Introduction

Globally, 2014 is on its way to being declared the hottest year ever. Average temperatures over land and ocean surfaces for January-October 2014 were the highest on record. October was the hottest month since record keeping began in 1880, with the average surface temperature 0.74°C above the 20th century average of 14.1°C.

Closer home, in India, the annual mean temperature for the country as a whole during 2013 was 0.35°C above the average (with 1961-90 as the base period), making 2013 the 13th-warmest year on record since 1901. Eight out of the 10 warmest years in India were during the recent past decade (2001-10), making it the warmest decade on record with a decadal mean temperature anomaly of 0.49°C.

The temperature increases we are witnessing in India are not on account of natural causes. The Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) has now established the unequivocal influence of humans on the climate system. It is scientifically proven that the temperature increase is largely because of anthropogenic emissions of greenhouse gases (GHGs) and as the world continues to spew GHGs into the atmosphere, temperatures will increase further.

According to AR5, the globally averaged combined land and ocean surface temperature shows a warming of 0.85°C in 1880-2012. It is now more or less certain that the temperature will further increase by 0.3°C-0.7°C over 2016-35 relative to 1986-2005. So the world is now destined for a temperature increase of at least 1.2-1.5°C by the mid-2030s.

What has been the impact of a temperature increase of 0.85°C? What will happen when the temperature increases by 1.5°C and more? How have communities, especially the poor and vulnerable, adapted and will adapt to these changes and impacts?

Impacts: Global

There is clear evidence that in recent decades, changes in climate have caused impacts on natural and human systems across the world.

In many regions, changes in rainfall patterns and melting snow and ice have altered the hydrological systems, affecting water resources in terms of quantity and quality. The change in the hydrological cycle coupled with changes in climatic conditions, like temperature, has led to negative impacts on crop yields in many parts of the world.

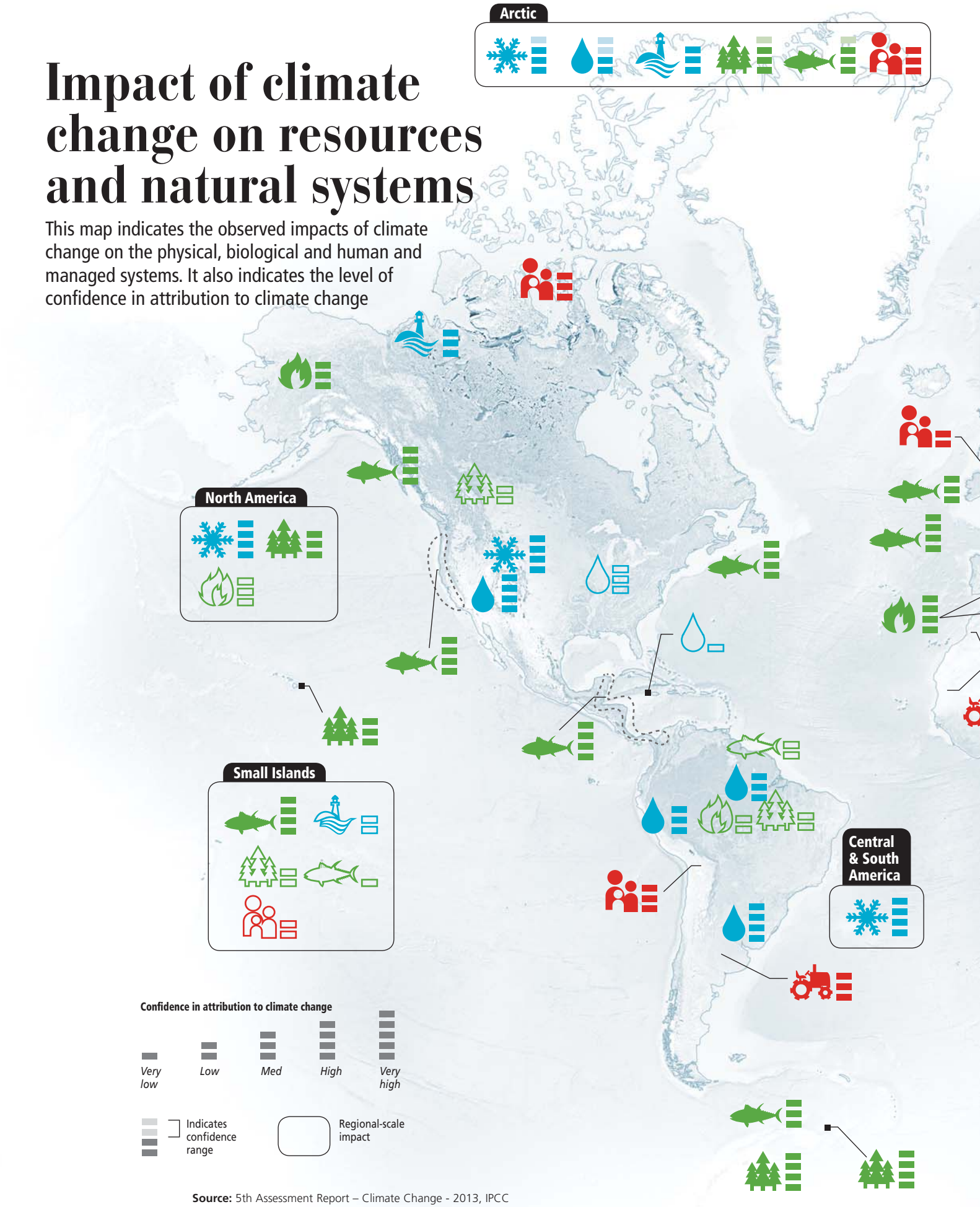
Weather extremes have increased across the globe. There is a clear evidence of a decrease in the number of cold days and nights and increase in the number of warm days and nights. The frequency of heatwaves has increased in large parts of the world, leading to increased heat-related human mortality. Extreme precipitation is increasing, leading to floods and droughts. Impacts from recent climate-related extremes, such as heatwaves, droughts, floods, cyclones and wildfires, reveal significant vulnerability and exposure of some ecosystems and many human systems to current climate variability[1] (see Map: *Impact of climate change on resources and natural systems*).

For the poor and impoverished, who depend on natural resources for their lives and livelihoods, these changes have meant additional burdens and challenges. The very survival of the many living in extremely vulnerable areas and on the margins of society is threatened by these changes.

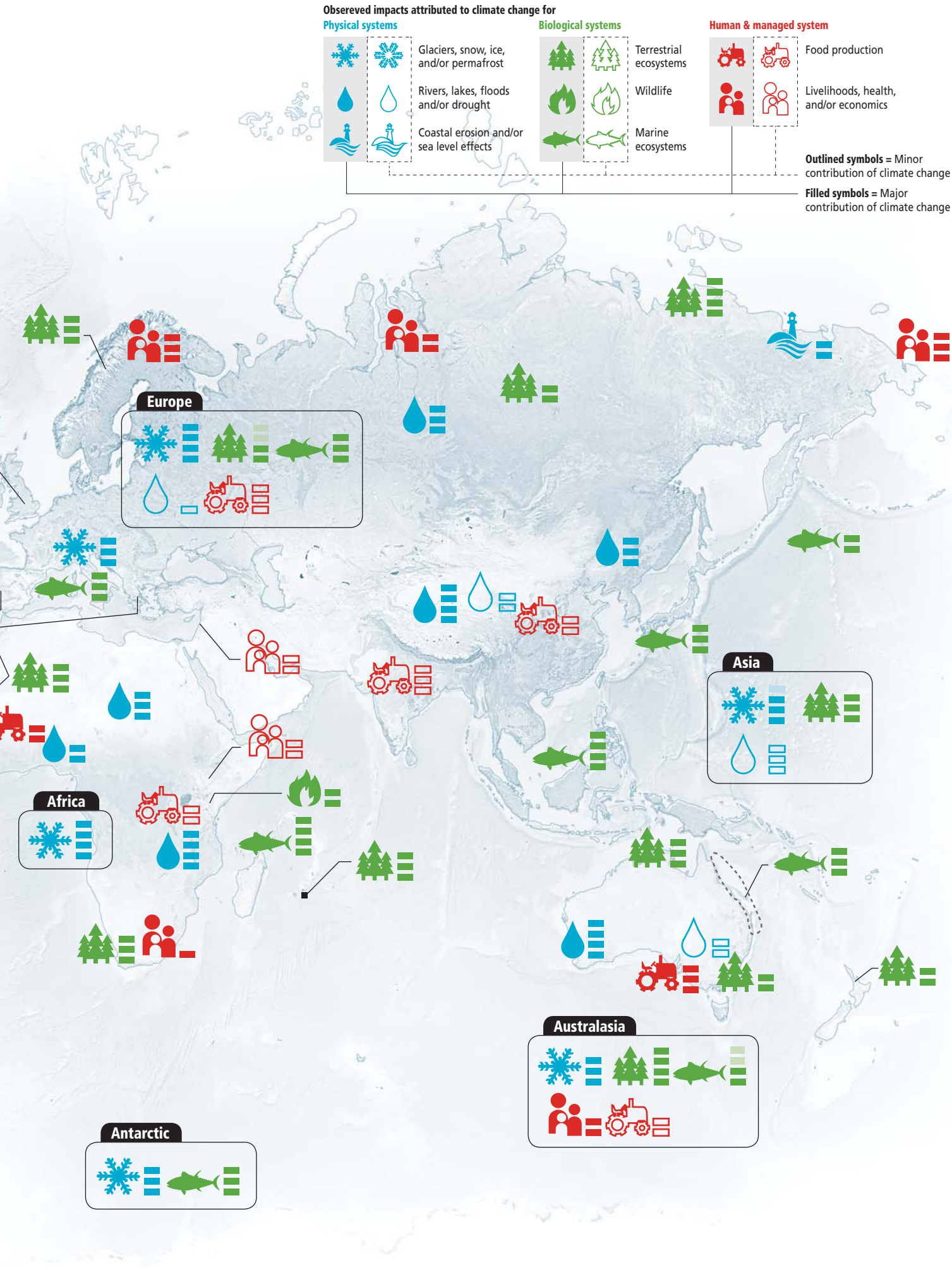
But this is just the beginning of things to come. As the surface temperature rises over the 21st

Impact of climate change on resources and natural systems

This map indicates the observed impacts of climate change on the physical, biological and human and managed systems. It also indicates the level of confidence in attribution to climate change



Source: 5th Assessment Report – Climate Change - 2013, IPCC


Obsereved impacts attributed to climate change for
Physical systems
Glaciers, snow, ice, and/or permafrost
Rivers, lakes, floods and/or drought
Coastal erosion and/or sea level effects
Biological systems
Terrestrial ecosystems
Wildlife
Marine ecosystems
Human & managed system
Food production
Livelihoods, health, and/or economics
Outlined symbols = Minor contribution of climate change
Filled symbols = Major contribution of climate change
Europe
Asia
Africa
Australasia
Antarctic

century, climate variability and its impacts will intensify. The sea level rise projected throughout the 21st century and beyond will have adverse impacts, such as submergence, coastal flooding and coastal erosion, on coastal systems and low-lying areas. Climate change is projected to reduce freshwater resources – surface as well as groundwater – significantly in most dry subtropical regions, intensifying competition for water among sectors and regions. As temperatures rise further, major crops (wheat, rice and maize) in tropical and temperate regions will witness a decline in productivity. There will also be shifts in production areas of food and non-food crops across the world. All aspects of food security, including food access, utilisation, agricultural incomes and price stability, will be potentially affected by climate change.

The projected climate change by the mid-21st century and beyond will cause a distribution of global marine species and reduction in marine biodiversity in sensitive regions which will challenge the sustained provision of fisheries productivity and other ecosystem services (*high confidence, as the AR5 puts it*).

Climate change is expected to lead to increase in ill health in many regions, especially developing countries with low incomes.

Impacts: India

India is home to 33 per cent of the world's poor. The poor in India are concentrated largely in areas that have a low Human Development Index (HDI) and high development deficit. They are mostly dependent on agriculture, forest produce, fisheries and animal husbandry. They comprise the most vulnerable sections of Indian society and their vulnerability will be exacerbated by climate change (see Box: *How vulnerable is India to climate change?*).

Agriculture and food security

The net impact of climate change on agriculture in India will be negative. According to a report by the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), Indian agriculture already deals with high levels of climate variability, which will worsen with climate change. Indian agriculture is heavily dependent on the monsoon system – over 60 per cent of the cultivated area in India is rain-fed – and rainfall is projected to become highly variable in the future.

According to India's latest National Communication to the United Nations Framework Convention on Climate Change (UNFCCC), by the end of the 21st century, rainfall in India will increase by 10-12 per cent and mean annual temperature will increase by 3-5°C, with the maximum increase over northern India. Overall, temperature increases are likely to be much higher in winter (rabi) than in the rainy season (kharif). Precipitation is likely to increase in every time slice in every month except December-February, when it is likely to decrease. Eastern India will receive more rain, while the southern plateau and Rajasthan are projected to receive less.

The food and nutritional security of India currently depends to a great extent on the production of wheat and rice, which constitute about 75-80 per cent of the total foodgrain production. The National Mission on Sustainable Agriculture, set up as part of the National Action Plan on Climate Change (NAPCC), estimates that a 2°C rise in temperature will result in a 15-17 per cent decrease in rice and wheat yields for India. Wheat, a winter crop, will face higher winter temperatures and will be worse affected than rice.

High temperatures and drought conditions will also affect the quality (grain number and weight) of wheat. These estimates, however, do not take into account losses due to other climate-related factors such as water availability, pests and extreme events. For instance, a case study in the Brahmani-Baitarani estuary region in the state of Odisha shows that increased tidal storm surges and intensified cyclonic wind due to climate change will cause vulnerability in agriculture in the area. Fertile agricultural land will be inundated by saline water, hindering crop production for several years. Erosion of agricultural land will have an overall negative impact on crop yield.

Some of these changes are already taking place, with consequences for agricultural productivity. According to the Central Research Institute for Dryland Agriculture (CRIDA) in

How vulnerable is India to climate change?

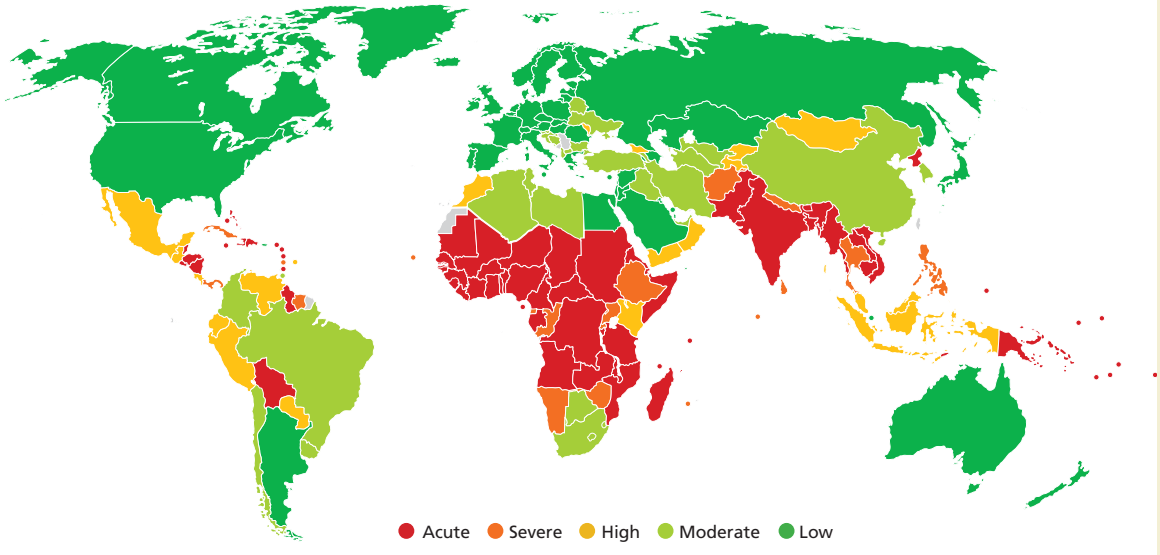
The impact of climate change on a community depends on the vulnerability of the community, defined as the lack of capacity of a community to cope and adapt. At the most basic level, the vulnerability of a country can be broadly judged by its Human Development Index (HDI). HDI measures the status of basic development indicators, like health, education and income of the population of a country. The lower the HDI, the lower is the capacity of a country to adapt to changing climate. In 2014, India ranked a low 135 among 187 countries on HDI. This is largely because India has more poor people than all the Least Developed Countries (LDCs) put together. As poor people have low adaptive capacities, a large proportion of India's population is highly vulnerable to climate change.

In the last few years, many organisations have come out with comparative vulnerability of countries. One of the most widely used, developed by UK-based global risks advisory firm Maplecroft, is the Climate Change Vulnerability Index (CCVI). Maplecroft uses 42 social, economic and environmental indicators to arrive at the CCVI of countries. In its 2014 report, India was ranked as the 13th most vulnerable country to climate change out of 194 countries of the world. The report identifies 32 'extreme risk' countries, which include India along with countries like Bangladesh (most vulnerable), Cambodia, Myanmar and Pakistan (24). "Almost the whole of India has a high or extreme degree of sensitivity to climate change, due to acute population pressure and a consequential strain on natural resources. This is compounded by a high degree of poverty, poor general health and the agricultural dependency of much of the populace," says the report.

A similar picture emerges in the Climate Vulnerability Monitor Report, *A Guide to the Cold Calculus of a Hot Planet, 2nd Edition,* released by DARA International. The report mentions that the United States, China and India in particular are expected to incur enormous losses due to climate change. The economic costs for these three countries alone in 2030 due to the rise in temperature is estimated to be US $2.5 trillion. The report also states that of the over three million deaths per year – or half of all mortality – the majority are most likely to be in India and China.

The multi-dimensional vulnerability map on climate below categorises the range of climate vulnerability for India as 'severe' for 2010 and 'acute' for 2030, with climate-induced loss estimated at up to US $90,000 million PPP (purchasing power parity) for 2010 and US $700,000 million PPP for 2030. Climate-related mortality was 200,000 people for 2010 and 350,000 people for 2030.

Multi-dimensional vulnerability – climate



Source: Climate Vulnerability Monitor*: A Guide to the Cold Calculus of a Hot Planet,* 2nd Edition, Climate Vulnerable Forum, DARA

Hotspot of food insecurity

Climate change could combine with existing food insecurity parameters to make India a hotspot for food insecurity. The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) mapped hotspots for food insecurity due to climate change in the global tropics by overlaying climate change impacts on food production on existing food insecurity parameters, including food availability, access and utilisation. South Asia, and India in particular, emerged as a global hotspot of food security.

For India, the following impacts of climate change were considered:

- The length of the growing period will decline by 5 per cent or more in the Indo-Gangetic Plain.
- The length of the growing period will go down to less than 120 days in India, crossing the critical threshold for a number of crops as well as rangeland vegetation.
- Reliable crop-growing days will decrease to critical levels, below which cropping might become too risky to pursue as a major livelihood strategy in the Indo-Gangetic Plain and south India.
- High temperature stress (above 30°C) will be widespread in north and south India.
- Tropical countries such as India already experience high variability of rainfall, above the median of 21 per cent for cropped areas. Any increase in this variability will make agriculture riskier.
- Drought-prone areas will be at an even higher risk of drought. In addition, new areas, such as central India, may also become more drought-prone.
- An increase in rainfall intensity in the Indo-Gangetic Plain could make the area prone to increased erosion and run-off. Some of these areas (such as eastern India) are currently flood-prone. Food availability indicators considered include current crop yields and the per capita net food production index number. Access indicators include current GDP per capita and poverty levels. Utilisation indicators include the prevalence of malnutrition and the population using unimproved water sources. The key factors of concern that emerge for India are the high levels of poverty and a low performance for the utilisation indicators (malnutrition and water sources), along with stagnating net food production.

Hyderabad, preliminary evidence indicates that the decrease in rice yields in the Indo-Gangetic plains in the recent past is associated with a slight rise in minimum temperatures. Wheat yields in India have reduced by four-six million tonne in recent years because of increased heat in February-March. Rising temperatures in Himachal Pradesh have resulted in decreased apple productivity and the apple belt is gradually shifting to higher elevations.

These changes, according to India's National Communication, will add to the existing stresses of yield stagnation, land use, competition for land, water and other resources. It is estimated that by 2020 the demand for foodgrains in India will increase by 30-50 per cent. This will have to be produced from the same, or even shrinking, land resources resulting from increasing competition for land and other resources by non-agricultural sectors.[2]

Animal husbandry, fisheries and allied activities will also be affected by rising temperatures. India is the largest producer of milk, third largest producer of fish and second largest producer of freshwater fish in the world.

Dairy and fish products are important sources of protein in the country. Both will be affected by climate impacts. Increased heat stress will cause distress to dairy animals. It is estimated that India already loses 1.8 million tonne of milk production due to climatic stresses in different parts of the country. By 2020, global warming will further negatively impact milk production by 1.6 million tonne. Rising sea-surface temperatures will also affect coastal fisheries.[3]

Reduced agricultural productivity due to climate change will have implications for the food security of the poor. According to a recent report by the World Bank, total crop production and per-capita calorie availability is projected to decrease significantly with climate change in South Asia.

Without climate change, total crop production is projected to increase significantly by 60 per cent in the region. With 2°C warming, by the 2050s, more than twice the imports might be required to meet per-capita calorie demand when compared to a case without climate change. Decreasing food availability is related to significant health problems for affected populations, including

childhood stunting, which is projected to increase by 35 per cent, compared to a scenario without climate change, by 2050, with likely long-term consequences for populations in the region.[4]

Another study by CCAFS highlights India as a hotspot of food insecurity when climate impacts combine with other parameters, including availability, access and utilisation (see Box: *Hotspot of food insecurity*).

Extreme weather events on the rise

Every year, India faces extreme weather events in the form of heatwaves, cold spells, extreme rainfall, floods, droughts and cyclones, which take lives, destroy homes, crops and property. It is when such events show a departure from the normal trend that the question of whether climate change is influencing the change arises. At the same time, while climate change is generally expected to exacerbate the intensity of occurrence of such events, it remains challenging to tease out the footprint of climate change on a single event or even a series of events. Nevertheless, a quick analysis of the past two years shows that different parts of India are now being battered by extreme weather events that have started to hurt.

Cyclones

In the last two years, India has been hit by high-intensity cyclones. The year 2013 saw an unusual amount of cyclonic activity, with four cyclones hitting the east coast. The first cyclone that crossed the Indian subcontinent in 2013 was cyclone Mahasen, which, although it did not physically cross the coast of Andhra Pradesh, caused isolated, but heavy rains.[5]

The next was Cyclone Phailin, which was recorded as the most intense cyclone to hit India. It led to one of the largest evacuations in the history of the country, pushing the government to relocate 700,000 people from coastal areas.[6] Registered as a severe super cyclonic storm, it recorded a maximum wind speed of 215 km/hour, with a maximum storm surge of 2-2.5 m.[7] It was also reported that inland inundation of seawater from the coast was up to approximately 1 km.[8]

Though improved levels of disaster preparedness and management meant preventing the loss of many lives, the cyclone still caused massive structural damage. Over 18,000 villages in Odisha and 294 villages in Andhra Pradesh were affected. The Odisha government estimated that losses caused by Phailin and subsequent floods amounted to Rs 21,770 crore. This was more than the state's annual plan outlay of Rs 21,467 crore for 2013.

Andhra Pradesh too bore the brunt of Phailin, but felt the impacts of two other cyclones – Helen and Lehar – in late November. Helen brought with it isolated heavy rainfall in some places while most of coastal Andhra experienced moderate rainfall. Wind speeds reached up to 120 km/hr with a storm surge of 1-1.5 m.[9] Twenty thousand people were evacuated, there were isolated incidents of death and 8,700 ha of crop were damaged.[10] While Helen caused an estimated loss of Rs 1,628.66 crore,[11] Lehar, with moderate wind speeds of 50-60 km/hr,[12] brought rainfall, necessitating the evacuation of 43,814 people.[13]

The trend continued in 2014 with cyclonic storms devastating villages near Shillong and Agartala in northeastern India[14] and Visakhapatnam on the southeastern coast. Cyclone Hudhud, which struck Visakhapatnam in October 2014, is estimated to have been one of the most economically damaging cyclones to hit India. Recent estimates put losses at up to Rs 70,000 crore (as reported in various newspapers).

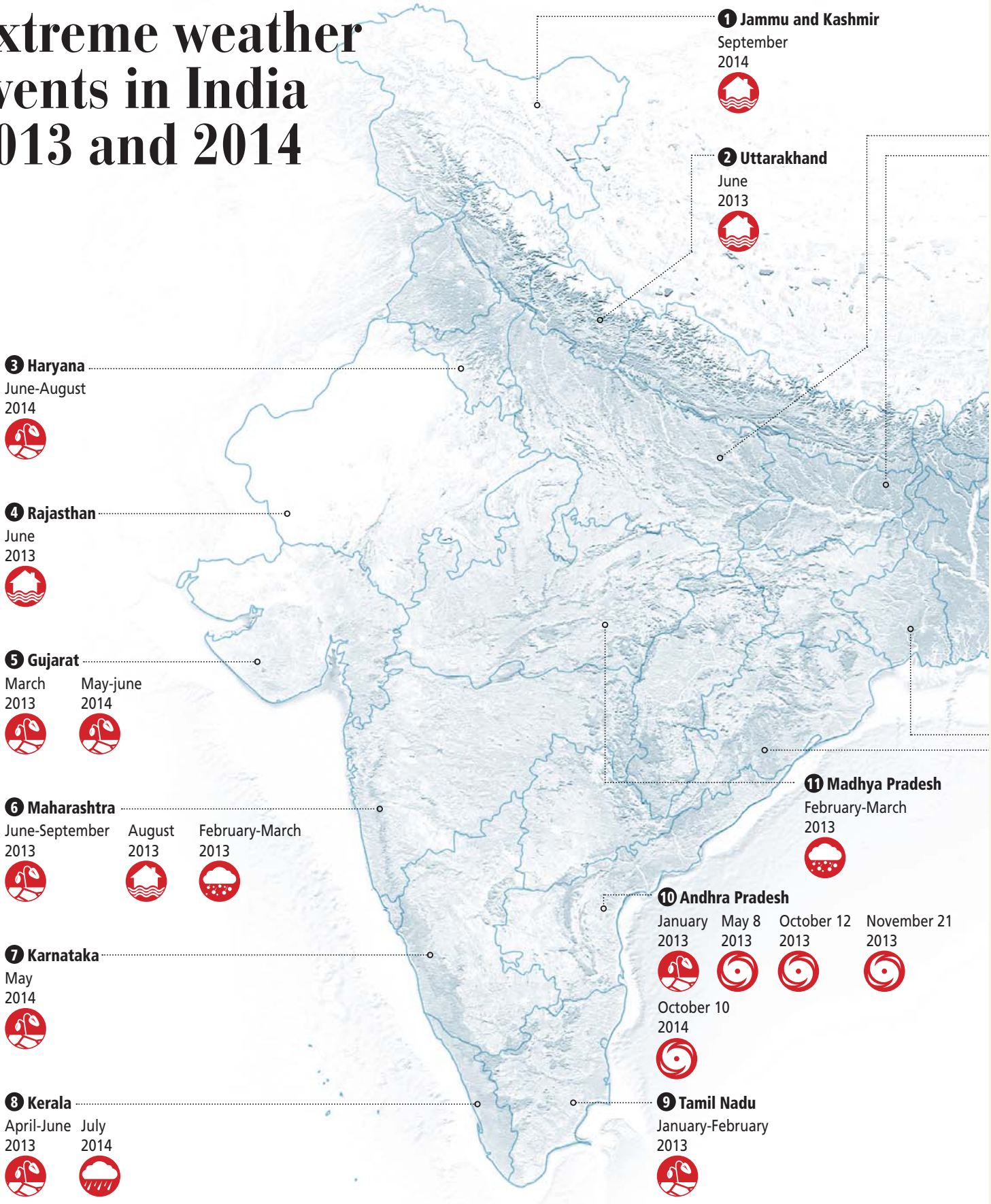
Scientists in India are now concerned about the severity of cyclones hitting the country. They are also predicting an increase in intensity of cyclones.[15]

Extreme rainfall and floods

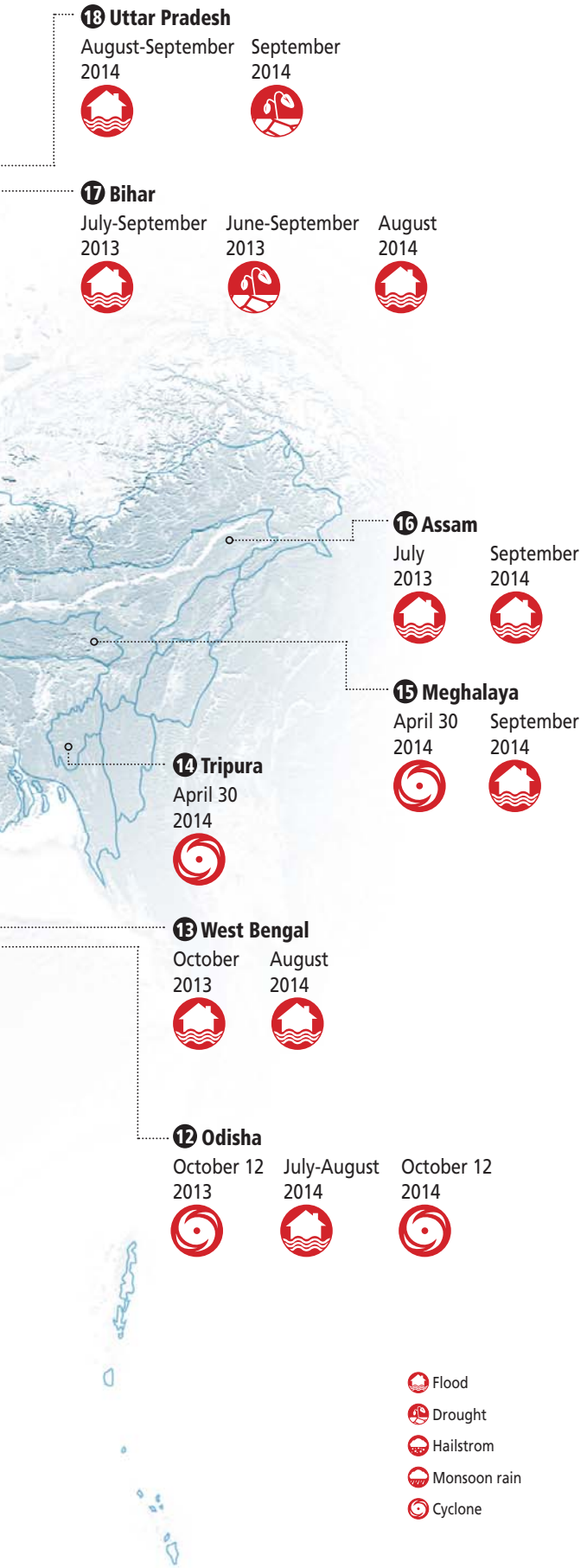
Different parts of India face floods and droughts regularly and they are part of the natural climatic landscape of the country. Recent hydro-meteorological events, however, seem to be a departure from the normal.

There is clear evidence that in the past five decades heavy rainfall events (> 100 mm/day) and very heavy events (>150 mm/day) have been increasing and moderate events (5-100 mm/day) have been decreasing.[16] This trend was experienced with devastating impacts in 2013 and 2014 during which extreme rainfall events devastated Uttarakhand, Jammu and Kashmir and

Extreme weather events in India 2013 and 2014



Source: The information in this map has been collated from various sources



Impacts of the extreme weather events

1 Jammu and Kashmir: 260 lives were lost and close to 5 million people affected, 4.5 million in the Kashmir Valley and half a million in Jammu. Immediate loss of Rs 5,400-5,700 crore

2 Uttarakhand: Over 5,000 died, 110,000 affected, economic loss of Rs 7,346 crore

3 Haryana: 18 out of 21 districts in Haryana affected by drought

4 Rajasthan: Flash floods in west Rajasthan. 300 people evacuated and 70 houses washed away

5 Gujarat: March 2013: 4,000 villages, 17 districts, mostly in Saurashastra affected. 10-15 per cent cash crops failed

May-June 2014: 106 villages in the Kutch area affected by drought

6 Maharashtra: June-September 2013: 12,000 villages; 8,500,000 ha agricultural land affected. Loss worth Rs 2,400 crore

August 5, 2013: 20 people died and around 3,000 people in Chandrapur district displaced. More than 15,000 houses damaged in six districts of east Vidarbha. Around 11.82 lakh ha farmland damaged.

February-March 2013: 20 lakh ha farmland across 28 districts of the state hit by heavy hailstorm

7 Karnataka: 28 districts drought-affected

8 Kerala: April-June 2013: For the first time, drought was declared in each of Kerala's 14 districts.

July 2014: 29 lives lost on account of the incessant rainfall in Kerala. 366 people were evacuated, crop loss worth Rs 11.2 crore

9 Tamil Nadu: 31 of 32 districts drought-affected

10 Andhra Pradesh: January 2013: 234 mandals affected

May 8, 2013: Cyclone Mahasen affected 30,000, eight lives lost.

October 12, 2013 – Cyclone Phailin: 6,192 ha of land damaged

November 21, 2013 – Cyclone Helen: 10 people and 19 livestock died, 70,303 people affected in 96 villages in the district, loss of Rs 1,628.66 crore

October 10, 2014: Death toll 46, initial estimated loss up to Rs 70,000 crore for Visakhapatnam, Srikakulam and neighbouring districts

11 Madhya Pradesh: At least 32 people and 294 livestock died. Around 244,615 ha land in 3,190 villages affected. Hailstorm damaged crops worth about Rs 893.93 crore

12 Odisha: October 12, 2013 – Cyclone Phailin: 58 lives lost, 90 lakh people affected, 18,441 villages affected 668,268 ha cropland damaged

July-August 2014: 81 lost lives, about 1.8 million people, half a million livestock affected

13 West Bengal: October 2013: Nine died in five districts of West Bengal and lakhs in 80 blocks affected. 71,000 houses fully or partially damaged

August 2014: 319,506 affected, estimated damage worth Rs 1913.66 lakh

14 Tripura: 30 April 2014: one person died and 1450 houses damaged and unspecified number of people displaced

15 Meghalaya: April 30, 2014: 70 houses were damaged in Meghalaya.

September 2014: 52 people died and property, including roads, houses, livestock and agriculture, worth about Rs 2,000 crore damaged

16 Assam: July 2013: 250,000 people, 400 villages in 11 districts, 7,000 ha agricultural land affected. 1 person died

September 2014: 44 people died and nearly 12 lakh people affected, economic loss worth Rs 2010 crore. Average loss of Rs 200 crore reported every year

17 Bihar: July-September 2013: 201 people and 299 livestock died; 1.6 million people displaced; 1,000,000 ha agriculture land affected

June-September 2013: 33 of 38 districts in Bihar affected

August 2014: 36 died, over 18 lakh affected, crops worth over Rs 56.44 crore damaged in 16 districts

18 Uttar Pradesh: August-September 2014: 106 people died, 1.4 million affected, 60,000 people in 9 districts bordering Nepal were displaced

September 2014: 53 out of 75 districts drought-affected.

many places in the northeast of the country.

The most damaging extreme rainfall event occurred in June 2013 in Uttarakhand. In a space of four days, June 13 to 17, the state received more than 375 per cent its normal rainfall, resulting in one of the worst flash floods in India.[17] An estimated 5,000 people lost their lives. Economic losses have not yet been accurately estimated.

A similar extreme rainfall event – 400 per cent the monthly average of rainfall fell in a few days – devastated Jammu and Kashmir in September 2014. Close to five million people were affected and 284 people lost their lives.[18] Similar extreme rainfall events also struck Assam and Meghalaya in 2014, leading to a major loss of lives and properties.

Parts of India also experienced "normal" floods, interspersed with extreme rainfall events, which destroyed millions of hectares of crops and affected millions of people. One of these is explained in the following paragraphs to illustrate how "normal" floods are becoming abnormal.

An incidence of "abnormal" weather extremities was the flood in the Vidarbha region of Maharashtra this year (2014). Reeling from the effects of severe drought in 2012-13, Vidharbha is known as a drought-ravaged district but the uncharacteristic intense episodes of rainfall this year led to flood in the region.

On June 14, the Manora and Mangrulpir tehsils of Washim district experienced 374 mm of rain in a span of three hours, which caused intense flash floods in this hilly area. By end of July, drought-prone districts like Buldhana, Akola, Washim, Amravati, and Yavatmal in western Vidarbha received anywhere between 1.5 to 2 times the average rainfall.[19] The floods caused extensive damage to agriculture and civic amenities. The rains damaged crops on an estimated 600,000-700,000 ha of agricultural land. The floods reportedly caused 237 deaths, out of which 112 in Vidarbha. Sources reported that some 3,800 houses were completely destroyed by the rain. The figures provided by the Regional Meteorological Centre (RMC) revealed that the Vidharbha region received as much as 98 per cent of its annual average rainfall by the end of July 2014.[20]

In the northeast, a cloudburst in Arunachal Pradesh washed away several roads, bridges and houses while causing damage to 80 per cent of the crops in the area. Malda in West Bengal was struck by floods in September in which 192 villages were submerged.[21]

Drought

Droughts, or drought-like situations, are recurrent phenomena in India. The failure or shifting pattern of monsoons have exacerbated the trend, leading to water shortages and severe droughts. The years 2013 and 2014 saw several droughts and drought-like situations in various parts of the country.

In 2013, Maharashtra was the worst-hit state in India, facing its worst drought in the past 50 years. Over 11,000 villages were affected.[22] In early January, following a drought in 2012, Andhra Pradesh declared 234 mandals drought-hit.[23] For the first time ever, Kerala declared a drought in each of its districts in May. The drought was further compounded by the increase in the number of bore wells, which severely decreased the level of groundwater.[24] Tamil Nadu was affected too – 31 of its 32 districts were declared to be suffering from drought. Gujarat also suffered drought – 4,000 villages and 17 districts were affected. Bihar received 25 per cent less rainfall than the annual average, affecting paddy cultivation.[25]

The scenario has changed little in 2014. In early May 2014, the Karnataka government in view of a severe drinking water crisis declared 28 of its 30 districts drought-hit.[26,27] With the average rainfall deficit pegged at 64 per cent, Haryana is set to face severe drought which would also have a major impact on its kharif crop production.[28]

Hailstorms

In a departure from normal weather conditions, unseasonal rain between February and March 2013 was accompanied by hailstorms which played havoc with the lives of millions of farmers in six Indian states – Punjab, Uttar Pradesh, Rajasthan, Madhya Pradesh, Maharashtra and Andhra Pradesh. The unprecedented event lasted 20 days and it came just as farmers were preparing to harvest crops. According to estimates, 4.65 million ha of standing crops were ravaged in the worst-hit Maharashtra and Madhya Pradesh alone. Within a month, more than a hundred farmers in the region reportedly committed suicide on account of debt-related worries.

Climate projections for India

The report of the Working Group II, AR5 of IPCC, made the following broad projections for India:

- An increase in both the mean and extreme precipitation in the Indian summer monsoon. There will be an increase in the number of monsoon-break days.
- Floods and droughts are likely to increase since there will be a decline in seasonal rainfall, coupled with increase in extreme precipitation during monsoon.
- Changes are projected in more than a third of the forest area by 2100, mostly from deciduous to evergreen forest in response to increasing rainfall, although fragmentation and other human pressures are expected to slow these changes.
- It is likely that tropical cyclone-related rainfall rates will increase with further warming. An increase in mean tropical cyclone maximum wind speed is likely, although increases may not occur in all tropical regions.
- In the Indo-Gangetic Plain, a changing climate has been projected to reduce monsoon sorghum grain yield by 2-14 per cent by 2020, with worsening yields by 2050 and 2080.
- There will also be alterations in rice yields as with rising temperatures the process of rice development accelerates and reduces the duration of growth. Large reductions in wheat production in the Indo-Gangetic Plain are also projected.
- On the east coast of India, clusters of districts with poor infrastructure and demographic development are also the regions of maximum vulnerability. Hence, extreme events are expected to be more catastrophic in nature for the people living in these districts.
- Temperature variations will also lead to outbreaks of disease and disturb the already poor health indicators of the country.

Heatwaves

In 2014, unbearable heatwaves in summer swept through parts of Rajasthan, Odisha and northeastern states of India, claiming hundreds of lives across country. Over 500 deaths were in Andhra Pradesh – 169 people reportedly died in Hyderabad alone – while 12 casualities were reported in Ahmedabad. In Delhi, as many as 73 deaths in just seven days, from June 1 to 7, due to the intense heat, were reported.

A study of extreme weather events in India over the past two years clearly establishes big abnormalities in the weather patterns, the impacts of which disrupt lives, societies and economies, and slow down economic growth and poverty reduction. Extremes are projected to become more frequent and extreme in the future (see Box: *Climate projections for India*).

Is India prepared for climate change?

In India, there are several programmes, activities and projects, such as crop insurance and weather advisory systems, that address existing climate variability in the agricultural sector. However, there is very little understanding on how to deal with impacts of climatic variability on sectors like forestry, fisheries, energy and urban infrastructure.

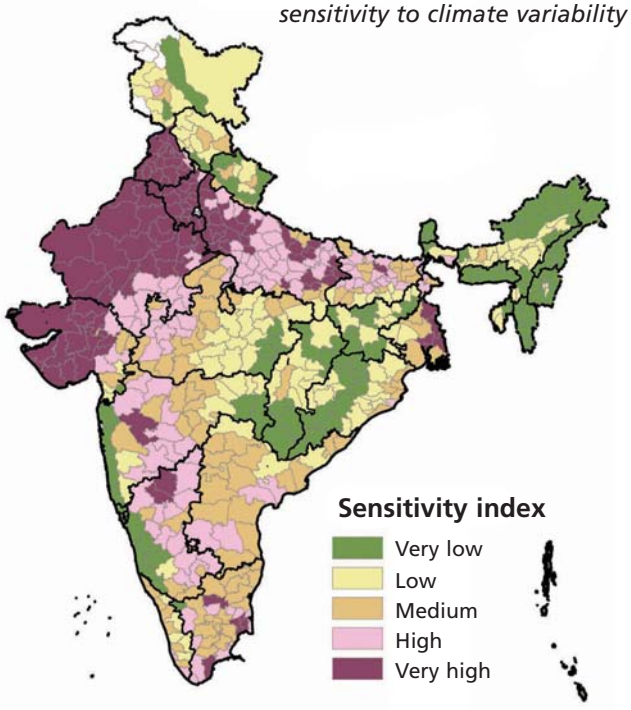
In recent years, India's cyclone prediction and preparedness has improved considerably, reducing loss of lives, but the same cannot be said about extreme rainfall events. Prediction of extreme rainfall and flood forecasting remains inadequate, resulting in major loss of lives in the last decade.

The Indian Council of Agricultural Research (ICAR) launched in February 2011 the National Initiative on Climate Resilient Agriculture (NICRA) as a "mega-pilot" in the 100 most climate-vulnerable districts in India, which experience climate extremes from drought to extreme rainfall. NICRA mapped all the districts of India on climate vulnerability. Central Research Institute of Dryland Agriculture (CRIDA) has implemented the initiative as well, focussing on elements like research, technology demonstration and capacity-building (see Map: *Districts' vulnerability to climate change*). Interventions at the local level are designed in crop-production mechanisms,

Districts' vulnerability to climate change

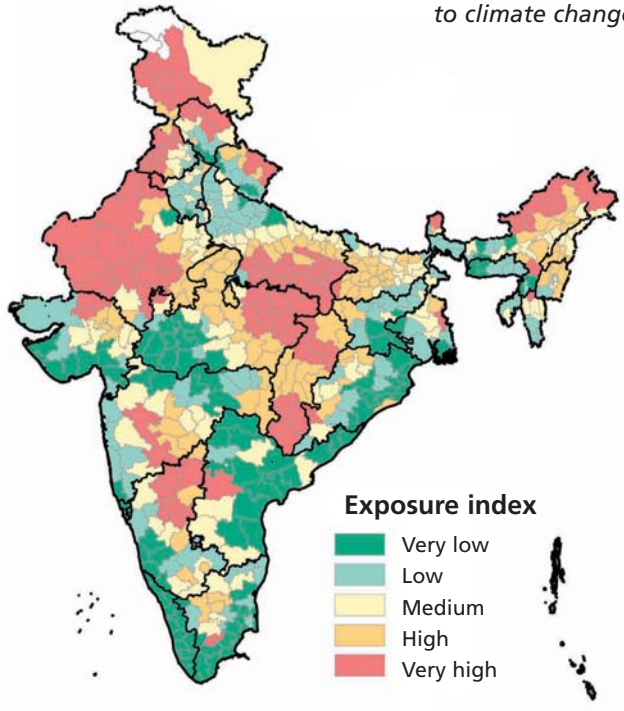
District-wise sensitivity

The northwestern states are highly sensitive to climate variability while the northeastern states have low sensitivity to climate variability



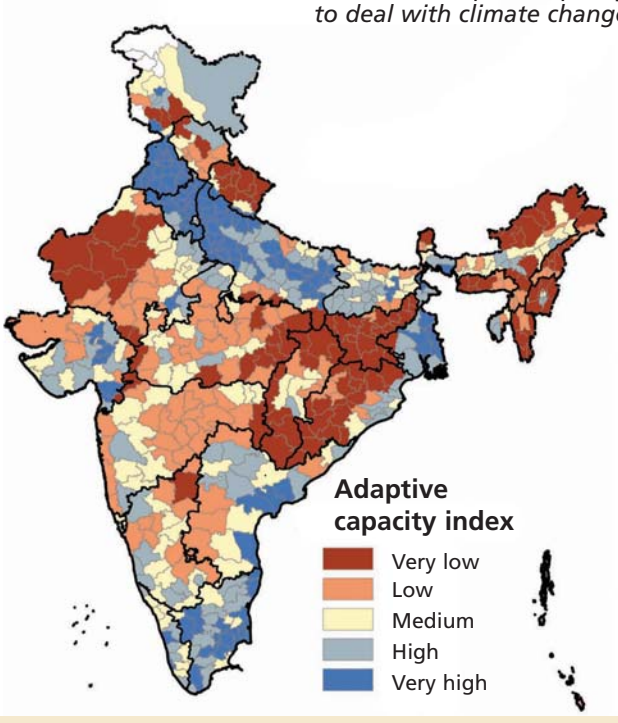
District-wise exposure (2071-98 over 1961-90)

Parts of northwest, northeast and central India are projected to have very high exposure to climate change



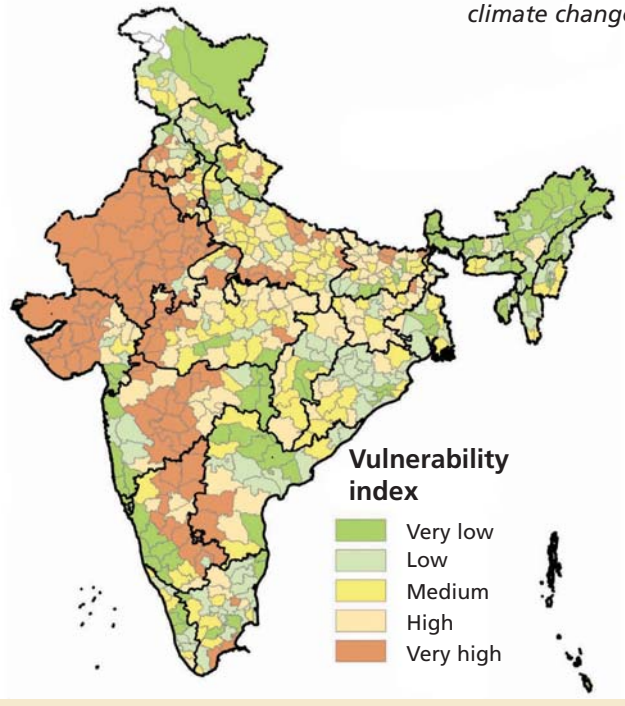
District-wise adaptive capacity

Uttarakhand, Rajasthan, Chhattisgarh, Jharkhand, Odisha and the northeastern states have low adaptive capacity to deal with climate change



Vulnerability of agriculture to climate change

Rajasthan, Gujarat and parts of Maharashtra and Karnataka have high variability of agriculture to climate change



Source: CRIDA (2012)

livestock management, natural resource management and institutions. These are early days to judge the actual performance of NICRA, but initiatives such as this are certainly required in others sectors as well.

Similarly, the Mahatma Gandhi National Rural Employment Guarantee Scheme (MNREGA) has enormous potential to reduce the vulnerability of the poor if adequate attention is paid to building local capacity for planning and implementation, and building climate-resilient assets. However, India's formal intervention to tackle climate change comes in the form of National and State Action Plans on Climate Change.

National Action Plan on Climate Change

The National Action Plan on Climate Change (NAPCC), released in June 2008, outlined the existing and future policies and programmes addressing climate change mitigation and adaptation in India. It has eight missions designed to promote the country's development objectives while also yielding co-benefits of addressing climate change effectively[29] (see Box: *The eight missions of NAPCC*).

Of the eight missions, at least four are of direct relevance in addressing the vulnerability of the rural poor in India – National Mission for Sustainable Agriculture, National Water Mission, National Mission for a Green India, and the National Mission on Strategic Knowledge on Climate Change.

The most recent review of the progress made under the eight National Missions has thrown up mixed results. Missions related to mitigation have made much more progress than those related to adaptation.[30]

The National Mission on Enhanced Energy Efficiency is confident of achieving emission

The eight missions of NAPCC

- **National Solar Mission:** The Mission promotes the development and use of solar energy for power generation and other uses with the objective of making solar competitive with fossil-based energy options. The Mission has set the ambitious target of deploying 10,000 MW by 2017, and 20,000 MW[1] by 2022. Recently, the government has increased the solar target five-folds and now wants to install 100,000 MW solar power by 2022.
- **National Mission for Enhanced Energy Efficiency:** The plan recommends improving efficiency in large energy-consuming industries, reduced taxes on energy-efficient appliances and financing for public-private partnerships to reduce energy consumption. The Mission will enable about Rs 75,000 crore worth transactions in energy efficiency by which it will, by 2015, help save about five per cent of India's annual energy consumption.
- **National Mission on Sustainable Habitat:** The Mission seeks to promote energy efficiency as a core component of urban planning and includes elements like urban waste management and recycling, automotive fuel economy standards and incentives for the use of public transportation.
- **National Water Mission:** With water scarcity projected to worsen as a result of climate change, the plan sets a goal of a 20 per cent improvement in water use efficiency through pricing and other measures.
- **National Mission for Sustaining the Himalayan Ecosystem:** The plan aims to conserve biodiversity, forest cover and other ecological wealth in the Himalayan region where glaciers that are a major source of India's water supply are projected to recede as a result of global warming.
- **National Mission for a "Green India":** Goals include the afforestation of 6 million ha of degraded forest lands and expanding forest cover from 23 per cent to 33 per cent of India's territory.
- **National Mission for Sustainable Agriculture:** The plan aims to support climate adaptation in agriculture through the development of climate-resilient crops, expansion of weather insurance mechanisms and agricultural practices.
- **National Mission on Strategic Knowledge for Climate Change:** To gain a better understanding of climate science, impacts and challenges, the plan envisions a new Climate Science Research Fund, improved climate modelling and increased international collaboration. It also encourages private sector initiatives to develop adaptation and mitigation technologies through venture capital funds.

reduction by around 98.55 million tonne by 2015, saving of 23 million tonne of oil equivalent of fuel savings, and distribution of 2.58 million LED bulbs. The designated consumers in the Perform, Achieve and Trade (PAT) scheme would be enhancing energy efficiency by 4.05 per cent per year which would reduce energy cost by Rs 7,500 crore per year. The Committee suggested the Mission enhance its targets in the next PAT cycle.

The Solar Mission reported the addition of grid solar power of 2,870 MW and off-grid solar applications of 364.27 MW along with solar thermal collectors of 8.42 million sq m till 2013-14 and total CO_2 reduction of 15.5 million tonne. New projects of solar parks, solar PV power projects on canal top/canal banks and solar power-driven agricultural pump sets and water pumping station are being launched in 2014-15 along with the implementation of green corridors transmission infrastructure.[31]

Progress on other initiatives envisaged under NAPCC – water efficiency, public transport, strategic knowledge, biodiversity, disaster management, protection of coastal areas, creation of capacity to deal with climate change at different levels of government etc – was found to be slow. The lack of adequate funding was flagged as the major challenge in this regard.[32] But the real reason is that while mitigation missions like solar energy and energy efficiency can be run in a centralised-mission mode, the adaptation missions will have be implemented in a decentralised fashion, at the local level with local ownership. This can only be done if the State Action Plans are designed and implemented properly.

State Action Plans on Climate Change

NAPCC led to the formulation of State Action Plans for Climate Change (SAPCC). A common framework was developed by the ministry of environment and forests (MoEF) to guide the preparation of SAPCCs to ensure a certain level of coherence in national- and state-level actions, while retaining the necessary flexibility to accommodate state-specific circumstances and priorities. As part of SAPCC, states were asked to undertake impact and vulnerability assessments, identify and prioritise adaptation and mitigation options and identify financial needs and potential sources. As of November 2014, 28 states and Union territories have prepared draft SAPCCs, 19 of which have been endorsed by the MoEF and three are being reviewed. Several large states such as Maharashtra, Gujarat and Uttar Pradesh have not yet finalised their plans.[33] However, even where the SAPCCs have been completed and approved, states face significant and multiple challenges in implementation.[34, 35]

- Many states lacked information on current and future local climate vulnerability and impacts. This has meant that many states plans have not taken into account future climate change impacts. SAPCCs, therefore, should more appropriately be referred to as development plans that incorporate sustainable development concerns.
- SAPCCs were supposed to be mainly "adaptation" plans. But in many state plans, mitigation is a significant part of the concerned state's plans and proposals.
- The actions proposed by states vary from macro and generic actions like integrated watershed management and farming practices to micro and specific actions like moving a bus stop. No state offers a clear, consistent and well-argued set of recommendations that amounts to either a vision or an action plan. Similarly, the NAPCC's call for a "directional shift in the development pathway" of India in response to climate change is not visible in SAPCCs.
- There is also no clarity on the how and who of implementation. The MoEF's common framework asked the states to estimate "additional resource requirements" and explore "existing and new and additional carbon finance potential". At the time the Centre requested states to develop plans within the context of the promise of substantial funds under the Twelfth Five-Year Plan. But the funds never materialised. In fact, there is just Rs 100 crore for adaptation in the 2013-14 Union Budget. This fact is significant – sustained financial resources will have to be found to implement many of the large-scale adaptation measures that are needed, such as retrofitting core infrastructure assets that are at risk from extreme weather events.

The key challenge going ahead is to make the SAPCCs dynamic action plans, revised periodically to reflect growing knowledge on climate variability and impacts. The most important challenge would be to mainstream the SAPCCs into the existing plans and policies so that resilience is built in the communities and economy from the ground up.

Protecting people: Adaptation with an ear to the ground

Climate change has begun to hurt India. Cyclone Phailin in 2013 alone led to a loss of more than Rs 20,000 crore. Though there are no peer-reviewed comprehensive estimates on the total loss due to slow-onset and extreme events in India, Government of India estimates for 2012 suggest that expenditure on adaptation to climate variability exceeds 2.6 per cent of the GDP, with agriculture, water resources, health and sanitation, forests, coastal zone infrastructure and extreme events, being specific areas of concern.[36]

These costs will only rise with increasing frequency of extreme weather events. In a recent speech, the prime minister of India seemed to suggest that in 2014, India is spending over 6 per cent of its GDP on adapting to the consequences of climate change,[37] while an Asian Development Bank report suggests these costs would rise to a little under 10 per cent by the end of the century.[38]

The first Adaptation Gap Report that was released by the United Nations Environment Programme (UNEP) in Lima during the COP20 in December 2014 also warns that the costs of adaptation will be very high for developing countries like India.[39] According to the report, the estimates of the COP for the costs of adaptation in developing countries is likely to be much lower than what is actually required. For instance, the IPCC projected adaptation costs in the range of US $70-100 billion a year globally by 2050. However, as the Adaptation Gap Report says, the adaptation costs of South Asia alone could be as much as US $40 billion. For all developing countries, it could be as high as US $150 billion per year by 2025 and US $250 to 500 billion per year by 2050.

There is general consensus that as compared to developed countries, developing countries are more economically vulnerable to climate extremes largely because:[40]

- Developing countries have less resilient economies that depend more on natural capital and climate-sensitive activities
- They are often poorly prepared to deal with the climate variability and physical hazards they currently face
- More damages are caused by maladaptation due to the absence of financing, information, and techniques in risk management, as well as weak governance systems
- There is generally little consideration of climate-proof investment in regions with a fast-growing population and asset stocks (such as in coastal areas)
- There is an adaptation deficit resulting from the low level of economic development and a lack of ability to transfer costs through insurance and fiscal mechanisms; and
- They have large informal sectors.

Our preliminary analysis shows that due to the above-stated factors, the incremental costs that climatic changes will impose on development are going to be harder and harder for the government to cover on its own without a proper strategy of dealing with climate change that includes both national and international action on mitigation and adaptation. It is also clear that without sufficient mitigation efforts globally, and even with adaptation, warming by the end of the 21st century will lead to high to very high risk of severe, widespread and irreversible impacts globally.

Adaptation and mitigation are complementary strategies for reducing and managing the risks of climate change.[41] India, therefore, must push for an ambitious global action to reduce green house gas emissions so that the temperature increase can be limited to less than 2°C. Beyond this temperature rise, the "costs" will be too just high for India to manage. Also with limiting emissions nationally and globally, India must also work towards building resilience in communities and various sectors of the economy to manage climate change impacts.

Mainstreaming adaptation and building resilience

People who are socially, economically, culturally, politically, institutionally or otherwise marginalised are especially vulnerable to climate change.[42] The first thing India must do is to eliminate this marginalisation. Reducing poverty can go a long way in reducing marginalisation and building resilience to climate change.

However, more than six decades of development planning in India has not shown desired results. This will have to change. Reducing poverty in the changing climate will mean doing development better and faster. This will also mean mainstreaming climate change responses into existing policies, processes, programmes and institutions.

Internalise the serious risk posed by climate change

India's response to climate change is more driven by international climate negotiations than by national imperatives. This is reflected in lukewarm response and involvement of many state governments to issues related to climate change. Also, most in the government have not yet internalised the problem sufficiently to recognise the seriousness of the threat posed by climate change. Many still view climate change as "western conspiracy" to derail India's growth story. And most in the government view climate change as in direct conflict with development.

This narrative will have to change. The new narrative has to be that building resilience against climate change is about eradicating poverty by doing sustainable development better and faster, something that the country has been trying to do for a long time.

Prioritise the needs of poor as part of climate change adaptation

Climate change will exacerbate existing "poverty traps" and create new ones. India's national and global response to climate change impacts, therefore, should clearly and strongly prioritise the current and long-term needs of the poor who will suffer worst from climate impacts, and address the root causes of their vulnerability.

The root cause of their vulnerability is lack of rights and entitlements that guarantee their rights to benefit from, and care for, the natural resource base they are so heavily reliant on. Through central laws like the Forests Rights Act and MNREGA and several state laws, rights and entitlements are being given but they need to promoted further and the capacities of communities need to be enhanced to manage these resources in a sustainable manner. This is also important for adapting to the climatic variability.

Climate change adaptation will require local planning, solutions and ownerships; it cannot be top down. For this, communities must be empowered, trained and supported to taken leadership role in adaptation.

Promote effective decentralisation

The impacts of climate change are likely to be extremely localised. Hence, the responses will also have to be designed locally in order to be effective. Although India is committed to decentralisation and PRIs are increasingly being given the right to plan and implement, there are many hurdles to be overcome when it comes to implementation and fiduciary devolution.

To begin with, central and governments will have to overcome their preference for "centralised decentralisation", where a large proportion of the funds allocated to local authorities come as central or state-sponsored schemes that are already earmarked for specific sectors, leaving little flexibility at the local level for more integrated planning that is focused on local needs. Local bodies are left mainly to implement these schemes, reduced to delivery mechanisms rather than governance bodies. Instead, untied funding should be made available to panchayats to undertake village-level development plans or strategies that take into account the full range of development concerns, including long-term livelihood and ecological sustainability, and climate change variability and change. In order to deal with increasing climate variability these plans must have flexibility built in for changes/responses in the face of uncertainty. Government bodies should play mainly a facilitating and advisory role and be made fully accountable to the people.

Considerable investments will need to be made at the local level to strengthen local governance. To promote informed decision-making, quality information will be needed on what is

at stake for communities, and their options, before the plans are drawn up. This will need heavy investments in local science and technology institutions geared to provide information tailored to local needs, rather than heavy investment in national institutions. This kind of localised S&T capacity will be crucial to dealing with climate variability change, in for instance providing information to farmers on what and when to sow on the basis of seasonal predictions or in developing local integrated water-management strategies.

Investments will also need to be made in strengthening the capacity of panchayats, gram sabhas and people, to carry out the planning, implementation and monitoring of these plans, and in fiduciary management. People should be an integral part of every step of the process. Investments will have to be made to set up systems for participatory monitoring and evaluation.

Mainstream responses to climate variability and impacts

Addressing vulnerability and building the resilience of the poor to climate variability is not entirely a new science that needs to be reinvented. Numerous policies, programmes and schemes have been implemented to address poverty over the last six decades of India's independence, taking into account the existing variability of India's climate. There will, no doubt, be many additional actions that need to be taken, for instance keeping up with the pace and uncertainty of climate change and the frequency and intensity of extreme events. Also, some of the past "bad practices" will also have to be filtered out.

However, such action must build on and be integrated with existing development efforts rather than reinvented or even rebranded and "adaptation" placed in a new silo where it will undoubtedly perish for want of sufficient attention and funding. The "Mission" approach promoted as a state-of-the-art response to the proliferation of central and state programmes is not necessarily the answer to this fragmentation. "Mainstreaming" and "integration" are required.

Developing state-, district- and village-level climate action plans that are part of the development plans can integrate and mainstream. For instance, district plans should be revised (where already developed) or new district plans should integrate various aspects of development and mainstream climatic concerns into them. Similarly, mainstreaming has to be an integral part of all new plans and policies. Tools like climate change impact and vulnerability assessment must be made part of the policy and project design. This is very important for building resilient economies and infrastructure that can withstand extreme weather events.

Promote and disseminate research and best adaptation practices

Many adaptation projects and practices are currently underway in India, bringing out good as well as bad practices and raising awareness about these issues. Such projects and programmes should be further promoted by governmental or non-government organisations. The results and design of successful adaptation measures should be widely disseminated and capacity of local communities enhanced to absorb good practices. The National Adaptation Fund should be converted into a National Adaptation Research and Dissemination Fund.

Adaptation research for India must reveal specific concerns, gaps, threats and solutions. This can be achieved only by documenting local responses, collating scientific data on local changes in environment parameters and understanding the state of development on the ground. Only such exercises carried out in every vulnerable ecosystem will lead to insights into varied adaptation needs in this country and help prioritising intervention.

Strengthen social safety nets

Even the best planning and implementation will probably not be able to cope with the level of climate change predicted. As the climate dice is "loaded" more and more towards extreme events and disasters, communities are likely to suffer repeated setbacks to their livelihoods and resources. The lack of financial capital to cushion the blow from climate change can push them further into "poverty traps", with further negative repercussions on their limited assets, health and education and reliance on climate-sensitive sectors.

Social safety nets such as MNREGA will become more and more important in this scenario.

The shortcoming of MNREGA should be addressed urgently, particularly by ensuring that the scheme takes a more integrated, decentralised, longer-term view on the creation of livelihoods and opportunities for the poor by creating climate-resilient assets with clear ownership. It should not be viewed merely as a cash-transfer mechanism, but as an opportunity for the poor to build assets that will serve them for years to come and which they own and care for.

However, recent developments suggest that the current government could be cutting back on the size of the programme.[43] This could have major financial and social implications for the poor and further reduce their resilience.

Scrutinise global policies and mechanisms for their impact on the poor

Finally, India must ensure that the interests of the poor are protected under all international mechanisms agreed under the UNFCCC, whether they relate to mitigation or adaptation. India has never really identified itself with the most vulnerable countries despite being one. Even if India finds after careful consideration and consultation that it will depend mostly on domestic capacity to deal with climate impacts as a show of solidarity with other vulnerable countries who need international assistance, it is in its own interest to engage proactively in the adaptation negotiations to ensure an equitable and just outcome.

Such an outcome must reflect the moral responsibility of countries most responsible for climate impacts towards countries who will suffer worst from these impacts, and also the primacy and urgency of empowering the poor within these countries to deal with climate impacts.