakhpur as well as peri-urban areas are particularly prone to recurring floods and water logging for 2 to 4 months every year. Unmanaged solid waste disposal is another risk that the city is facing. Prolonged water logging together with poor waste management has caused an increase in incidences of vector-borne diseases and related health problems, as well as contamination of ground water. Malaria and dysentery have historically been a problem; recent years have seen a rise in diarrhoeal diseases and other vector-borne diseases like Japanese Encephalitis. Water logging and flooding also leads to disruptions in transport systems, roads and property damage, thus, affecting livelihood systems and increasing the vulnerability of the poor.

Understanding why: Gorakhpur city is bowl shaped with a low to flat gradient and high groundwater tables. Till about 50 years back, there were 103 small and big water bodies within the city. These water bodies used to function as reservoirs of water during rainy season and also played an important role in maintaining the temperature of the city. With urbanisation, currently, less than a third of these bodies remain. Due to lack of maintenance, even the remaining lakes are facing challenges with wastes, filth, dirty water and faeces of the nearby residential localities finding their way into these water bodies.

In order to protect the city from flooding, more than 12 km of earthen bunds have been constructed along the length of the rivers and about 6–8 km have been constructed along the banks of Ramgarh

Lake. The embankments, while protecting the city from riverine floods, add to the problem of water-logging as rainwater does not find easy exit from the city.

The existing city's sewerage system was designed exclusively to carry domestic sewage, but because of open drains laid in the core city area, storm water also enters the trunk sewer. This leads to tremendous pressure on the sewerage network during monsoons. Moreover, the existing sewer lines in the city are more than 54 years old and cover only 22% of the total city. Most of the new areas are developed in an unplanned manner and are not connected to the current drainage system of the city, only adding to the urban flooding issues faced by residents.

Large scale conversion of agriculture land for non-agriculture uses is exacerbating climate change risks by increasing water logging and run-off. The peri-urban area towards the western part of the city is prone to floods and gets inundated every year. In spite of this being flood plains and a no construction zone, rapid encroachment is observed in many parts; and between 2002 and 2015, about 33% of land has been converted into built up area. This phenomenon of converting the existing agricultural land on the periphery of the city is leading to decreased green/open spaces and reduced natural drainage of excess storm water.

Building resilience

Gorakhpur Environmental Action Group (GEAG) – a leading NGO in the city has conducted many studies and research on building resilience of Gorakhpur from climate impacts like flooding and water-logging and related secondary impacts on livelihoods and health. Some of the measures related to eco-systems services, suggested by these studies are:

- a. Conservation of water-bodies and removing encroachments. GEAG led the formation of citizen's movement to conserve lakes and as a result, the Government provided funds and a mandate to the civic authorities to remove encroachments and beautify the largest lake in the region *Ramgarh Tal*. Moreover, ISET and GEAG's research on losses due to water-logging and flooding in Gorakhpur indicates that the benefits far outweigh the costs of investing in flood resilient measures.
- b. Preservation of peri-urban agriculture – as a draining area for excess storm water, with added co-benefits of improve livelihood opportunities for poorest, diversifying food source for urban populations, making use of urban waste for fertilizer, irrigation (recycled waste water), etc. The pilot projects in peri-urban areas have resulted in increased income for farmers, demonstrating climate resilient cropping methods, decentralised solid waste management with production of fertilizer as by-product, and use of recycled waste water for irrigation (from decentralised water treatment).

REFERENCES

- Enhancing climate resilience of Gorakhpur by buffering floods through climate-resilient peri-urban agriculture; The Rockefeller Foundation Monitoring & Evaluation Office. May 2016 <http://e-lib.iclei.org/wp-content/uploads/2017/03/enhancing-climate-resilience-of-Gorakhpur-by-buffering-floods-through-peri-urban-agriculture.pdf>
- Peri-Urban Agriculture and Ecosystems Resilient Narratives: Gorakhpur Environmental Action Group (GEAG), 2016. <http://geagindia.org/pdf/Resilient-Narratives.pdf>
- Advocacy on conservation of Ramgarh lake in Gorakhpur. <http://geagindia.org/content/advocacy-and-campaign.aspx>



CASE STUDY UFR-2

END-TO-END EARLY WARNING SYSTEM FOR SURAT CITY

In case of sudden onset of disasters like floods, landslides and storm surges, it is the timing and accuracy of warning that helps preparedness and averts losses. The earlier the warning, better is the preparedness. For example in case of Cyclone Pahilin in 2013, the Indian Meteorological Department, provided credible information on the intensity and impacts location over several days prior to the event, which helped the preparation and response efforts. Efficient early warning system and rapid evacuation measures deployed by national and local governments helped in saving nearly 500,000 people. The development of end-to-end early warning system for the city of Surat (Gujarat) is presented here as a case study that could be replicated for cities in Maharashtra.

Surat, located near the mouth river Tapi (where it meets Arabian Sea) in Gujarat, is the eighth most populous city in India and an industrial hub of textiles, diamonds and heavy industries. Since most of Tapi's catchment area lies in high rainfall zone, Surat used to face flood on a regular basis. Post the 1980's increased industrialization necessitated that the reservoir capacity of Ukai dam was maximised to cope with the increased demand. Over the time, there have been other changes like siltation and embankment along the river bank that reduced the carrying capacity of the river within the city. As a result during the end of monsoon period –when the reservoir is filled to its maximum capacity, any increase in the inflow due to unpredictable/severe rainfall within the catchment area forces a release of high volume of water within short period of time from the dam – leading to flooding in Surat city. In the last two decades, the frequency of floods had increased due to increased rainfall variability (extreme events), especially in the river's catchment area. The flooding and resulting impacts also aggravated over time due to constructions, landfills in flood plains, etc.

With an objective to reduce the impacts of floods and resulting damage in Surat, it was decided to set-up an End-to-End Early Warning System to monitor and forecast extreme precipitation events in Upper and Middle Tapi basin as well as *Khadi* (tidal creeks) floods. This was managed by first setting up of a Surat Climate Change Trust (SCCT) that coordinated efforts across three States – Madhya Pradesh, Maharashtra and Gujarat to cover the entire catchment area of Tapi river. SCCT also provided the common platform stakeholders and information holders at different institutions and levels (from National, State, District and City levels) to share information, learning and interact before and after floods and to plan and take integrated/ coordinated actions.

The key aspects of the Surat's End-to-End Early Warning System are:

- a. Increased institutional coordination and action
- b. Improved reservoir operation systems: Climate change informed hydrological and hydraulic modelling helped in development of reservoir inflow and outflow prediction models. This Hydrological Model provides advance information (5 day inflow forecasts) to the decision makers.
- c. All stakeholders responsible for flood information generation, dissemination, preparedness, warning and management range from national to state, district and city institutions brought on the same page
- d. Improved flood warning system in the city includes installation of weather systems, data transfer mechanism from catchment to reservoir to city level, development of weather and flow prediction models, improvement of existing flood preparedness and formulation of action plans.
- e. Installation of ten automatic weather stations and two water level measurement units across the city, to provide detailed weather, tide and flow information
- f. Development of city level spatial data (in GIS) for flood management

REFERENCES:

- End to End Early Warning System for Ukai and Local Floods in Surat City.
https://smartnet.niua.org/sites/default/files/resources/End%20to%20End%20EWS_Surat.pdf

Further reading on building Urban Flood Resilience:

Urban planning:

- Thailand Flood: A Case Study; Verne Baker Phillip Lui, Joint IACA, IAAHS and PBSS Colloquium in Hong Kong. www.actuaries.org/Hongkong2012/
- Urban Development and Flood Risk in Vietnam: experience in three cities. Synthesis of flood case studies and policy issues. <http://www.i-s-e-t.org/resource-iset-working-paper-2>

Ecosystems approach to resilience building:

- Integrating urban agriculture and forestry into climate change action plans: Lessons from Sri Lanka. https://cdkn.org/wp-content/uploads/2014/05/SriLanka_Inside_Story_final_web-res.pdf
- Climate Resilience Case Study: Quy Nhon city, Vietnam.
<http://www.i-s-e-t.org/resource-resilience-quy-nhon>

Early warning systems to reduce flood losses:

- Scaling up Early Warning Systems in Nepal - case studies and good practices. <https://practicalaction.org/scaling-up-ews>
- Elements of an effective Flood early warning system.
- http://www.un.org/waterforlifedecade/waterandsustainabledevelopment2015/pdf/Lydia_Cumis-keyGDG.pdf
- Flood Early Warning in Bangladesh.
https://www.preventionweb.net/files/workspace/7935_casestudy3.pdf

As cities continue to grow, especially in the developing and low/middle income countries, more and more people in these cities are rendered vulnerable to the health impacts resulting from climate change. Climate change induced weather changes may alter the distribution of vector species and its increase new areas, or an increase in temperature and humidity may lengthen the breeding/transmission window. Similarly, mortality due to heat wave are routinely reported from several parts of the country. The 5th IPCC Assessment Report maintains that climate change impacts human health in three ways – (i) direct exposure to climate extremes (heat waves, etc.); (ii) indirect exposure (water or air quality, vector borne diseases, etc.), and (iii) disruption in social and economic systems – leading to phenomenon such as migration.

In this section, we analyse case studies on building resilience for two of the more prominent impacts – (a) direct (heat waves and/or urban heat island) and (b) indirect (impact of diseases on human health).



CASE STUDY UHR-1: HEALTH SURVEILLANCE SYSTEM IN SURAT

Surat, located on the bank of River Tapi, is one of the most populous cities in the west coast of India. Surat is prone to flooding and has experienced 24 river floods in last century, the latest being in 2013. The plague outbreak post 1994 flood was the turning point in the history of Surat city's governance, sanitation and health system reforms. Surat has continuously been rated as one of the best governed cities in India and is also one of the pioneers to bring in climate agenda in urban planning.

The weather of Surat with high temperatures and humidity also happens to present suitable breeding grounds for vectors such as mosquitoes. Coupled with high incidence of flooding, the vulnerability of city to vector borne diseases like filariasis, malaria and dengue etc. is very high. The city is also home to a large migrant population owing to its industrial base and this population is especially at risk due to unhygienic living conditions.

As part of the Asian Cities Climate Change Resilience Network (ACCCRN) programme, the Urban health and Climate Resilience Center (UHCRC), Surat was established in 2013, through Surat City Climate Trust (SCCT) wherein Surat Municipal Corporation (SMC) was a main stakeholder. SMC continues to support this one-of-a-kind Centre on disease surveillance in cities. Surat is the first city in India with universal and almost real time mosquito born disease surveillance system as part of its urban health programme. The key facets of this health surveillance system that help make Surat resilient to negative impacts on health due to climate change are:

Urban health service network: There are total 43 urban primary health centres (UHCs) –majority in the vicinity of urban poor/slum areas. There are two medical officers per UHC and visiting specialists, two staff nurses, 4-5 Auxiliary Nurse Midwife (ANM), a compounder and an HIV counsellor. Ten UHCs have been upgraded as maternity homes.

Disease surveillance: The major strength of the health department of SMC is its routine health surveillance system. The national programme of Integrated Disease Surveillance Programme (IDSP) is complemented by urban service monitoring system (UrSMS). The UrSMS provides real-time information collected and compiled daily from three public hospitals, 43 UHCs, 63 private hospitals and 475 private clinics and a few laboratories. Surat is the first city to adopt active vector and malaria case, house-to-house surveillance on a fixed day (15-day cycle), by 600 surveillance workers. This overall system not only provides real-time data for monitoring and action but also keeps the system alert for epidemics, resurgent/new infection, disasters and adverse weather events.

Public-private partnership (PPP): The Health Department also sustains and active PPP environment with more than 500 private medical care units sharing data with the SMC daily. In case of epidemic or disaster these private health care professionals work as per mutually designed SOPs, provide honorary consultation services at UHCs, participate in health camps, run Directly Observed Treatment Short Course (DOTS) centres and provide maternal and child healthcare services under Chiranjivi and Balsakha Yojana.

Community participation: As part of the disease surveillance system, community is actively involved in providing information and cooperating with the Health Department. Also, the Surat community is quite active and enthusiastic about sustaining initiatives on urban sanitation and environment.

Key learning/Conclusion

The vector borne disease surveillance system collects daily mosquito born disease case information from more than six hundred public and private hospitals, clinics and laboratories. This provides real time information about ongoing trend and clustering or outbreak forecast for timely action to help prevent the spread of disease in the city.

Surat city experience of building urban health resilience shows that most important factors for a sustainable health surveillance and action system includes community participation, inter-sectoral convergence, disease surveillance, health information system, Public-private partnership, participation of academic institutions and cross learning.

REFERENCES:

- Smith, K.R., et.al 2014: Human health: impacts, adaptation, and co-benefits. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. https://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-Chap11_FINAL.pdf
- Counting to reduce count: Surat City Health Surveillance system. Dr. Vikas Desai, Dr. K. G. Vaishnav, Priyanka Jariwala, Dr. Suresh Rathi, Dr. Hemant Desai, Urban Health and Climate Resilience Centre, Health department Surat Municipal Corporation. <https://www.acccrn.net/sites/default/files/publication/attach/SURAT%20Mosquitoborn%20disease%20surveillance.pdf>



CASE STUDY UHR-2

HEAT ACTION PLAN, AHMEDABAD

Ahmedabad is the largest city in the state of Gujarat and the sixth largest city in the country. In the month of May 2010, an intense heat wave was observed in Ahmedabad when peak temperatures of 46.8°C was recorded. This led to a spurt in the heat-related morbidity and mortality in the city. Besides directly affecting the physical health of humans across the city, the heat wave period increased the risks to a large workforce working under various occupational settings, especially those working in the unorganized and informal sectors.

The severity of the heat wave impact brought together the Ahmedabad Municipal Corporation (AMC), Indian Institute of Public Health of Gujarat (IIPHG) and National Research Development Corporation (NRDC) to look for solutions addressing heat waves and urban heat island effect. The Ahmedabad Heat Action Plan was developed as a result of this collaborative effort and the city is one of the first ones in Asia to comprehensively address health threats emanating from extreme heat.

Key aspects of Ahmedabad Heat Action Plan are:

- a. Build public awareness:** Engaging media (television, radio and print), community meetings and workshops, distribution of pamphlets in schools, billboards and other digital visual displays
- b. Initiate early warning system** along with **inter-agency coordination** to respond to heat wave conditions: In Ahmedabad, the Health Department as the lead agency for Heat Action Plan monitors daily temperature forecasts, sends heat-health alerts and public health messages to all local government departments including media to raise awareness regarding preparedness and response.
- c. Train medical and community healthcare workers** on emergency response during heat waves, covering the entire city

Specific measures undertaken during heat wave are:

- City gardens kept open during afternoon hours to provide shaded areas for the general public, extend hours of operation
- Daily monitoring of heat illnesses and related deaths
- Change in school summer holiday schedules
- Alter working hours to cooler hours
- Water tankers provided to slums and informal settlements and limit non-essential use
- Drinking water distributed at bus stops, temples, etc.
- Power utilities to provide uninterrupted supply to critical facilities and vulnerable communities

The pre, during and post event actions as part of Heat Action Plan can also be applied for other disasters like floods, cyclones, etc.

REFERENCES:

- Addressing heat-related health risks in urban India: Ahmedabad's Heat Action Plan https://cdkn.org/wp-content/uploads/2014/05/Ahmedabad_Inside_Story_final_web-res1.pdf

Management of solid waste (collection, transportation, segregation and processing/disposal) has been a challenge all over the world for urban local bodies and authorities. With increasing urbanization and development, the quantum of solid waste generated also increases and municipal solid waste management, like most other urban services is fast becoming a huge problem area – affecting urban health, environment and general well being. Climate change impacts like concentrated rainfall in short duration (causing water-logging or flooding), extended warm periods, etc. multiplies the challenges of un-managed solid waste.

Options for MSW disposal:

Sanitary Landfill: The solid waste collected from households is transported off-site to a landfill site. The waste is dumped in a large excavation pit in the ground, which is back filled with excavated soil. If managed properly, this is one of the most economical and fast ways to dispose off urban solid wastes.

Energy generation: Energy generation from MSW is possible through the following processes (a) Composting/Biomethanation for wet biodegradable wastes, (b) Combustion of Refuse derived fuel (RDF), and (c) Direct incineration MSW - Complete combustion of MSW as it is received to generate power



CASE STUDY WM-1

WASTE MANAGEMENT IN YOKOHAMA, JAPAN

Yokohama, in Japan is a city with a population of about 37 lakhs (2011). The city had seven waste-to-energy plants in 2005 of which only four were functional by 2010 because of its waste management policies. The power generation plants in Yokohama are most efficient as only combustible household waste like non-recyclable paper, kitchen waste, wood and trees, and non-recyclable plastic items is incinerated.

In 2003, Yokohama generated over 1.5 million tonnes of trash per annum, which was reduced to 1.1 million tonnes by the year 2005, after the launch of an intensive recycling programme called 'Yokohama G30 Plan'. Buoyed by this success, the city authorities launched the 3R (Reduce, Reuse, Recycle) campaign in 2011 that will run through 2025. The 3R campaign is aimed at intensifying the city's strict waste management system and making it even more stringent with better segregation, recycling and reuse policies. The strictness of this system can be gauged by the fact that if residents do not separate their garbage, it is left behind by collection agencies!

Yokohama has an aggressive publicity and awareness system for waste management that includes:

- Separation briefing to residents
- Educational campaign in front of train stations
- Early morning educational instruction at collection points
- Visit elementary and Junior High schools for delivering lectures on waste management
- Demonstration of collection work and conducted tours to incineration plant

The city authorities and civil society organizations together conducted about 3,300 campaigns and 11,000 seminars across the city to make people understand best waste management practices, after the 3R campaign was launched.

The city also uses door-to-door waste collection practice as an opportunity to check up on the elderly population living alone – thus providing a much needed social service to the rapidly ageing society.

The key message from Yokohama Waste Management programme is that the focus of city authorities is more on reducing solid waste generation in the city rather than on collecting as much waste as possible for power generation.

Conclusion

One of the significant problems in urban India is almost no segregation of MSW and proper disposal – although this practice has been initiated in many cities. As envisaged under the Swachh Bharat Mission, there is an urgent implement measures to achieve 100% scientific processing and disposal of Municipal Solid Waste by 2019. While in countries like Japan, environmental concerns rather than energy recovery is the prime motivator for better waste management, in the Indian context, energy generation from MSW will improve the economic viability of waste management practices and projects. The solid waste generated from the urban areas in India at present has a potential to generate approximately 500 MW power (given the way quantum of waste generated is increasing, this potential is estimated to be 1,075 MW by 2031 and 2,780 MW by 2050), of which about 62 MW is estimated from Maharashtra. There are a number of waste-to-energy power plants already operational in India and many more are on the anvil.

REFERENCES:

- https://citynet-ap.org/wp-content/uploads/2011/10/Intergrated_solid_waste_management_in_Yokohama.pdf
- Standing committee on energy. 2015-16. Power Generation from Municipal Solid Waste. Ministry of New and Renewable Energy, Govt of India. http://164.100.47.193/lssccommittee/Energy/16_Energy_20.pdf

FURTHER READINGS:

- Mumbai: <http://iced.cag.gov.in/wp-content/uploads/C-34/Jaipur%20Presentation%20-%20Final.pdf>
- Mysore: http://www.seas.columbia.edu/earth/wtert/sofos/Yadav_Studies%20on%20Municipal%20Solid%20Waste%20Management%20in%20Mysore%20City.pdf
- General: <https://www.ijmter.com/papers/volume-3/issue-5/municipal-solid-waste-management-case-studies-in-india-a-review.pdf>

India has a large coastline of more than 7500 km, 70% of which is comprised of the coastline in the mainland with the rest belonging to the islands. Maharashtra is one of the western States in India that has a huge coastline of about 720 kms encompassing 6 coastal districts – Palghar, Mumbai suburban, Mumbai city, Raigarh, Ratnagiri and Sindhudurg.

If not planned properly, development in or around coastal areas reduces the ability of natural systems to respond to climate change. Building Coastal Resilience is based on the premise that coastal habitats and other infrastructure are planned, implemented and maintained to offer cost-effective and sustainable solutions to reduce risks emanating from sea level rise, storm surges and floods.



CASE STUDY CR-1

RESILIENCE BUILDING IN PANAJI, GOA

Panaji is the capital city of the Goa – a neighbouring State of Maharashtra on the west coast of Arabian Sea. Goa, the smallest State in India, is located between Arabian Sea on the West and the Western Ghats on its east – making its weather quite unique. The 2014 TERI study established that the mean sea level for Panaji coast is increasing at about 1.26 mm/year over a period of 1875-2010. Modelling exercise for the future (year 2100) also project an increasing sea level at 0.3 mm/year.

Goa is also urbanizing at a high pace and this has led to filling up and development in low lying areas reducing the capacity to absorb excess water leading to water logging and flood like situations. This couple with growing tourism is putting extra pressure on the city's infrastructure that poses a major threat to the city's natural resources and ecology, such as mangroves, khazan lands and sand dunes.

The 2014 study 'Climate Resilient Infrastructure Services' in Panaji, conducted by TERI (supported by USAID) focused on inventorying urban infrastructure along with developing a climate vulnerability assessment approach for infrastructure services to support climate resilient planning efforts. This was followed by another effort in 2015 by ICLEI-SA that helped CCP (Corporation of City of Panaji) implement a toolkit for city governments to help them assess their vulnerabilities to climate change and to develop corresponding climate resilience strategies.

Based on the data collected through these studies, a total of seven urban sectors vulnerable to the impacts of climate change were identified: water supply, health, transportation, sanitation, land, storm water and ecosystems.

The recommendations that emerge from these studies cover structural and non-structural measures. These include:

- Ecologically sensitive areas, i.e. mangroves: these require rehabilitation and preservation measures, and the maintenance of spatial maps of sensitive natural assets, including beach erosion levels near cities.
- Solid waste management: waterproofing measures are required, such as barriers to reduce contact with flood-water, and creating elevated storage areas. Siting regulations should be reviewed and alternative sites identified upon vulnerability assessment.
- Heritage and tourism: structural improvements are required to reduce the impact of flooding, and buildings should be checked for stability and efficiency, accounting for sea-level rise. Emergency plans are required to ensure the safety of tourists, requiring data on intensity and flows of tourists year round.
- Water supply: work to prevent leakages and infiltration of flood water into pipelines, establish emergency supply plans; and ensure quality and frequent monitoring, especially during rainy

season. Data required includes information on the age and capacity of treatment plants and seasonal reports on water quality.

- **Sewerage and drainage:** the vertical elevation of the outfall channel needs to be above high tide level to avoid back flows, and climate resilient planning of new drains to support vulnerable city zones is needed. Alternative energy sources in vulnerable zones housing pumping stations should be identified, and mapping, capacity, and seasonal data on structures and water levels are recommended.
- Specific recommendations were made for maintaining beach erosion information, undertaking rehabilitation and preservation measures around sand dunes and mangroves, so as to prevent impacts from predicted sea level rise.

REFERENCES:

- <http://www.teriin.org/sites/default/files/2018-03/case-study-panaji.pdf>
- <http://www.teriin.org/opinion/towards-developing-climate-resilient-panaji>
- <http://www.teriin.org/opinion/deciphering-impacts-climate-change-go>



CASE STUDY ARD-1 PERI-URBAN AGRICULTURE IN GORAKHPUR, UTTAR PRADESH

Gorakhpur, a secondary city, located in eastern Uttar Pradesh at the confluence of rivers Rapti and Rohin, has grown rapidly into an economic and institutional hub in the region. Its proximity to Himalayas has made the city susceptible to floods and water logging due to multiple factors such as bowled shaped topography and lower riparian city of river Rohin, due to which there is discharge of excess water from adjoining country Nepal. These problems are further exacerbated by climate uncertainties, impacting the livelihoods of poor and marginalized communities. Climate projections have indicated that the intensity of extreme rainfall in Gorakhpur is likely to increase in the coming years causing significant flooding in the city. Climate change is likely to increase the intensity of similar rainfall events by 10 to 20% in the future. The peri-urban areas of Gorakhpur are particularly prone to recurring floods and waterlogging for 2 to 3 months every year due to which small and marginal farmers suffer from crop losses.

Problem locale in the city: In the peri-urban areas of Gorakhpur, 8089 hectares of land is prone to flood. This is in the western part of the city and gets inundated every year. In spite of flood plains and being a no construction zone, the rapid encroachment is being manifested in many parts. As per the satellite images of two-time period (2002 and 2015), 267.42 hectares (33%) of land has been converted into built-up area. The north, north-east, east and south-eastern part of the city periphery are free from water logging and flood. This segment accounts 11558.17 hectares which is marked as agriculture land/green land. The city is growing in this direction. Due to rapid urbanization, the land mafias (builders) are more active in this zone and converting the open spaces/agriculture lands into residential area.

The rapid urbanisation occurring in Gorakhpur is straining the natural resources and is absorbing the existing agricultural land on the periphery of the city leading to decreased green/open spaces,

interrupted supply of food items to cities, disrupted livelihood patterns, and reduced natural drainage of excess storm water. Large scale conversion of agriculture land for non-agriculture uses is exacerbating climate change risks by increasing water logging and run-off.

About 54% of the peri-urban area represented in the Gorakhpur city Master Plan-2021 for agricultural use, has a population of 0.1 million of which a significant proportion belongs to small and marginal farmers' category. These farmers are hit by several problems of flood and waterlogging, sewage dumping, increasing cost in agriculture, changing land use patterns and governance issues which make them socially and economically vulnerable.

The peri-urban spaces had provided vital ecosystem services such as recharging water bodies and acting as buffers. These services, and their contribution to the city's resilience, are being lost. Supporting services, including nutrient dispersal and cycling, seed dispersal, and primary production have been altered, changing the nature of all other services. The people in Gorakhpur's peri-urban villages now increasingly rely on the market for food and medicines and other goods. There is an acute fuel shortage, leading to reliance on expensive sources of energy and electricity.

The solution: Peri-Urban Agriculture – Strategy for Building Urban Resilience in Gorakhpur

GEAG undertook the initiative which sought to mitigate flood risks through maintenance of open spaces by strengthening peri-urban agriculture based livelihoods around the city of Gorakhpur. While the initiative aimed at enhancing incomes and increasing food security for low-income residents, it also targeted to influence citywide land use planning decisions towards the goal of developing greater flood resilience. Today, peri-urban agriculture in Gorakhpur city of India represents a practical mechanism for diversifying urban livelihoods, particularly those of poor and marginalised communities, ensuring the availability of local food supplies, particularly vegetables and fruits and maintaining open areas that can serve as flood buffers. The land use pattern and ecosystem services in these areas are maintained to promote climate resilient peri-urban agriculture with innovative methods. This has resulted in securing livelihoods of small and marginal farmers, enhancing agricultural productivity and ensuring urban food security.

REFERENCES:

- Gupta, A.K., Singh,S., Wajih,S.A.,Mani,N., and Singh,A.K. (2017). Urban Resilience and Sustainability through Peri-Urban Ecosystems: Integrating Climate Change Adaptation and Disaster Risk Reduction, GEAG (U.P) India.
- Mitra, A., Wajih, S., and Singh, B.(2015). Wheezing ecosystems, livelihood services and climate change resilience in Uttar Pradesh. IIED, working paper series 18:2015.



CASE STUDY ARD-2

PARTICIPATORY WATERSHED MANAGEMENT: A SUCCESS STORY OF RALEGAON SIDDHI, AHMADNAGAR

Watershed management is a concept for the efficient use of rain run-off by collection, storage and judicious utilization of water for irrigation and other purposes. The sustainability and key to success of any participatory watershed project depends on people's participation and case of Ralegaon Siddhi is a classic example.

Ralegaon Siddhi is an acute drought prone village located in the Parner Tehsil of Ahmadnagar district in central Maharashtra. It is characterised by erratic and low rainfall ranging between 450-650 mm with average temperature of 12-44°C. Before 1975, the village was plagued by acute poverty, deprivation, fragile ecosystem, neglect and hopelessness. Ground water table was very low and well water could not irrigate even 60-70 acres of land. The yield per acre was very less and food insecurity was quite prevalent. The village witnessed stressful migration and most of the households were living in the state of absolute poverty. In 1972 Ralegaon Siddhi suffered the acute drought in the history of the village.

The village witnessed an era of transformation after the intervention of "Anna Hazare" from 1975 onwards. Anna's approach was to bring behavioural change in a participatory manner by establishing strong value system which was based on the principles of sharing, compassion and equity. The first objective was to fight drought where water and community participation became the key to prosperity. Anna followed "Vilasrao Salunke's Pani Panchayat Model" of trapping the rainwater wherever it falls. With the aid of Government and following the basic principle of watershed management, the entire village was divided into four watersheds. The first step was constructing nalla bunds to check the soil runoff and aid in water percolation. Other interventions included renovation of percolation tank, planting of trees around the tank, digging wells near percolation tank, construction of gully plugs and contour trenches along the hillsides, plantation of grass, trees and shrubs. All these interventions recharged the aquifers and made more water available for irrigation. Villagers used to monitor the project under the *shramdaan* initiative, hence the intervention became participatory watershed management.

Watershed reforms have changed the land use and cropping pattern of the village. The village now has two percolation tanks, 50 nalla bund, 50 borewells and 7 cooperative wells, check dams and private wells to irrigate the agricultural land. In terms of land use, kharif (summer crop) land (irrigated) has increased threefold, from 188 ha in 1970-1980 to 470 ha in 1991-1992 (ibid). Irrigated cultivated land went from 543.32 ha in 1975-1976 to 651.12 ha in 1991. Similarly, uncultivable lands were reduced from 241.39 ha (1975-1976) to 1221.71 (1991); reserved forests went up from 100.30 ha (1975-1976) to 136.00 ha (1991).

Role model: The success of Ralegaon Siddhi paved the way for the initiation of 42 "model watersheds" across the country by the Indian Council of Agricultural Research during 1980s. As a result of which, the National Watershed Development Program for Rainfed Areas (NWDPR) was initiated in 1990 under the Ministry of Agriculture. The Government of Madhya Pradesh established "Watershed Management Mission" in 1995 to replicate the success of Ralegaon Siddhi. The Government of Maharashtra implemented the "Adarsh Goan Yojna" to replicate the Ralegaon Siddhi model in 300 villages of Maharashtra to overcome frequent drought. Hivre Bazaar, a village located in the rain-shed area of the Ahmadnagar district was the biggest success of that time.

REFERENCES:

- Mehta, A.K. & Satpathy, T.(2008).Escaping Poverty: The Ralegaon Siddhi case. Indian Institute of Public Administration, New Delhi. Retrieved from https://www.files.ethz.ch/isn/127255/WP119_KapurMehta-Satpathy.pdf.



CASE STUDY ARD-3

DIVERSIFYING LIVELIHOOD TO NON-FARM SECTOR: PRADAN'S EXPERIENCE IN DHOLPUR, RAJASTHAN

This case study illustrates how well targeted development interventions can expand the capability of communities to enhance living standards. Inherently, therefore development serves a disruptive function as it redefines the way natural resources, labour, and markets are reorganized to create opportunities to raise income, access knowledge, and higher levels of human security for the households.

The Dholpur district in north-eastern Rajasthan is remote and the presence of Aravali ranges affect the topography, demography, resources and livelihoods for this region. Agriculture in Dholpur is primarily rainfed and out of total geographical area of 301 thousand hectares (ha), the gross cropped area is 198 thousand ha. The average annual rainfall is 754 mm, with vast variation across months (671 mm in June –July). 80% of ground water is over utilized i.e. extraction is higher than recharge rate. Further, scanty rainfall, scarcity of water (surface as well as groundwater) and the inefficient water management practices constitute the major challenges vis-à-vis crop productivity of the district. Both, crops and animals are prone to quirks of nature. Frequent droughts lead to decline in productivity and reduced performance and even death of animals.

The severe water shortage has retarded the growth of the farm sector. As a result the farmers have diversified into animal husbandry for subsidiary income. Dholpur district has an interesting mix of agriculture and non-farm sector as both contribute equally to the household income. Cattle and buffaloes are a permanent feature of wealthier village households. The dairy farming is thus well-developed and almost all big villages with a population of 5000 and above have got a village dairy for the milk collection by “**Rajasthan Dairy Cooperative Federation**” and by private dairies. With limited irrigation facilities and a highly skewed land-holding pattern (53% households owning only 16% of cultivable land), agriculture is mainly for subsistence purpose. Proximity to Delhi makes Dholpur an attractive milk catchment area, which unfortunately is a business dominated by private middlemen who charge high interest of 36-60% per annum on the credit amount given to villagers of Dholpur and an even lower than market price for the milk which is pledged till the time the credit is repaid.

In 2004, Professional Assistance for Development Action (PRADAN) began implementing the ***District Poverty Initiative Project (DPIP)*** in 126 villages across two blocks of Dholpur and dairy promotion was identified as the major area for livelihood intervention. While the DPIP focused only on asset creation for the Below Poverty Line (BPL) households, the Trusts support provided for addressing critical gaps in strengthening backward and forward linkages for dairy, ranging from timely and quality veterinary care, supply of cattle feed and a Bulk Cooling Unit (BCU) enabling the aggregation and direct supply of milk from members to organized buyers like Mother Dairy. The Self-Help Groups (SHGs) of the members provided a platform for members to save regularly and through inter-lending and access to bank loans eventually coming out of the debt traps of money-lenders.



CASE STUDY ARD-4

APPLYING ECOSYSTEM BASED APPROACH IN WATERSHED MANAGEMENT: A WOTR INTERVENTION IN KUMBHARWADI WATERSHED

Ecosystem approach to disaster risk reduction is widely advocated as second paradigm shift in disaster management and climate change adaptation, as it directly links with the livelihood of the people and sustainability of their resources (Gupta, 2012, Singh et al., 2013). This calls for emphasis on natural resource management, ecosystem services, land-use and adaptation to climate change within the strategies of disaster prevention, preparedness and post-disaster relief and recovery process (National Policy on Disaster Management, 2009, section 5.1.6). The benefits of this approach is manifold and includes carbon sequestration, improved biodiversity, pollination and water infiltration, community development and improve resilience to drought. One such intervention was done by Watershed Organization Trust in Kumbharwadi village, which has gained worldwide attention.

Kumbharwadi is a rainfed watershed lying in the region of Ahmednagar district in Maharashtra state. Total area of the watershed is 910 hectares and the terrain is hilly, making irrigation difficult. Rainfall occurs primarily during the monsoon period from June through October, with average annual rainfall at 450 mm. The area sometimes experiences periods of high intensity rainfall (50–75 mm/ hour) which contributes to high soil erosion. Two villages that lie within the watershed are Kumbharwadi and Jondalwadi. Kumbharwadi village constitutes the majority of valley land and includes the highest proportion of landowners. Jondalwadi village lies on the ridge or hilly area of the Kumbharwadi watershed and includes a tribal community who mostly rent land.

WOTR began work in Kumbharwadi in two phases between 1998 and 2002. The first phase was a capacity building phase and the next phase was the implementation phase. Villagers and field staff worked with WOTR to identify and implement watershed interventions that were best for each parcel of land. With available funds they were able to implement technical, ecosystem-based, and social interventions. Technical interventions were meant to harvest rainwater and capture it as soil-moisture, ground water, or surface water. Interventions included one check dam or weir, two nala bunds, and seven loose boulder structures for trapping rainwater. Ecosystem-based interventions were meant to regenerate the landscape and harvest rainwater and included farm bunding on 492 hectares, and tree planting and contour trenching on 375 hectares of previous forestland, wasteland, and grassland. Social interventions included the formation of 11 female self-help groups (SHGs) comprising 143 women, who handle micro-finance loans for farm equipment and other needs. These SHGs undertake other activities including establishing kitchen gardens and using cleaner cooking fuels to reduce indoor air pollution.

Results from the project completion report and follow-up impact assessment indicate an improvement in groundwater levels, soil health, and overall human welfare. Due to improved groundwater levels, small-scale irrigation is now possible and villagers no longer rely on government-supplied water tankers to supplement drinking water supply during dry periods. Before intervention, for a given household, spent an average of two to three hours per day collecting drinking water. As income has increased per household, villagers have been able to install more wells that decrease travel time needed to collect fresh drinking water. Women from these groups are also now more actively involved in village decision-making processes for developmental decisions as a result of the self-help groups. Improved crop production has been one of the largest benefits for Kumbharwadi, as net agricultural income has increased significantly. The value of cropland has correspondingly increased and villagers no longer migrate for work as they are able to sustain agricultural employment in the watershed year-round. As fodder availability and agricultural incomes have improved, villagers have also invested

more in cross-bred cattle as opposed to indigenous cattle. As crossbred cattle have higher milk yields, livestock income has correspondingly increased.

REFERENCE FOR FURTHER STUDY:

- Gray, E., and Srinidhi, A. (2013). Watershed Development in India: Economic Valuation and Adaptation Considerations. Working Paper, WRI. Retrieved from https://www.wotr.org/sites/default/files/wsd_in_india.pdf.
- Rizvi, A.R., Baig, S., Verdone, M. (2015). Ecosystems Based Adaptation: Knowledge Gaps in Making an Economic Case for Investing in Nature Based Solutions for Climate Change. Gland, Switzerland: IUCN. v + 48 pp. Retrieved from https://www.iucn.org/sites/dev/files/content/documents/the_economic_case_for_eba_en_1.pdf.



CASE STUDY ARD-5: SYSTEM FOR RICE INTENSIFICATION: A PRADAN'S INTERVENTION IN NALANDA DISTRICT OF BIHAR

Rice is one of the staple food crops in India and accounts nearly for 43 per cent of total food grain production. Production of rice has increased considerably along with other food grains and had made India from “food deficit” to “food surplus” country post “Green Revolution”. But downside of the picture is that rice cultivation is highly dependent on availability of large quantities of surface and ground water. Recent projections on climate change and climate variability shows that with rainfall being more erratic and skewed, stresses on natural system will aggravate including the hydrological and ground water resources. These challenges paved the way for new technology to increase water use efficiency in rice cultivation and the System for Rice Intensification (SRI) offers a valuable option in this context. SRI is a package of practices (PoP) which reduce water requirement in rice cultivation by 25% to 50%, along with increasing yield and reducing the need for input of seeds, chemical fertilizer and pesticides. Depending on current yield levels, the output per hectare is increased usually by 50 percent. The minimal capital costs make SRI technique more accessible to poor farmers. Though SRI was developed for improving production for irrigated cultivation, its concepts and methods have been extended to rain fed agriculture and other crops like wheat, finger millet and sugarcane.

TABLE 3.1: COMPARISON OF SRI AGAINST CONVENTIONAL PRACTICES

Practices	SRI	Conventional
Nursery Management	Moist but well drained soil	Flooded soil
Nursery seed rate	5kg/ha	35-40kg/ha
Plant Management		
a) Age of seedlings	12 days	24 days
b) Transplanting	Single seedlings in grid	Random Transplanting
c) Planting density	16/sq.m	60-70/sq.m
Soil water management	Sprinkler irrigation	Flooding
Weed Management	Soil-aerating weeding	Herbicides
Nutrient management	Farm yard manure and vermin compost with green manure	NPK applications with green manure

Source: PRADAN (2012)

PRADAN, an NGO that works for strengthening livelihoods for rural poor in eight states, had applied this technology to improve farmer's income and ensure food security in Nalanda District of Bihar. The region receives average rainfall of 850 mm and average temperature varies between 4°C to 44°C in winter and summer respectively. Five farmers from Darveshpura village demonstrated the technique of SRI, which recorded the highest yield in 2011 across the world. The main influence on the differential yield would be attributable to agronomic practices, which is of significant interest (Table 1). A much smaller plant population, which matured in shorter period, gave a significantly higher yield. This also reduced water application by two-third and emphasised on organic soil amendments. The operative principle for aerobic soil condition is to provide both roots and soil biota with optimizing amounts of both water and oxygen. The result is larger and deeper root growth which gives rice plants more resilience to adverse climatic conditions such as drought, storms or extreme temperatures. The result from the Nalanda district show that though improvements in genotype can make a significant contribution to raising the paddy yield but changes in management practices, providing plants with optimum growing conditions, can even have larger impact.

REFERENCES FOR FURTHER READING

- Uphoff, N. and Kassam, A. (2009). Agriculture techniques for developing countries: Case study on System for rice intensification. Cornell University: USA. Retrieved from http://www.europarl.europa.eu/RegData/etudes/etudes/stoa/2009/424734/DG-IPOL-STOA_ET%282009%29424734_EN%28PAR05%29.pdf.
- V&A Programme (2009). Vulnerability and Adaptation experiences from Rajasthan and Andhra Pradesh: The System of Rice Intensification SDC V&A Programme, India. Retrieved from https://www.eda.admin.ch/dam/countries/countries-content/india/en/resource_en_192486.pdf.
- Diwakar, M.C., Kumar, A., Verma, A., and Uphoff, N. (July-August, 2012). Nalanda District Bihar-World Record SRI Yields. NewsReach, 12(8), pp:1-10. Retrieved from http://www.pradan.net/images/Media/news_reach_july_aug2012.pdf.



CASE STUDY FOR-1: JOINT FOREST MANAGEMENT: BULDANA EXPERIENCE

To sustainably manage the forests, formulation of Joint Forest Management (JFM) policy was conceived, which was an outcome of National Forest Policy, 1988. The policy pointed towards a major shift, taking into cognizance the customary rights and privileges of the forest dwelling communities. Participatory management practices like JFM and Village Eco-development (VED) gradually evolved. JFM program represents the need to involve people in managing the resource. It reposes trust in people, and their capacity to manage the resource in their own, as well as in the larger interest. It can result in rebuilding people's institutions at local level. This shifted the emphasis of the forest sector towards preservation and regeneration through co-management of forests, in which villagers cooperate to protect forests in exchange for a share in the usufruct and final harvest. Currently, there are 84632 JFM Committees covering 28 States in India. About 83,00,000 families are involved in these efforts and a greater number of indirectly benefiting families too. Some of the non monetary positive incentives under the JFM programme are institutionalisation of peoples' involvement, empowerment at local level especially the panchayats, awareness of the need to manage environmental resources, Accrual of forest a benefit which helps improve the non-timber forest produce and also strengthens the participation and belief of people.

One such JFM experiment was run in Buldhana forest division which is north-central district of Maharashtra State. Known for good quality grass, it has a large area declared 'degraded' under reserved forest and faces challenges of illegal felling and grazing by migrating cowherds from Gujarat. The local communities suffered from scarcity of fuel and fodder. The region faces hazards related to climatic variability's, high temperatures, increase in precipitations, low rainfall seasons, extreme heat wave conditions and frequent drought seasons.

Buldhana JFM programme: Five factors that played an important role in wide acceptance of JFM in Buldhana were: taking up of activities generating income in the short term; freedom given to the locals to take decisions according to their priorities; co-ordination between various developmental agencies working in the area; devolution of authority with the forest department; and introducing the element of flexibility and continuous learning. With the intervention of the forest department, frequent discussions were held on various issues relating to the deteriorating status of forests. Faith of villagers was reinforced to believe that the forest resource surrounding their villages was to be inherited by them. Soon 12 villages agreed to formally join JFM arrangement. Forest Protection Committees (FPC) in all 12 villages started working on several fronts simultaneously, though specific activities differed from village to village, according to priority. Encouraged by the remarkable success of these 12 villages, many more villages expressed their willingness to join JFM. Within a year, 69 more villages were added to this list of self-initiated, co-managed groups that spread across the Buldhana division.

Botha Village Experience with JFM: a small village in Khamgaon tehsil of Buldhana district, Botha is well-known for its success in JFM. The forest of Botha is classified as a Class A forest and covers an area of 1510 ha. The village lies on the outskirts of the Dnyanganga wildlife sanctuary, and part of the conserved forest falls within the sanctuary. The major tree species found in the forest are ain, dhavada, palash and teak. The total human population of Botha is 270, distributed in 63 households. The inhabitants of the village are mainly Mahadeo Koli tribals and the scheduled castes. The total geographical area of the village is 1662 ha. 49 % of the villagers are landless, while 51 % of the population consists of marginal farmers growing crops like paddy and nachani. Livestock rearing is also practiced. The villagers are dependent on the forest for fuelwood and fodder. Another important source of revenue is the leaves of anjan, which, being a high-value fodder, fetches a good

price. A few villagers collect medicinal plants from the forest. Due to excessive illegal grazing and degradation of the forest, the villagers of Botha decided to protect the forest in their area. The JFM programme of the Maharashtra Forest Department was adopted by the villagers. The gram sabha and panchayat formed a Forest Protection Committee (FPC). With the active participation of the villagers, a micro-plan was prepared and a participatory rural appraisal was conducted to know more about the village and to understand the needs of the people. 1486 ha of forest land was allocated to the village for protection. The responsibilities of the FPC included: protection of forests, regulated use of forest products, maintenance duties, ensuring equitable sharing of any benefits to the entire village from the forest produce, and protection against fire. In the first year of JFM (1997), a community hall was built and a leaf plate-making machine was purchased. A check-dam was also constructed to increase the availability of water in the village and bamboo plantation was carried out on 20 ha. In the next year, mixed plantation was undertaken on 25 ha. A separate bank account for the FPC was also opened. Fodder grown on the protected forest land was harvested and distributed in the village and the surplus was sold in the market and the money was deposited in the FPC account.

Way forward: People's participation must be viewed as a movement towards greater humanization and democratization to attain equity and sustainability. Even if belatedly, the process in this direction has begun with a promise in the form of JFM. In India, there are already too many agencies and too many developmental schemes for rural development which are much uncoordinated, short sighted and fragmented. The sustainability of such initiatives largely depends upon building trust, confidence and mutual bonding between rural people and government functionaries. JFM programmes must be integrated with other departmental efforts and step by step local involvement in capacity building will play a key role.

REFERENCES FOR FURTHER STUDY:

- Organization for Economic Co-operation and Development (OECD): (<http://www.snvworld.org/cds/rgSFB/Biodiversity/readings/OECD.pdf>).
- Botha village, Buldhana; Case study of Joint Forest Management: http://www.kalpavriksh.org/images/CCA/Directory/Maharashtra_CaseStudy_BothaVgeBuldhana.pdf
- Joint Forest Management: Constituting New commons; a case study from Maharashtra, India: Rucha Ghate, Department of Economics, University Campus, Nagpur, May 2000.



CASE STUDY FOR-2: IMPORTANCE OF INDIGENOUS KNOWLEDGE IN CONSERVING BIODIVERSITY: MONPA TRIBE IN ARUNACHAL PRADESH

Indigenous knowledge is the essence of tribal people and plays a significant role in food security, resource management and conservation of biodiversity. A study was done by Singh et al., in 2005 in rain fed agro ecosystem of Eastern Himalayan Region belonging to *Monpa Tribe* in Arunachal Pradesh for understanding the importance of indigenous knowledge in conservation biology.

The observations from the study revealed that tribal farmers are quite aware about the importance of biodiversity and natural resource management. *Monpa* tribe has developed the location specific indigenous practices for conserving the indigenous crop varieties, grown by only using the dry leaves

of *Paisang* [*Quercus rex* (Hemsl.) Schottky, Oak tree] and pine. Seeds of local variety of maize are spread in the fallow land, ploughed using the bullock drawn local plough, then the collected dry leaves are spread uniformly over the soil primarily by the women folk. There are three indigenous varieties of maize, namely *Fenthina* (dwarf variety, duration 3 months), *Thinasheru* (tall variety, duration 5 months) and *Baklangboo*, [medium tall variety sown in *Lohsar* festival (January to February), duration 4 months]. These indigenous varieties are location specific in nature and grown under varying micro-farming situations by applying the dry leaves of *Paisang*. *Fenthina* is grown in most fertile soils near kitchen gardens, *Thinasheru* is grown in main agricultural land where soil is black to brown and land is undulating, while *Balangboo* is cultivated in gentle slope and shifting land. Less quantity of dry leaves of *Paisang* are used in black soil than in light textured and undulating lands.

The selection of crop species and types of cropping (mostly mixed) is decided by whole community of village based on amount of *Paisang* tree leaves to **avoid the crop loss** and **sustain the crop productivity**. If maize is grown after using the dry leaves of *Paisang* and pine as natural mulch, then there is a better opportunity to increase the productivity of crops by **diversifying the cropping** systems. When ample quantity of dry leaves of *Paisang* is available as organic manure, then the indigenous varieties of black gram, soybean and rajma bean are incorporated as mixed crop. The local varieties conserved by local people using dry leaves of *Paisang* are compatible to the customs, culture, socio-economic conditions, and biophysical parameters, spirit, food habits and ethnic values of Monpa tribe.

To conserve the *Paisang*, pine trees and local crops, *Chheskaran* festival is celebrated during March for the spirit to protect them from insect pests and evils. With the passage of time, some changes have been seen in the methods of use of *Paisang* leaves. About 20 yrs back, semi decomposed leaves of *Paisang* tree were used in the standing crop of maize and other crops to increase the fertility, control soil erosion, conserve soil moisture and suppress the weed intensity. The women folk collect the dry leaves of *Paisang* from private and community forest and store in the agricultural fields in a specially made bamboo structure. The leaves were piled tightly and left till the onset of rains for decomposition. When the reddish solution is secreted from the bottom of stored leaves, it indicates that leaves are partially decomposed and are ready to apply in maize and other local crops. Now a days the dry leaves are directly collected and used (as mulching material cum organic matter just after sowing of maize seeds) without partial fermentation.

The informal *in-situ* indigenous agrobiodiversity conservation at *Monpa* is remarkable. The **agro-ecosystem is rainfed** and most of the farmers are economically poor. Besides these factors, the biophysical condition of this area does not allow them to apply the inorganic fertilizers, thereby making them dependent on the dry leaves of *Paisang* and pine.

REFERENCE FOR FURTHER STUDY:

- Singh, R.K., Singh, D., and Sureja, A.K. (2006). Community Knowledge and biodiversity conservation by Monpa Tribe. Indian Journal of Traditional Knowledge, 5 (4),pp:513-518. Retrieved from [http://www.niscair.res.in/sciencecommunication/researchjournals/rejour/ijtk/Fulltextsearch/2006/October%202006/IJTK-Vol%205\(4\)-October%202006-pp%20513-518.htm](http://www.niscair.res.in/sciencecommunication/researchjournals/rejour/ijtk/Fulltextsearch/2006/October%202006/IJTK-Vol%205(4)-October%202006-pp%20513-518.htm)



CASE STUDY WSI-1: TRADITIONAL DIVERSION-BASED PHAD IRRIGATION SYSTEM IN DROUGHT PRONE VIDHARBA, MAHARASHTRA

Droughts have caused huge loss of crops and livelihoods of population dependent on agriculture in India. Vidharba, the northeastern region of Maharashtra, is prone to droughts. It has witnessed many severe droughts since the beginning of the millennium. To meet the irrigation water requirements communities from this region have devised and managed water through a Phad Irrigation system, traditionally in vogue since the 16th Century. It is a small scale community-managed irrigation system in which communities construct an obstruction across a river/ stream and divert water through local channels to their fields for meeting the irrigation water needs. A Phad is a block of 8-40 ha of land parcels owned by multiple farmers for irrigation. A uniform cropping pattern is followed within a Phad in a season, while the crop type can vary across Phads. Depending on the rainfall year type (good, average or bad rainfall year) the extent of area under various crops was decided. For example in a good rainfall year the community would decide to grow sugarcane in three and millet in one Phad, in an average year sugarcane in two and millet in the other two Phads, while in a bad year allow sugarcane in one, millets in two, and keep the fourth Phad fallow.

A core component of Phad irrigation system consists of series of bandharas (weirs) or obstructions constructed across a river to store its post-monsoon flow. They are usually constructed with the locally available materials such as black stones and coarse concrete mixed with small pieces of bricks. The site for a bandhara is selected considering the availability of command area--the area to be irrigated. The bandharas are spaced considering its height and the slope of the bed of the river; in a manner that there is a continuous stretch of stored water across the bandharas with the water stretch of one bandhara reaching till the bandhara located just upstream of it. The post-monsoon flow is used for irrigating rabi (winter season) crops and in some cases, depending on the availability of water, even the summer crops. A diversion weir is constructed to remove the stored water automatically once the water level rises above the level of the weir. Offtake channels are constructed from the diversion weir to irrigate the fields in its command with the flow controlled by a head regulator. The water flows in the channel through gravity with the average flow around 7-10 cusecs. A silt-trap kind of arrangement called scouring sluices is constructed at the offtake point and on key points along the channel. They help in clearing the sand and silt from the channel flow. The number of such scouring sluices depends on the length of the channel.

Lessons Learned and recommendations

- The Phad irrigation system has succeeded in regions of medium rainfall and is seen to mitigate risk of crop failure by providing protective irrigation leading to avoiding drastic reduction of agriculture production.
- The success of Phad irrigation system depends on robustness of community-based institutions: the involvement of all members/ farmers in the decision-making process, the conflict-resolution mechanisms in-built in the functioning of institutions, and equity in allocation of water to its members.
- Communities contribute in construction and regular maintenance of Phad irrigation system when they see the benefits of the same.
- Dilasa, the organisation that revived the Phad irrigation system in Vidharba has demonstrated an improved model by use of pipeline-based irrigation system. Hence, a combination model of open channel (as in the traditional model) and pipelines can be tested and promoted in schemes of Irrigation department of Maharashtra.

- Funds under MNREGA can be used for reviving the Phad irrigation system to build resilience of communities to drought.

REFERENCES AND FURTHER READING

- Presentation on Diversion-based Irrigation by Dilasa, http://www.cwsy.org/html/presentations-for-national-workshop/presentation17_dilasa.pdf
- Traditional Diversion-based Phad Irrigation system, India Water Portal accessed <http://www.indiawaterportal.org/articles/traditional-diversion-based-phad-irrigation-systems-help-mitigate-risk-crop-failure-drought>



CASE STUDY WSI-2: GROUNDWATER MANAGEMENT IN DROUGHT-PRONE AREAS: A CASE OF PANI PANCHAYAT, MAHARASHTRA

India is the largest user of groundwater in the world accounting for 25 per cent of the world's total groundwater use. More than 60 per cent of irrigated agriculture and 85 per cent of drinking water demand in India is met through groundwater (World Bank 2012). Groundwater buffers the risks a farmer faces from climate variability manifested through droughts and extended dry spells. Despite its critical significance for the livelihoods of millions the ineffective groundwater management regime has led to its severe degradation in several parts of the country. It has crossed sustainable level of extraction in several states in north India (such as Delhi, Punjab, Haryana and Rajasthan) while is on margin of reaching unsustainable level in states such as Gujarat, Tamilnadu, Karnataka and Uttar Pradesh with extraction more than 70 percent of the annual replenishable recharge. However, several pockets exist even in these lesser-exploited states where groundwater level has declined to several hundreds of feet. A major factor contributing to such severe degradation is the groundwater law of the country that gives near absolute right to land owners to exploit groundwater. Decoupling land and water rights is the need of the hour in formal groundwater governance and regulation system in India. The case of Pani Panchayat is a unique experiment demonstrating how land and water rights can be decoupled for equitable distribution and conservation of groundwater.

Pani Panchayat was a social movement started by Mr. Vilasrao Salunke in 1974 for motivating farmers of Naigaon village in the drought-prone Purandhar taluka of Maharashtra. In view of the precarious groundwater conditions and failure of government to manage it, he took a 40 acre land on lease from the village temple trust for constructing a recharge pond, a dug well in the discharge zone and a lift irrigation system. The encouraging results of the experiment triggered setting up of Gram Gaurav Pratisthan (GGP) with a mandate to scale-up integrated management of surface and groundwater in the village.

Key principles adopted by GGP for scaling-up include: focusing only on community irrigation schemes that benefited a group rather than an individual; decoupling land rights and right over groundwater use—even the landless were provided access to groundwater by providing land on lease for farming; water distribution was on per capita basis rather than on area of landholding—it limited providing irrigation water to 0.5 acre land per capita that would fulfill the basic food grain need; it banned intensive water crops such as sugarcane; banned running of wells in the command area of scheme; promoted community managed groundwater institutions operating on democratic principles—equity in decision-making, levying water charges, transparency and accountability.

Lessons Learned

The Pani Panchayat movement successfully ran for two decades, till 1994, after which it collapsed. The key factors contributing to its success and failure include:

Success factors:

- A supportive environment: The movement had support of then District Magistrate of Pune and local authorities, local industrialists and initiative and dynamism of students of Government Engineering College (Pune). However, the support could not continue due to changing character of GGP over the years.
- Emphasis on community participation: The community groups were homogenous to sustain it longer. All the members were small landholders, hence more or less from the same economic background.
- Availability of technical manpower: The lift irrigation schemes relied on effective functioning of water pumps. The GGP trained local Industrial Training Institute's diploma holders who provided timely and cheap support for undertaking the needed repairs of pumps. Further, GGP had conducted regular training programmes for people on maintenance and repair of pumpsets and other irrigation devices.

Factors contributing to failure:

- Increase in government-sponsored participatory irrigation management schemes challenging the rationale of existence of GGP as promoter of community models of water resource development and management. The beneficiaries of the GGP schemes saw the government sponsored programmes as yet another alternative of techno-economic assistance.
- The average size of Pani Panchayat group was 35, between 8 and 50. Even international literature on community institutions evidences that such sized groups have not been sustainable for longer-term.
- Water availability: The core resource around which the community institution was formed. In years of successive droughts the dwindling water availability worked as a deterrent to continue as a group. Moreover, farmers were inclined to alternative water supplies through having their own wells and pumps to sustain their livelihoods, pushing them to opt out of the group.

REFERENCES AND FURTHER READING:

- ACWADAM (2010): Pani Panchayat: A model of groundwater management, accessed May 25, 2018 from <http://www.indiawaterportal.org/articles/pani-panchayat-model-groundwater-management-presentation-acwadam>
- World Bank (2012): India Groundwater: A Valuable but Diminishing Resource, <http://www.world-bank.org/en/news/feature/2012/03/06/india-groundwater-critical-diminishing>
- Chaudhury, S.K. (ed) (2013): Volume VII: Sociology and Environment, in Readings in Indian Sociology edited by Ishwar Modi, Sage Publications India Pvt Ltd: New Delhi



CASE STUDY WSI-3: CONJUNCTIVE WATER MANAGEMENT: ADDRESSING WATER SUPPLY CHALLENGES IN INDORE CITY

India is urbanizing rapidly. It is one of the three countries in the world along with China and Nigeria that will experience the maximum urban growth by 2050. India's urban population is projected to grow from about 30 percent (2011) of total population to 50 percent in 2030 and more than 60 percent in 2050.

Large-scale, rapid and unplanned urbanization has increased the water demand manifold while diminishing the supplies through contamination of water resources by indiscriminate disposal of wastewater and solid waste. Consequently, cities are increasingly not able to meet the growing water needs of urban population especially of the poor and marginalized where even the basic infrastructure for provisioning such services is too inadequate. The problem gets compounded with cities relying more and more on distant water sources incurring huge costs without judicious use of local available supplies. Higher costs for sourcing distant water supplies coupled with low recovery of water taxes is reducing capacities of cities to provide reliable water supply of desired quality to its inhabitants. The problems of quality and reliability of urban water supply are likely to be exacerbated by climate change especially in areas already experiencing acute water shortages.

To address the above challenges of urban water supply, TARU Leading Edge in partnership with Indore Municipal Corporation, local NGOs and communities piloted the concept of Conjunctive Water Management (CWM) in Indore city located in water scarce region of Central India.

Indore has a population of 2.5 million and depends on a distant water source in Narmada river 70 kms away, which constitutes 90 percent of public water supply. This leads to high-energy cost for transporting water. The remaining 10 percent is sourced from local groundwater sources. Despite spending huge amount on transporting distant water, reliable water supply and water quality is still a serious concern in the city. In addition, high-quality Narmada water is supplied even to low end uses.

The pilot demonstrated how Conjunctive Water Management of local and distant sources could be practically implemented to provide reliable access of water supply at affordable costs of varying qualities needed for different end uses. The CWM emphasises understanding the demand and meeting it through a judicious mix of the local as well as distant sources based on quality, availability and cost. It further emphasizes demand-focused end use of water—low quality water for low end uses whereas high quality water for high end-uses. Four communities in the city were selected for pilot implementation. After undertaking detail assessment of demand, quantity and quality of available supplies, various technological options were evaluated and implemented in each community. All the four communities were facing severe problem of reliable water supply and/ or water quality:

- **Devshree Nagar (MPUSP slum):** Under the MPUSP programme two bore wells were drilled with stand-posts at each bore well with multiple outlets but without taps. Also, no storage tanks were constructed at each bore well. Every time community needed water the bore well had to be switched-on wasting a lot of water and energy. In addition, the communities do not have household (HH) level storage tanks resulting in more trips to bore wells for meeting their daily needs. The intervention included: two HH level readymade storage tanks modified with tap at the bottom and, a community level cement storage tank at each bore well; also for the reason that cement tanks are heavy and cannot be stolen. The Basti Vikas Samitee (BVS) formed under the MPUSP programme managed all the operation and maintenance of systems and associated costs.

- **Ganesh Nagar: (low middle class settlement):** The settlement has four community bore wells connected to piped water system. In addition, 23 private bore wells exist. The groundwater is contaminated with pathogen and also TDS is high. In summers most bore wells go dry. All the houses have brick walls and RCC roofs. The intervention included: Community level rain water harvesting and recharging system using the two defunct open wells; and individual roof-top rainwater harvesting and storage system for meeting drinking water needs.
- **Rahul Gandhi Nagar (notified slum):** Bore well based water supply system was started under the MPUSP programme. However, water quality of borewells has high TDS and also has been contaminated with higher level of pathogens and E. coli essentially due to poor sanitation. Hence, the intervention involved setting up a community level RO plant of 3000 ltrs/ hour capacity with UV filtration and ozonisation. The wastewater from RO plant is used for flushing community/ individual toilets and other low end uses. Further, a door-to-door distribution of the RO treated water is established for which households pay INR 5/ 20 litres. As RO is a high technology intervention, AMC is signed with the vendor. The Basti Vikas Samittee set up under the MPUSP programme manages the O & M and collection of payments from HHs.
- **Narwal Kankad (very old slum):** Here too, bore well based water supply system has been commissioned under the MPUSP. The houses are made of brick walls and tin roofs. Due to space constrains households are able to store only 100-150 litres in drums, cans and other utensils which are kept in kitchen or outside the house below the sit-out benches. Lesser storage facilities require the women and children to spend long hours over frequent trips for fetching water; an opportunity cost for women to engage in other productive activities and children in studies. Hence, the intervention involved providing HH level storage tanks of 500 litres readily available in market modified with a concrete cover lid, a tap and drainage outlet at the base. These tanks can be easily installed in kitchen/ verandah.

Lessons learned

- CWM approaches can enhance water availability at the community and household levels, especially for the poor
- Community mobilization and social cohesion are critical for such interventions
- The poor are ready to pay if the service is reliable
- Domestic water requirements comprise different uses, from high end use-- drinking water needing high quality, to low end uses such as flushing and other uses. Appropriate systems of treatment and reuse need to be devised.
- Appropriate technological solutions need to be identified only after a comprehensive analysis of contexts of communities—problems, constraints and opportunities.

REFERENCE

- TARU (2014), Conjunctive Water Management in Indore city, ACCCRN. Accessed from <https://smart-net.niua.org/content/cef69d2b-c566-4b3b-993f-6ecc66fa23c9>



CASE STUDY DM-1: EARLY WARNING SYSTEM FOR CYCLONES: A CASE STUDY PHAILIN 2013

Improper infrastructure planning and development, poverty and inadequate risk management capacities of communities and ineffective warning systems can cause huge loss of lives and property due to hydro-meteorological hazards. The impacts get compounded due to untimely and improperly packaged warnings that are difficult for communities to understand and interpret. Often communities do not have the capacities and resources to respond effectively to the hazards.

Odisha and Andhra Pradesh are located on the eastern coast of India that is relatively more prone to cyclones than the west coast. Odisha alone has around 480 kms of coastline that constitutes 17 per cent of the eastern coast of India. High population density and poverty makes the coastal areas of Odisha very vulnerable to cyclones—in fact Odisha is twice more vulnerable than other eastern coastal states of India. The Super Cyclone (1999) and Phailin (2013) that struck Odisha (and other neighbouring states) were the deadliest, categorised as “Very Severe”, cyclones in India in recent history. While the Super Cyclone caused lots of deaths (more than 10000) the deaths due to Phailin were very minimal (38). The commendable reduction in loss of lives is attributed to effectiveness of early warning system combined with effective coordination and preparedness. This case study presents key features of the above in case of Phailin.

Early warning and Coordination: The Indian Meteorological Department (IMD) continuously tracked and issued regular warnings, following the multi-stage macro to micro scale assessment of intensity and track, as per NDMA Guidelines for Cyclones (2008), days ahead of the Phailin’s landfall. The information was translated by SDMAs and DDMA’s into possible impacts spatially considering the available data on vulnerability. The Phailin Advisories were issued through various digital communication medium such as local cable TV, voice sms, live radio programmes of direction and expected wave height of the cyclone on FM radio, local newspapers and periodic flash news/ bulletins. In addition, various NGOs, Foundations and Trusts were engaged to communicate the advisories to the most vulnerable. All this enabled evacuation of population living in low lying areas and kutcha houses or tin roof houses within 0-10 km of the coastline to be evacuated to nearby cyclone shelters or other identified safe buildings. That way more than 10 lakh people were evacuated to safe places within 36 hours—it was one of the largest evacuation exercise in the history of Disaster Management in India. The evacuation was successfully conducted due to very effective coordination between key agencies including Central Government, State Government, District Administration, Local Authorities, Odisha Disaster Rapid Action Force (ODRAF), National Disaster Response Force (NDRF), Central Reserve Police Force (CRPF), Odisha State Armed Police (OSAP), and the Indian Air Force (IAF) and International NGOs.

Preparedness: The state government made advance preparations by deploying manpower, machinery and materials at various locations so as to restore the critical infrastructure in short time. The cyclone caused large scale damages to power supply, water supply, main highways were affected due to uprooted trees; railway infrastructure was damaged resulting in cancellation of 165 trains; and the Biju Patnaik airport at Bhubaneswar was disrupted and majority of flights had to be cancelled. All the damaged critical infrastructure was temporarily restored within a record short time. Further, the preparedness fostered opening 4197 free kitchens, mobilizing 185 medical teams and 338 medical relief centers that became functional immediately after the cyclone’s landfall.

Lessons learned

- Accurate and days in advance forecasts combined with effective coordination can reduce the casualty drastically.

- For effective warning multiple modes of communication medium (TV, Radio, voice sms, newspapers, and communication through NGOs) are required that caters to information needs of various stakeholders who have differential access to above medium and have varying literacy level/ capacities to interpret the warnings.
- Having a well laid-out preparedness plan for each district comes handy in terms of assessing availability of resources (manpower, machinery and equipment) and locations for emergency shelter and relief. The preparedness plans enables appropriate deployment of resources spatially across the region.

REFERENCES:

- Prakash, S. and T. K., Saha Roy (2014), Proceedings of National Workshop on Phailin Cyclone (2013): Lessons learned, National Institute of Disaster Management: New Delhi.



CASE STUDY DM-2: USE OF INDIGENOUS KNOWLEDGE FOR EARLY WARNING FROM FLOODS: A CASE FROM BRAHMAPUTRA VALLEY, ASSAM

Prior to modern technologies to forecast floods communities relied on Indigenous Traditional Knowledge (ITK) to prepare for and respond to floods. Even in remote and flood-prone areas such as Dhemaji and Lakhimpur districts of Assam where the forecasts arrangements of government are not so effective communities relied on indigenous knowledge till a decade ago. ITK on forecasting can be divided into two categories: hydro-meteorological and biological. The indicators in the two categories aided community to decide on appropriate response strategy—whether they should continue to live in their houses and endure the floods or whether they need to leave their homes to safe places.

ARANYAK, an NGO, under an ICIMOD supported programme conducted research in 2008 on understanding ITK of flood forecasting and coping strategies of three indigenous communities living in Lakhimpur and Dhemaji districts of Assam—“Mishing”, The “Ahom”, and “Chutiya”. These communities are rarely aware about the rain and flood forecasting system of IMD and CWC. Also, the few who know from TV/ radio do not have faith in it. Hence, they rely on traditional wisdom and knowledge of local environment to forecast rains and floods. Some indicators include:

- Black and grey clouds in the sky indicates rains in couple of hours while dark clouds in the distant horizon over the hills warns about heavy rains in the hills and consequent floods in their area in 3-4 hours.
- Villagers assess how soon a flood wave will hit by observing the currents and rate of increase of water level of the river.
- Rainfall on ‘maghi astami’ (the eighth day of the month of Magha) predicts floods in that year.
- Cows behave erratically just before a flood. Frog calls indicate rains ahead while uninterrupted frog calls warn about heavy showers and probable flooding.
- If there are no fishes or few fish in the early rainy season, there will be floods.

However, with the changing climate the accuracy of ITK-based forecasts has reduced. Perhaps new ITK-based indicators both on hydro-meteorological and biological aspects need to be explored. Also, the younger generation has lesser faith in the ITK leading to its diminishing use generation after generations.

Lessons Learned and recommendations

- ITK-based flood forecasting is an alternative system to conventional early warning system of the government and has helped communities effectively in past.
- A compendium of ITK-based forecasting needs to be developed through research covering sudden as well as slow-onset climatic hazards, particularly in the context of changing climate;
- Awareness on ITK-based forecasting needs to be created and promoted.

REFERENCES

- Das, P; Chutiya, D; Hazarika, N (2009), Adjusting to floods on the Brahmaputra plains, Assam, India. Kathmandu: ICIMOD



CASE STUDY DM-3: **EARLY WARNING SYSTEM IN AGRICULTURE: A CASE FROM INDO-GANGETIC PLAINS OF EASTERN UTTAR PRADESH**

The Indo-Gangetic plains are famous for rice-wheat cropping system having highest coverage of net sown area. The system provides employment and food security to millions in the region. However, climate change manifested through increase in, temperatures, frequency and intensities of precipitation, and inter-annual variability is majorly impacting the rice-wheat system. Specifically, in eastern UP recurring floods with extended monsoon season, delay in onset of rainfall, extended dry spells, untimely winter rainfall alongwith rising temperatures are significantly impacting rice and wheat production. With 90 per cent of the population dependent on agriculture for livelihoods climate change is impacting the population in a big way. Short-term weather forecasts (of 4-5 days) combined with agro-advisories can enable farmers to change timing of crop planting, crop variety, and scheduling irrigation and pesticide inputs to mitigate the loss in agriculture production from climate change.

In response to challenges posed by climate change in eastern UP, Gorakhpur Environmental Action Group (GEAG) with technical support from IMD and Narender Dev Agriculture University, initiated a programme of providing five-day weather forecast and agro-advisories to farmers in four districts of the region. For this GEAG established a network of six rain gauges and two observatories (with one being automatic) and combined with IMD data (through paid subscription) from seven automatic weather stations and two observatories, in effect used data from 17 points, to generate the forecast using Numerical Weather Prediction (NWP) model on a 9 km grid. However, NGOs cannot issue forecast on their own and hence the forecasts are being issued after approval of IMD. For agro-advisories support of the agriculture university is sought. The weather forecasts and advisories are refined considering the stage of crop growth:

- Farmers are provided information on wind gusting during harvesting time as it can damage the crop produce;
- Advisory on use of bio-pesticide is issued especially when temperatures are rising during moderate humidity;
- Advisory on timing of nursery/ sowing to cope with change in onset date of monsoon or more variable monsoon;
- Advisory on whether to schedule irrigation or not depending on whether dry spells or extreme heavy rainfall event is expected;
- Advisory on frost damage control through irrigation and smoke;
- Advisory on timing of harvest especially when moisture content in the grain is optimal to avoid post-harvest losses based on forecast of cloudy weather; and,
- If there is a flood warning issued by CWC/ DDMA, the warnings are also included.

As of 2014, the forecasts reached to 563 farmers from 50 villages through SMS, and further 2500 farmers, indirectly. In addition, forecasts are also displayed on notice boards in the villages so that farmers who are not registered on the system are able to access the information. Farmer Field Schools (FFS) provide training and facilitate interpretation of forecast and appropriate farm-level action. The FFS are also used to obtain feedback on accuracy, reliability and usefulness of the forecasts and agro-advisories.

Lessons Learned

- Accuracy and reliability of forecast are important: The accuracy of GEAG's forecast has been 75-100 per cent. This has led to substantial increase in number of farmers' subscription year-after-year, though some farmers took almost 6 months to develop trust and subscribe to the forecasts and advisories;
- Weather forecasts need to be combined with agro-advisories for timely and proper response by farmer;
- Monitoring and feedback system as obtained through FFS-meetings are very useful to enhance the quality and reliability of forecasts;
- Multiple-mode of communication is more effective: In this case forecasts were disseminated through SMSs and on notice boards in each village. If the SMS-forecast gets buried under innumerable advertising SMSs s/he gets it from the notice board. In addition, farmers who have not subscribed also are able to access the information—which over a period of time helps garner trust of unsubscribed farmers resulting in enhancing demand for such service; and,
- Timely forecast reduces input costs (of irrigation, fertilizer and labour), reduces loss and increases production value.

REFERENCE AND FURTHER READINGS

- Christian Aid (2014): Developing Climate Services in India: Programme Review, accessed [http://geagindia.org/pdf/Developing-Climate-Services-in-India-\(April-2014\)-final.pdf](http://geagindia.org/pdf/Developing-Climate-Services-in-India-(April-2014)-final.pdf)
- Gunda, J. et al. (2017): Impact of seasonal forecast use on agricultural income in a system with varying crop costs and returns: an empirically-grounded simulation, Environmental Research Letters 12(3), IOP Publishing Ltd. accessed from <http://iopscience.iop.org/article/10.1088/1748-9326/aa5ef7>



CASE STUDY DM-4: REAL TIME MONITORING OF HYDROLOGICAL PHENOMENA, GROUNDWATER: ASSESSMENT AND DROUGHT PREDICTIONS: A JOINT INITIATIVE BY GSDA, MRSAC WITH TECHNICAL SUPPORT FROM UNICEF

Background: India used surface storage and gravity flow to water crops for a very long period. During the last 40 years, however, India has witnessed a decline in gravity-flow irrigation and the rise of a booming 'water-scavenging' irrigation economy through millions of small, private dugwells/ tubewells/ borewells. For India, groundwater has become at once critical and threatened. Maharashtra is also facing a similar situation with around 2 million irrigation wells (dug/borewells) extracting around 54% of annually replenishable groundwater. Maharashtra also has more than 5000 big dams for storage of surface water. Even after such huge investment Maharashtra has issues of water management. Maharashtra Water Resources Regulatory Authority has made it mandatory to prepare basin wise Integrated Water Resources Plan for the State. Similarly, as per Section 9 of Maharashtra Groundwater (Development and Management) Act, preparation of Integrated Watershed Development and Management Plan is mandatory and it should be a part of the sub-basin and

basin water plan. Accordingly, the GoM has initiated the water planning work on the watershed/aquifer, sub-basin and basin unit. The integrated water plan for Godavari basin is ready, where as for other basins it is under preparation. Water Scarcity is one of the key challenges troubling pockets of Maharashtra consistently for recent few years along with large dry spells resulting in crop failures and this trend could continue in the State. Climate variability will further act as a force multiplier; it will enhance groundwater's criticality for drought-proofing agriculture and simultaneously multiply the threat to the resource. From a climate change point of view, Maharashtra's groundwater is critical for climate change mitigation as well as adaptation. Groundwater pumping with electricity accounts for huge carbon emissions. To achieve both, Maharashtra needs to make a transition from surface storage to 'managed aquifer storage' as the center pin of its water strategy with proactive demand and supply-side management components.

Intervention: In order to integrate these complex considerations in assessing droughts and water scarcity, the historical data for selected locations in a block of Chandrapur district were analyzed using statistical methods for the following parameters: rainfall magnitude and pattern; runoff/stream flows, including lean season flows; depth to water levels in wells during different seasons; pre-post monsoon fluctuation in water levels in wells; the cropping pattern & cropped areas (in different seasons); and occurrence of droughts in terms of intensity and extent. The outcomes of this analysis were in the form of several regression models that together formed a Decision Support Tool (DST) for drought prediction. The same can be applied to the data obtained from real time monitoring of precipitation and water levels in observation wells to improve the predictability of 'drought occurrence' and 'emergence of drinking water shortage'. As part of the initiative, a network for real time monitoring of water levels in wells and rainfall was set up by GSDA in Jiwati block of Chandrapur, which makes the data available to the users simultaneously. Data acquisition from this network is being undertaken using mobile technology and the same is being processed. The application of this decision support tool envisages periodic collection of relevant data on predetermined indicators illustrating status of groundwater resources. The data collection will be at the village level and will be communicated periodically by 'SMS' technology to a central node for further tabulation and analysis for prediction of groundwater situation, and probability of occurrence of droughts and summer scarcity. This will help inform the existing decision makers for a more proactive response to ensure ground water safety and security. The project was executed in one water stressed tribal block (Jiwati) of Chandrapur District. But, it is expected to benefit other areas of the district having similar agro climatic and geomorphological settings, for: 1] predicting meteorological droughts; and, 2] establishing relationship between a) rainfall and water level trends in wells (post monsoon and summer), and b) hydrological events (rainfall, recharge and lean season outflows) and socio-economic droughts.

Development of Web-based Programme

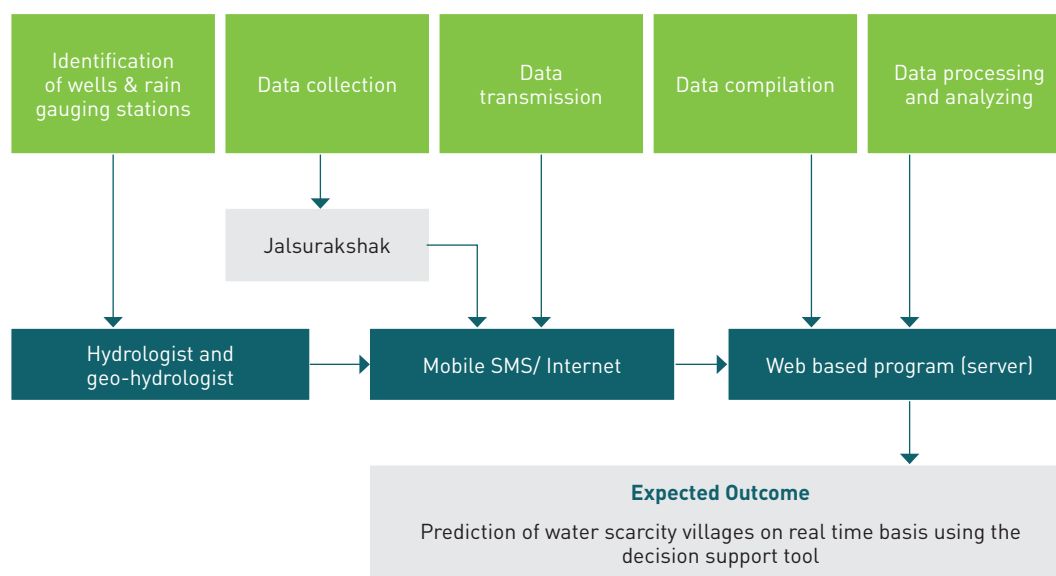
MRSAC is involved in the project as a partner to set up a web-based programme, which would use these statistical models and real time data for drought predictions. The web-based tool has three distinct features:

- a. Built-in statistical models to analyse the historical data on rainfall and its pattern,
- b. Assessing the probability of occurrence of rainfalls of different magnitudes and
- c. Standard Precipitation Index.

The web based programme will recall the data on monsoon arrival obtained on real time basis to estimating the probability of occurrence of a meteorological drought in that year. It would also recall the data on groundwater level fluctuations during monsoon to estimate the monsoon recharge. Based on the data on monsoon rainfall, it would give following outputs: estimation of runoff, gross infiltration, total base flow and utilizable groundwater recharge; and predicting socio-economic outcomes such as cropping and irrigation intensities; intensity of droughts in terms of number of

villages likely to be affected; and summer water levels in wells. The web-based programme would also periodically update the time series data of rainfall to modify the estimates of rainfall and drought intensity probability curves already established for the area. Most of the features of the programme would be in the public domain. The models can be updated with most recent data of rainfall. It has simple mathematical models, to estimates the key hydrological variables for a given magnitude of annual rainfall and pre-post monsoon groundwater level fluctuations. It has models for prediction of the occurrence of meteorological droughts and intensity of socio-economic droughts based on date of arrival of monsoon and annual rainfall, respectively.

Methodology:



Scale up

GSDA, with technical support from MRSAC has now scaled up this project for all the blocks and villages of Maharashtra. Observation wells for each village have been identified and these are mapped geo-spatially with latitudes and longitudes with an interactive dashboard and android based application to record and upload the static ground water level data on real time basis. At the same time rainfall data is also captured till circle level. *Jalsurashaks* for each GP has been engaged to record the observation well data and transfer it to the server for further backend modelling and predictions.

Lessons Learned

- The existing groundwater monitoring system is not robust enough to capture all the spatial variation in fluctuation in water levels in wells due to poor monitoring network
- The present model can predict the following: the probability of occurrence of meteorological droughts in a particular year, based on date of arrival of monsoon
- There is scope for refining these models for enhancing their performance in terms of reliability of predictions
- Finally, the experimental data on rainfall-runoff-base flows need to be generated for pilot catchments of the region for sufficiently large number of years at different spatial scales through hydrological monitoring so as to improve the accuracy of utilizable groundwater recharge assessments

REFERENCES:

- Mishra, A. K., & Singh, V. P. (2011). Drought modeling–A review. *Journal of Hydrology*, 403(1), 157-175.
- Central Ground Water Board (CGWB) (2009). Ground water information Chandrapur district Maharashtra. CGWB Central Regional Office, Nagpur, Maharashtra, India.
- Gupta S. K., & Deshpande, R. D. (2005). Groundwater isotopic investigations in India: What has been learned? *Current Science*, 89(5), 825-835.



SECTION 4

**CONTEXTUAL
LESSONS:
CONCLUSIONS AND
WAY FORWARD**

The frequency and the severity of disasters, caused by climate related functions and events have been increasing all over the world. Findings from the Inter-governmental Panel on Climate Change (IPCC) through their Fourth and Fifth assessment reports and Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX) clearly indicates that there exists a relationship between climate change and extreme weather and climatic events that have implications on society and sustainable development (IPCC 2012). Anthropogenic climate change is one of our greatest environmental, social and economic threats. Natural hazards by themselves do not cause disasters – it is the combination of an exposed, vulnerable and ill prepared population or community with a hazard event that results in a disaster.

Climate change will therefore affect disaster risks in two ways, firstly through the likely increase in weather and climate hazards, and secondly through increases in the vulnerability of communities to natural hazards, particularly through ecosystem degradation, reductions in water and food availability, and changes to livelihoods. Climate change will add yet another stress to those of environmental degradation and rapid unplanned urban growth, further reducing communities' abilities to cope with even the existing levels of weather hazards.

While the community at large is trying to adapt itself to these regular occurrences, the economic and social costs continue to mount year after year. There is a need to have an integrated approach with inclusion of policy makers, planners, scientific fraternity and communities to work together to develop appropriate strategies to mainstream Climate Change Adaptation (CCA) and Disaster Risk Reduction (DRR) into development planning process.

INTEGRATING CLIMATE CHANGE ADAPTATION AND DISASTER RISK REDUCTION

INTERNATIONAL PERSPECTIVE

The year 2015 was a landmark year for the United Nations and Global Development Agenda. The convergence of interests and global concerns for sustainable development, disaster risk reduction and climate change led to the formation of a new roadmap for a sustainable and safe world together: The Sendai framework for disaster risk reduction, The Sustainable Development Goals and The Paris Climate Agreement. These agreements of global significance provide opportunities to build coherence across different but overlapping policy areas.

Protecting people's health and lives from the risk of disasters is both a social and economic necessity. 187 countries including India are signatory to the Sendai Framework (2015-2030) which is the successor instrument to the Hyogo Framework for Disaster Risk Reduction (HFR) that was adopted at the Third UN World Conference in Sendai, Japan, 2005. It encouraged the adoption and practice of a number of innovations with strong emphasis on Disaster Risk Reduction (DRR) and enhancing resilience with explicit focus on people, their health and livelihoods. The Sendai Framework is a 15-year, voluntary, non-binding agreement which recognizes that the State has the primary role to reduce disaster risk to be shared with other stakeholders including local government, the private sector. It clearly encourages Nations to take up local risk reduction strategies and substantially reduce disaster damage to critical infrastructure and disruption of basic services, through developing their resilience by 2030 as two of their global targets.

Also, the Sustainable Development Goals (SDGs), otherwise known as the Global Goals, are a universal call for action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity. The SDGs are an inclusive agenda with inter-connected goals which work in the spirit of pragmatism to improve living in a sustainable manner for future generations. These include poverty, hunger, health, education, climate change, gender equality, water, sanitation, energy, urbanization,

environment and social justice. To achieve the SDGs, tackling the dual threats of climate change and disasters is essential. By building resilience and ensuring that all development is risk-integrated and informed, communities can protect against damages and losses alongside simultaneous boost of economic growth, create opportunities and livelihoods, strengthen access to health and education, and ensure prosperity for all.

Further, the Paris Agreement or Paris climate agreement which is an agreement within the United Nations Framework Convention on Climate Change (UNFCCC) dealing with greenhouse gas emissions mitigation, adaptation, and finance starting in the year 2020. The language of the agreement was negotiated by representatives of 196 parties at the 21st Conference of the Parties of the UNFCCC in Paris and adopted by consensus on 12 December 2015. The agreement aims to respond to the global climate change threat and additionally, the agreement aims to strengthen the ability of countries to deal with the impacts of climate change. Better preparedness will help corroborate better ability to cope with the disasters and recover from them more quickly and strengthen integration of stringent measures for disaster risk reduction.

INDIAN PERSPECTIVE

Environmental Protection Act 1986 is the umbrella legislation for environment and climate related measures along with Environment Policy of 2006, and more particularly the initiatives of Prime Minister's Council on Climate Change which led to a National Action Plan on Climate Change (NAPCC). NAPCC is being implemented under 8 national missions. States and UTs have their State Action Plans (SAPCC) on the lines of NAPCC. On the disaster management front the Disaster Management Act 2005 is applicable all over the country, with many of the states with their disaster management policies and plans developed to deal with disaster risk and events systematically and effectively. The national policy on Disaster Management and the DM Act equally emphasizes on the mainstreaming of disaster risk management into developmental process.

Mainstreaming of disaster management along climate actions for adaptation and resilience have to go hand in hand since the players, actors, stakeholders and beneficiaries mostly common in the cases. There is significant pace in India and its States & UTs in bringing the convergence at actionable level from policies and strategies. In this line, there is need for more clarity on strategies, approaches, process tools and entry points for affecting this convergence for larger benefits. The focus of developing and implementing disaster management plans at sub-national, district and local levels (ULBs and PRIs) offer opportunity for integrating the two. But, however, solid examples are needed to understand the entry points and models of this convergence that would offer dual benefits – i.e. for disaster risk reduction and climate change adaptation in one go.

In addition, the modern approaches for ensuring early warning communication hold key to success of disaster preparedness. Water management is one of the biggest challenges that attributes to disaster risk associated with climatic shocks in both, urban and rural systems. Resilience in drinking water is equally important. There are significant opportunities and options of mainstreaming CCA-DRR in agriculture systems as evident from the case studies incorporated in this compendium, and is much relevant as still being the major occupation in rural populations. Nonetheless, urban risk of climate shocks and disasters have grown manifolds over the decades with changing patterns of development, land-use practices, urban sprawl, ignoring peri-urban systems and loss/ degradation of ecosystems. Examples of urban and peri-urban setting offer significant entry points for mainstreaming CCA-DRR into urban planning and regional planning contexts, besides allowing for improvements in district and local body level departmental planning process. Resilience using forest systems, local and indigenous knowledge, waste management, heat management, etc. also offer important options and entry points for integrating the proposed mainstreaming. The table 4.1 shows that each case study offer significant entry points of convergence and mainstreaming into development and possess

potential for integration into department level developmental plans and actions which can further be implemented on ground actions.

MODEL FOR MAINSTREAMING CCA-DRR INTEGRATION

Mainstreaming Disaster Risk Reduction concerns in development planning can guide the allocation of resources towards the protection of life and assets, restoration of productive systems and livelihoods, regaining market access, rebuilding social and human capital and physical and psychological health. Development plans therefore take on a critical role in disaster risk management. The process of mainstreaming DRR into development planning needs to have appropriate tools and methodologies along with political commitment, public understanding, scientific knowledge and expertise. National and state level development schemes play a crucial role for the socio-economic development of the community. These schemes target huge population every year with large amount of funds for their implementation. Thus, there is tremendous potential for reducing vulnerability & risks through integration of DRR in national and state schemes through structured framework and operational measures.

The 18 case studies, including from Maharashtra and outside offer lessons for Maharashtra are to be considered indicative and not exhaustive examples of practical demonstrable models of developmental processes or initiatives integrating climate change adaptation and disaster risk reduction. Cost effective early warning system and use of traditional wisdom for the same is a crucial need of the adaptive development in developing communities.

The suitable utilization of these case studies would depend on drawing lessons as case examples for improving developmental plans and procedures, manuals and programmes/schemes by integrating innovations and components of resilience against climatic shocks and disaster risks, at all levels – state, district, sub-district and local (ULB, PRI) levels. Capacity building initiatives and efficient monitoring and review mechanisms for assessing the resilient planning and implementation would be a wise step to further ensure and improve the process of such mainstreaming. Besides this, a database of innovations and good practices and lessons to be maintained as dynamic process for continual improvement in the capacity building process would also be useful.

TABLE 4.1: EXTRACTS OF CASE STUDIES SUGGESTING PRACTICAL MODELS OF INTEGRATION

Best Practice	Business-as-usual Infrastructure/ ecosystems and change agents	Additionality/ changes observed in best practice for building resilience	Ideas for action; potential policies/ plans/ schemes for mainstreaming
<p>1. Eco-system based approach for urban flood resilience, Gorakhpur, Uttar Pradesh</p>	<p>The cities and urban agglomerations grow over time by expanding into the adjacent areas that are largely agricultural lands. Many a times these expansions do not follow the development plans prepared by urban development agencies. Unregulated urban planning and unauthorized/ improper constructions, including encroachments of low lying and natural wetland areas increase the exposure and impacts. Gorakhpur, a tier II city located in eastern Uttar Pradesh – that has grown rapidly into an economic, medical and institutional hub in the region – has shown all the above signs of unregulated and unplanned expansion resulting in regular flooding and waterlogging in various parts of the city.</p>	<p>At Gorakhpur, a city based NGO led the movement for building resilience of the city from flooding and waterlogging by leading a citizen’s movement to conserve the water-bodies (lakes) and removal of illegal encroachments along the shores. The second action undertaken by the NGO was to preserve peri-urban agriculture. Both these activities together enhanced the water drainage capacity within the city (lakes) and providing natural waterways and drainage areas for excess storm water. Conservation of peri-urban agriculture provided added co-benefits of improving livelihood opportunities for poorest, diversifying food source for urban populations, making use of urban waste for fertilizer, irrigation (recycled waste water), etc.</p>	<p>Eco-system based approaches for building flood resilience has been advocated for many areas including mega-cities like Chennai which saw devastating floods in 2015. Such efforts need to be spearheaded by the urban local bodies with support from NGOs that can mobilize communities. Further support and guidance needs to be taken from specific departments like Agriculture, Horticulture, Irrigation, etc. Such initiatives need also to be amalgamated into national programmes like AMRUT, Smart Cities Mission, etc.</p>
<p>2. End-to-end early warning system for flood resilience, Surat, Gujarat</p>	<p>Surat, a mid size city in Gujarat, situated at the mouth of river Tapi, used to face flood on a regular basis as most of Tapi’s catchment area lies in high rainfall zone. During the end of monsoon period –when the Ukai dam reservoir is filled to its maximum capacity, any increase in the inflow due to unpredictable/ severe rainfall within the catchment area forces release of high volumes of water within short period of time from the dam – leading to flooding in Surat city. The warning or information on such emergency was provided by authorities/Irrigation Department only at the time of actual event and that gave a very little lead time to the city. In the last two decades, the frequency of such floods had increased due to increased rainfall variability (extreme events), especially in the river’s catchment area.</p>	<p>With an objective to reduce the impacts of floods and resulting damage in Surat, it was decided to set-up an End-to-End Early Warning System to monitor and forecast extreme precipitation events in Upper and Middle Tapi basin as well as Khadi (tidal creeks) floods. This was done by first setting up of a Surat Climate Change Trust (SCCT) that coordinated efforts across three States – Madhya Pradesh, Maharashtra and Gujarat to cover the entire catchment area of Tapi river. Climate and hydrological modeling is used to forecast the amount of water in the catchment area that would come to Ukai reservoir. This forecast provides ample lead time (almost 72 hrs) for the city to plan for the excess release of water. SCCT also provided the common platform to stakeholders and information holders at different institutions and levels (from National, State, District and City levels) to share information, learning and interact before and after floods and to plan and take integrated/ coordinated actions.</p>	<p>The end-to-end early warning system at Surat was deployed with high level of cooperation amongst various agencies. However, this initiative was led by the Surat Municipal Cooperation through a high level, city wide body – Surat Climate Change Trust. The information sharing needs to happen throughout the catchment zone is not hampered by State borders. Such early warning systems are essential for areas that are regularly flooded so as to provide the people with ample lead time for evacuation and rescue missions. Again such initiatives can be supported under the urban development plans like AMRUT, Smart Cities Mission, etc.</p>

Best Practice	Business-as-usual Infrastructure/ ecosystems and change agents	Additionality/ changes observed in best practice for building resilience	Ideas for action; potential policies/ plans/ schemes for mainstreaming
3. Urban Health Surveillance system, Surat, Gujarat	<p>The weather of Surat with high temperatures and humidity also happens to present suitable breeding grounds for vectors such as mosquitoes. Coupled with high incidence of flooding, the vulnerability of city to vector borne diseases like filariasis, malaria and dengue etc. is very high. The city is also home to a large migrant population owing to its industrial base and this population is especially at risk due to unhygienic living conditions. There was no coordinated effort to combat these vulnerabilities in the city.</p>	<p>This initiative of Urban Health Surveillance Network was spearheaded by the Surat Municipal Corporation along with SCCT (Surat City Climate Trust). The Urban health and Climate Resilience Center (UHCRRC), Surat was established in 2013 to continuously monitor disease outbreaks. The 43 urban primary health centres (UHCs) form its Urban health service network. The Urban Service Monitoring System (UrSMS) provides real-time information collected and compiled daily from three public hospitals, 43 UHCs, 63 private hospitals and 475 private clinics and a few laboratories. Surat is the first city to adopt active vector and malaria case, house-to-house surveillance on a fixed day (15-day cycle), by 600 surveillance workers. The Health Department also has an active PPP environment with more than 500 private medical care units sharing data with the SMC daily. In case of epidemic or disaster these private health care professionals work as per mutually designed SOPs, provide honorary consultation services at UHCs, participate in health camps, run Directly Observed Treatment Short Course (DOTS) centres and provide maternal and child healthcare services under Chiranjivi and Balsakha Yojana.</p>	<p>The case of Surat Health Surveillance system is exemplary in the sense of its reach and comprehensive nature of surveillance. There is active cooperation between the civic and private agencies involved in healthcare. The use of technology (SMS based reporting and monitoring system) makes this system easy, efficient and highly replicable. Such initiatives can be supported under the national programme on disease surveillance like IDSP (Integrated Disease Surveillance Programme) that could be integrated into urban development programmes like AMRUT.</p>

Best Practice	Business-as-usual Infrastructure/ ecosystems and change agents	Additionality/ changes observed in best practice for building resilience	Ideas for action; potential policies/ plans/ schemes for mainstreaming
4. Urban heat island impacts: Heat Action Plan, Ahmedabad, Gujarat	As urbanization happens, the increased use of construction (buildings, roads, etc) and increased anthropogenic heat production (air conditioners, vehicles, etc.) lead to increased temperatures in urban areas as compared to rural areas. Lack of green areas and disappearing water bodies add to this phenomenon (Urban Heat Island – UHI) in many cities and is associated with environmental and public health consequences.	Increasing incidences of heat related morbidity and mortality in the city led a coalition of Ahmedabad Municipal Corporation, Indian Institute of Public Health and National Research Development Council to design and implement a Heat Action Plan. This involved building public awareness through media, community meetings and workshops, distribution of pamphlets in schools, billboards, etc. and initiate early warning system along with inter-agency coordination to respond to heat wave conditions. The Health Department as the lead agency monitors daily temperature forecasts, sends heat-health alerts and public health messages to all local government departments including media to raise awareness regarding preparedness and response. Medical and community healthcare workers have been trained for emergency response during heat waves, covering the entire city.	This lessons and learning from this example of an Urban Local Body spearheading the Heat Action Plan needs to be mandatorily implemented in all major urban cities experiencing high temperatures and humidity levels. All the urban development plans under programme like AMRUT, Smart cities Mission, etc. need to take cognizance of the mitigation measures of UHI so that they can be integrated in the plans, as well as Standard Operating Procedures need to be designed and put in place in case of emergencies due to excess temperatures.
5. Waste Management in Urban areas, Yokohoma, Japan	Rapid urbanization brings with it a host of challenges – waste management being one of them. The solid waste generated by the people needs to be collected and disposed off safely and hygienically. In several cities around the world, especially in the developing nations, this process of waste management is yet to be stabilized – mainly because of the rapid pace of urbanization. The Urban local bodies responsible for this are often overwhelmed by the sheer volume and need for safe places to dispose off the waste.	Yokohoma in Japan adopted a waste collection, segregation and disposal plan in the early 2000's along with power generation from the waste. This solved two problems – space for waste disposal reduced and extra power was available. Many cities in India have already adopted this waste management strategy and have started (or in the process of) energy generation from waste. However, city of Yokohoma did not stop at this. The city decided to reduce the gross waste generation and aggressively started the Reduce, Reuse, and Recycle (3R) campaign. By 2010, the city's waste generation was reduced by about 25% which led to shutting down of 3 (out of 7) waste to energy plants.	Waste management is one of the key services provided by the urban local bodies, and many large cities in India have already started producing energy from waste generated. However, there are several challenges for many of the urban local bodies to adopt these practices and generate energy from waste. Some of them are proper collection mechanism, waste segregation at source (already started in some cities), and finances. While a part of the finances for the whole waste management system – from collection to energy generation – can be met through urban development schemes like AMRUT and Smart Cities Mission, a majority of the financing can be done by the private sector. This way a lot more number of cities can benefit from this efficient manner of waste management.

Best Practice	Business-as-usual Infrastructure/ ecosystems and change agents	Additionality/ changes observed in best practice for building resilience	Ideas for action; potential policies/ plans/ schemes for mainstreaming
6. Peri-urban agriculture and ecosystems	<p>City Masterplans have areas designated for open and green spaces which often get converted into residential/ built-up areas reducing the flood buffering capacity of urban areas;</p> <p>The farmers in the peri-urban areas and small landholders and generally have no support from agriculture department;</p> <p>Discharge of urban wastewater and removal of top soil from fertile agriculture lands for landfill in construction degrades the (land and water) ecosystem;</p> <p>Degradation of ecosystem in peri-urban areas reduces agriculture production [including vegetables] impacting food and nutrition security of urban and peri-urban households;</p> <p>This phenomenon exacerbates risks from flooding and increases poverty.</p>	<p>Land-use change in areas where agriculture and vegetables are grown in peri-urban areas are minimised by promoting sustainable agriculture;</p> <p>It led to maintaining such spaces which enhanced flood buffering capacity of the city;</p> <p>The initiative enhanced the food and nutrition security of urban and peri-urban households;</p> <p>Treating urban wastewater through low-cost innovative decentralized treatment technologies created irrigation supplies for sustaining agriculture and vegetable production;</p> <p>It also resulted in arresting degradation of land and water ecosystem.</p>	<p>The initiative can be led by established NGOs having experience in agriculture development and urban areas;</p> <p>Such initiative can be supported by concerted capacity building activities targeted at peri-urban communities and network of City Development Authorities and ULBs in partnership with agriculture department;</p> <p>The capacity building component could be taken up by lead NGOs with funding under CSR funds, National Adaptation Fund, bilateral agencies and Foundations.</p>
7. Participatory watershed management	<p>Prior to participatory watershed management, the focus was using land and water resource for enhancing food production;</p> <p>The focus was more on enhancing supplies from groundwater pumping and constructing large-scale centralized irrigation structures</p>	<p>This initiative demonstrated potential of decentralized local action (at village scale) of land and water management;</p> <p>Communities were involved in planning and construction of many small-scale water harvesting activities;</p> <p>It resulted in sustaining agriculture production even during rainfall deficient years.</p>	<p>This experiment was taken up by ICAR and scaled-up at national level</p> <p>Even Maharashtra government designed a scheme on Adarsh Gaon Yojna to replicate the experiment in the state with dedicated finances.</p>
8. Diversification of livelihood to non-farm sector	<p>Increasing water scarcity, groundwater degradation and recurrent drought-like conditions in north-east Rajasthan made agriculture unsustainable for small and marginal farmers severely impacting their livelihoods;</p> <p>To augment livelihoods these small farmers opted for selling milk through private middlemen to Rajasthan Dairy Cooperative who paid lower than market rate and charged high interest on credit they provided to farmers.</p> <p>Resulting in increase indebtedness and poverty</p>	<p>The initiative promoted Self-Help Groups (SHGs) of small and marginal farmers households to promote the culture of saving and providing credit to its members;</p> <p>It strengthened backward and forward linkages to strengthening dairy as an effective occupation by facilitating selling of milk to organized marketing institutions like Mother Dairy in Delhi;</p> <p>The SHGs marketed directly to Mother Dairy in Delhi eliminating middlemen that fetched better price;</p> <p>The initiative helped these farmers come out of debt trap;</p>	<p>Such initiative can be led in water-scarce/ drought prone areas by established NGOs with technical support of National Dairy Development Board;</p> <p>It will need community mobilization and capacity building which can be undertaken by the lead NGOs</p> <p>Rural Banks can provide the needed credit to Community Groups for starting the venture;</p>

Best Practice	Business-as-usual Infrastructure/ ecosystems and change agents	Additionality/ changes observed in best practice for building resilience	Ideas for action; potential policies/ plans/ schemes for mainstreaming
9. Ecosystem based adaptation for mainstreaming biodiversity in watershed management	<p>The area is recurrently hit by droughts which made agriculture highly unsustainable especially for large number of small farmers;</p> <p>High natural resources degradation—soil and groundwater;</p> <p>Fodder scarcity was high with households rearing conventional breed cattle;</p> <p>All the above factors further deteriorated the livelihoods of many small farmers</p>	<p>The initiative promoted small structures like check dams and landscape level interventions such as trenches and gully plugs that harvested rainwater even in deficient rainfall years;</p> <p>It promoted and developed capacities of women SHG groups;</p> <p>The initiative enhanced natural resource base in the area—water, soil productivity and fodder;</p> <p>Overall the initiative addressed the challenges posed by droughts</p>	<p>Such initiative can be led by NGOs/ Rural Development Department;</p> <p>It can be supported by developing partnership with technical agencies/ cadre of technical experts on water harvesting and watershed development;</p> <p>It is being and can be further financed under watershed development programme of government.</p>
10. System for Rice Intensification	<p>Paddy was being grown using conventional agronomic practice, nutrient management through chemical fertilisers and flood irrigation in moderate rainfall area;</p> <p>Climate change is likely to magnify inter-annual variability and extremes that could likely create drought / rainfall-deficit like conditions having potential to adversely impact yield of paddy</p>	<p>The initiative included applying improved agronomic practice, irrigation water efficient technologies—sprinkler</p> <p>The resulting paddy crop has higher climate-resilience due to larger and deeper root growth;</p> <p>It increased rice production substantially.</p>	<p>The core underlying principles of the initiative can be applied to other crops too;</p> <p>Such initiatives can be led by ICAR in partnership with established NGOs;</p> <p>It can be supported by pilot demonstration and scaling up through IEC activities.</p> <p>It can be financed through programmes of ICAR and funds under RKVY scheme.</p>
11. Joint Forest Management, Buldhana experience, Maharashtra	<p>Common property resources like grasslands and forests continue to being illegally and unsustainably used by rural villagers and nomadic people in rural areas. The result is degraded grasslands and depleted forest resources leading to hardships for the very same people. If not managed judiciously, the fuel and fodder scarcity gets further aggravated due to the impacts climate change like increased temperatures and variable rainfall.</p>	<p>The Joint Forest Management (JFM) initiative as part of the National Forest policy puts the users in control of the resources and their sustainability. The Forest Department and community together make plans and work towards protection of the natural resources. Community participation is ensured by formation of Forest Protection Committee whose responsibilities included - protection of forests, regulated use of forest products, maintenance duties, equitable sharing of benefits to the entire community, and protection against fire</p>	<p>Protection and sustainable use of forest resources using community initiatives has been tried and tested and has been a successful initiative of the Forest Department in many States. There is a need to further strengthen such initiatives with the help of local NGOs and other community organizations. There are a number of initiatives/ programmes both by Central and State Govts. that can be utilized for bringing in more resources and better coordination – like the Special Package for Drought Mitigation Strategies, National Watershed Development Project, National livelihood Mission, etc. to bring about greater change in this direction.</p>

Best Practice	Business-as-usual Infrastructure/ ecosystems and change agents	Additionality/ changes observed in best practice for building resilience	Ideas for action; potential policies/ plans/ schemes for mainstreaming
12. Tapping indigenous knowledge for conserving bio-diversity, Monpa Tribe, Arunachal Pradesh	In pursuit of the need for higher productivity and profit margins, many farmers and farming communities are leaving the traditional wisdom and practices and embracing the more advanced and modern ways of agriculture that involves hybrid varieties and chemical fertilisers. This unfortunately also increases the chances of insects and pest attack and hence there is need for insecticides as well.	The traditional farming practices used by Monpa tribe in Arunachal Pradesh demonstrate that these methods are sustainable and provide good results. In many more areas, organic farming is being promoted/practiced and such traditional methods of farming would produce excellent returns for the farmers – especially the small farmers. Moreover, preserving this genetic germ pool is an integral part of food security. If we are unable to combat the problems of genetic erosion, it may lead to losing sources of resistance to pests, diseases and climatic stress and, finally, leading to crop failure in future.	A comprehensive study needs to be undertaken for the State of Maharashtra to document such traditional practices. These would need support from the State in terms of resources and that can be sourced from programmes such as the National Mission for Sustainable Agriculture (or its counterpart in the State), National livelihood mission, and from the programmes implemented under the National Biodiversity Action Plan of the MoEFCC.
13. Diversion based traditional irrigation system to mitigate risk of crop failure in drought prone area.	<p>The formal centralized irrigation system in this area is absent;</p> <p>If it existed, generally speaking access rights would have depended on size of land-holding;</p> <p>The systems are poorly maintained;</p> <p>Agriculture development—crop type and area, is not linked with water availability resulting in inequity with farmers at head of canal receiving much more water that tail end users.</p>	<p>The traditional system harvests post-monsoon flows of local streams and involves construction of such decentralized systems using locally available materials;</p> <p>The design reduces risks from extended dry spells of rainfall;</p> <p>Agriculture development—crop type and area, is linked to quantum of irrigation water harvesting</p> <p>The system is maintained by community groups ensuring sustainability;</p> <p>Access rights are uniform across members of the group;</p>	<p>Such initiatives need to be led by community groups in Public-Private/ community mode;</p> <p>Proliferation of such models can be incentivised by relevant departments assigning higher priority in planning such schemes;</p> <p>It will need building capacities of the departments and community for joint-planning which can be undertaken by NGOs established in the sector;</p> <p>Such programmes can be financed through schemes such as Rashtriya Krishi Vikas Yojna and watershed development</p>
14. Collective management of groundwater and surface water	<p>Development of surface and groundwater resources are not linked;</p> <p>Respective departments manage the resources;</p> <p>Right to access groundwater below your land is assumed as granted with generally no control over extraction</p>	<p>Community and decentralized models of management of surface and groundwater in an integrated manner;</p> <p>Crop type and area is linked to groundwater resource available;</p> <p>The model-design is geared to meet the irrigation needs in areas of low rainfall;</p> <p>There is equity in access to groundwater. Even landless have allocation of groundwater and quantity of access is independent of size of landholding;</p> <p>Involves community groups, irrigation department, and groundwater experts for joint-planning and development</p>	<p>Such models can be led by relevant departments by engaging groundwater experts and community groups;</p> <p>It can be incentivized by providing subsidy on micro-irrigation technologies on priority to areas where such groups show interest;</p> <p>There is need for creating outcome-based rewards/ incentive structures for community groups showing interests in such initiatives;</p> <p>Such models can be mainstreamed through RKVY scheme;</p> <p>The capacity building component can be financed under State Training Policy;</p>

Best Practice	Business-as-usual Infrastructure/ ecosystems and change agents	Additionality/ changes observed in best practice for building resilience	Ideas for action; potential policies/ plans/ schemes for mainstreaming
<p>15. Provision for drinking water: Conjunctive use of water</p>	<p>Formal urban water supply generally is centralized and relies on distant surface sources that incurs huge costs and energy for transporting water and hence unsustainable especially for urban areas situated in arid areas; It is developed and managed by concerned department, generally without involving the 3rd tier of Panchayati Raj system—the ward level committees;</p> <p>Same good water quality is supplied to both high end and low uses increasing the cost of delivery;</p> <p>Water supply is seen to be contaminated due to poor sanitation and leaky sewer systems posing health challenges;</p> <p>Water supply infrastructure in poorer and slum settlements are generally inadequate or absent;</p> <p>The water supply is generally unreliable;</p>	<p>The decentralized community-based models are suited to local context—geo-hydrological conditions and groundwater quality; The models are developed jointly by water experts, ward level committees, with needed support from Urban Local Body for provisioning land and regulatory support;</p> <p>The design involves low-cost technology development for safe water supply for high end uses—drinking etc., while lower quality water is provided for other domestic uses;</p> <p>The supply is highly reliable and of needed quality producing health co-benefits;</p> <p>The models are sustainably operated and managed by the community groups/ ward committees;</p>	<p>The concerned ULB can lead in partnership with Ward level committees with appropriate capacity building support;</p> <p>Capacity building can be undertaken by established NGOs/ agencies which state government can empanel;</p> <p>Can be incentivized through state government prioritizing ULBs for water supply grants which show interest in taking up such scheme;</p> <p>It can be financed by providing CAPEX cost through UIDSSMT/ AMRUT schemes while OPEX costs can be borne by community groups;</p> <p>Finances can also come from CSR funds of Industries/ Companies who depend on labour from such community groups</p>
<p>16. End to end early warning system to address floods/ cyclones</p>	<p>Conventional early warning systems are designed to provide information on climate extremes but seldom the extreme weather information is translated into possible risks spatially;</p> <p>Generally the communication is through limited medium hence does not reach the most vulnerable;</p> <p>The early warning information is not used effectively for planning preparedness;</p> <p>Non-government actors are seldom involved in dissemination of warnings</p>	<p>In this best practice the District Disaster Management Authority (DDMA) had already mapped the low-lying areas and vulnerable pockets and so were able to identify the areas which are high risk of inundation and vulnerability;</p> <p>The practice required scientific community like IMD to come together with DDMA and NGOs to generate and disseminate meaningful warning information;</p> <p>The warning was communicated through multiple-modes, TV, radio, sms, newspapers and most importantly through engaging with NGOs who visited the vulnerable pockets and disseminated the information in a lucid way to communities;</p> <p>The preparedness material was stocked considering the possible areas under risks.</p>	<p>Respective DDMA's can co-lead with IITM/ IMD;</p> <p>The practice can be supported by SDMA's who can also incentivize adoption by DDMA's;</p> <p>The capacities of DDMA's can be developed through training by concerned State Training Institute;</p> <p>It can be financed through various climate programmes of Department of Science and Technology and State Disaster Response Fund</p>

Best Practice	Business-as-usual Infrastructure/ ecosystems and change agents	Additionality/ changes observed in best practice for building resilience	Ideas for action; potential policies/ plans/ schemes for mainstreaming
17. Tapping indigenous knowledge of early warning	<p>Conventionally indigenous knowledge is not integrated in formal system for early warning</p> <p>Formal early warning system in several cases do not reach the community in time nor in an actionable format;</p> <p>Indigenous knowledge has proved useful in past but the socio-economic and hydrologic contexts are changing reducing the usefulness of such knowledge.</p>	<p>The study documents usefulness of indigenous knowledge in past where the communities did not have access to formal early warning system;</p> <p>It presents how it is becoming obsolete given the changing socio-economic contexts and hydrological parameters due to changing climate.</p>	<p>Formal agencies such as Centre Water Commission (CWC, IMD, Agriculture Ministry) can take lead in integrating indigenous knowledge in formal system;</p> <p>The uptake and updation of such knowledge can be done through joint studies by lead agencies in collaboration with NGOs and communities;</p> <p>Such initiatives can be financed through budgets of the lead agencies;</p>
18. Weather forecasting for climate smart agriculture	<p>Government of India has established system of issuing weather-forecast but its spatial resolution in several cases does not match the finer resolution needed; Hence, they do not have the needed accuracy required to trigger action;</p> <p>In addition, the agriculture extension system providing agro-advisories generally are not effective because they are not timely, consequently farmers suffer huge crop losses due to extreme weather events;</p>	<p>The weather forecasts are generated using the data from network of weather stations, IMD data and numerical modelling lending the accuracy at needed spatial resolution;</p> <p>The forecasts are followed up with tailor-made agro-advisories to farmers generated in partnership with local agriculture university and are disseminated through ICT system and strengthened agriculture extension system.</p>	<p>The initiative can be led by established NGOs/ Universities having skills in numerical weather modelling;</p> <p>It can be supported by promoting a network of lead NGOs, agriculture university, agriculture department and ICT specialists/ agencies;</p> <p>Such initiative can be financed from RKVY, budget of Department of Science and Technology and National Adaptation Fund.</p>

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Dilip Singh has over two decades of experience in the development sector and has been working on climate change adaptation, resilience building and mainstreaming CCA-DRR in development planning for more than a decade. His experience covers the functional areas of decentralized participatory planning, project management, institutional development, monitoring and evaluation, qualitative and quantitative analysis, socio-economic impact assessment, and capacity building. Dilip is an Agricultural Engineer and has a PG Diploma in Rural Management from Institute of Rural Management, Anand (IRMA), Gujarat.



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