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Collaborative Adaptation Research Initiative in Africa and Asia

Review of Current and Planned Adaptation Action in India

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About CARIAA Working Papers

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Titles in this series are intended to share initial findings and lessons from research and background studies commissioned by the program. Papers are intended to foster exchange and dialogue within science and policy circles concerned with climate change adaptation in vulnerability hotspots. As an interim output of the CARIAA program, they have not undergone an external review process. Opinions stated are those of the author(s) and do not necessarily reflect the policies or opinions of IDRC, DFID, or partners. Feedback is welcomed as a means to strengthen these works: some may later be revised for peer-reviewed publication.

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Abstract

India's unique geographic location and predominantly agrarian economy make it one of the most climate-sensitive regions in South Asia. Realizing that climate change threatens its development priorities and economic investments, India has initiated many adaptation actions across a range of sectors. A diverse set of policies are in place to facilitate the design, development, and implementation of adaptation actions in the country, both at the national and subnational levels. While most of these initiatives have been stand-alone sector-specific adaptation activities, there has been a gradual shift toward integrating adaptation as part of the country's larger development process. However, given India's sheer geographical size and diverse sociocultural context, adaptation needs of many sectors and vulnerable groups have not yet been adequately understood and addressed. In particular, there are gaps with respect to adaptation efforts that address the needs of the climate-sensitive regions in the northeast of India, the islands in the Indian Ocean, and the Sundarbans region, as well as those focused on the gender dimensions of climate change, health issues, and urban and peri-urban communities. This report presents a snapshot of the adaptation landscape of India, highlights some of its adaptation needs, both existing and emerging, and suggests ways that planned adaptation investments could meet these needs through new research and policy and practice engagements. This report is part of a series of country reviews prepared to provide the Collaborative Adaptation Research Initiative in Africa and Asia with an understanding of adaptation action in its countries of engagement.

Résumé

L'emplacement géographique unique de l'Inde et son économie principalement agraire en font l'une des régions les plus sensibles au climat en Asie du Sud. Consciente que les changements climatiques menacent ses priorités en matière de développement et d'investissement économique, l'Inde a mis en place de nombreuses mesures d'adaptation dans un grand nombre de secteurs. Un ensemble varié de politiques est en place afin de faciliter l'élaboration, la conception et la mise en œuvre de mesures d'adaptation dans le pays, aussi bien à l'échelle nationale qu'infranationale. Bien que la plupart de ces initiatives soient des activités d'adaptation autonomes propres à un secteur, le pays intègre petit à petit ces mesures au processus de développement à plus grande échelle du pays. Cependant, du fait de la taille de l'Inde et de son contexte socioculturel diversifié, les besoins d'adaptation de nombreux secteurs et groupes vulnérables ne sont pas encore compris ni pris en compte adéquatement. Il existe notamment des lacunes quant aux efforts d'adaptation visant à répondre aux besoins des régions sensibles au climat dans le nord-est de l'Inde, dans les îles de l'Océan indien et dans la région des Sundarbans, ainsi qu'en matière de prise en compte des aspects genre des changements climatiques, des enjeux liés à la santé et des communautés urbaines et périurbaines. Ce rapport fournit un aperçu du contexte d'adaptation en Inde, met en lumière certains de ses besoins d'adaptation existants et émergents, et propose des moyens grâce auxquels les investissements dans le domaine pourraient répondre aux besoins en se fondant sur de nouvelles recherches et sur l'engagement envers les politiques et les pratiques. Ce rapport fait partie d'une série d'examens des pays préparés dans le cadre de l'Initiative de recherche concertée sur l'adaptation en Afrique et en Asie, et permet de mieux comprendre les mesures d'adaptation dans les pays où elle est déployée.

Acronyms

ACCCRN	Asian Cities Climate Change Resilience Network
CAMPA	Compensatory Afforestation Fund Management and Planning Authority
CARIAA	Collaborative Adaptation Research Initiative in Africa and Asia
CCAFS	Climate Change, Agriculture and Food Security
CCKN-IN	Climate Change Knowledge Network in Indian Agriculture
CDKN	Climate and Development Knowledge Network
COP	Conference of the Parties
DFID	Department for International Development
ENSO	El Niño-Southern Oscillation
FAO	Food and Agriculture Organization of the United Nations
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GIM	Green India Mission
GOI	Government of India
IDRC	International Development Research Centre
INCCA	Indian Network for Climate Change Assessment
INDC	Intended Nationally Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
MGNREGS	Mahatma Gandhi National Rural Employment Guarantee Scheme
MOEF	Ministry of Environment and Forests
MOEFCC	Ministry of Environment, Forests and Climate Change
MOWR	Ministry of Water Resources
NAPCC	National Action Plan on Climate Change
NATCOM-II	Second National Communication to the United Nations Framework Convention on Climate Change
ND-GAIN	Notre Dame Global Adaptation Index

NITI Aayog	National Institute for Transforming India
NWM	National Water Mission
OECD	Organisation for Economic Co-operation and Development
SAPCC	State Action Plan on Climate Change
SDC	Swiss Development Corporation
TERI	The Energy and Resources Institute
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations International Strategy for Disaster Reduction
USAID	United States Agency for International Development
WRI	World Resources Institute

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Synopsis

Climate risks	• Changing patterns of temperature and precipitation • Increased frequency of climate extremes across geographies such as glacier-fed river basins, semi-arid regions, and delta regions	**Key sources of vulnerability**	• Large-scale dependence on climate-sensitive livelihood systems such agriculture, fisheries, and livestock • Socio-political and cultural factors • Rapid and unplanned urbanization in many parts of the country
Vulnerable sectors	**Illustrative potential impacts on vulnerable sector**	**Illustrative adaptation priority adaptation measures in each sector**	**Projects in sector[1]**
Agriculture	• Reduction in crop yield; for example, grain yield of rice declined by 10% for each 1oC increase in the growing season minimum temperature (Pathak et al., 2003)	• National Initiative on Climate Resilient Agriculture • Improved and efficient agricultural practices such as Climate Smart Agriculture • Risk-transfer mechanisms such the National Agricultural Insurance Scheme, which is the largest crop insurance scheme in the world	28%
Water	• Decline in water quantity as well as quantity because of increased evapotranspiration and extreme weather events	• National Water Mission, as part of National Action Plan on Climate Change (NAPCC)	28%
Cities	• Greater exposure of coastal cities to risks such as cyclones and sea-level rise, and associated risk of flooding and infrastructure damage	• National Mission on Sustainable Habitats, as part of NAPCC and ongoing Smart Cities initiatives • Preparation of City Resilience Strategy for many cities	11%
Health	• Increased incidence of water-borne diseases • Increased incidence of vector-borne diseases such as malaria and dengue	• Proposed National Mission on Health as part of NAPCC • Specific actions such as the Ahmedabad Heat Action Plan to cope with extreme heat waves.	6%

[1] Percentage of total identified discrete adaptation projects and programs based upon research undertaken as part of this review. Note that individual projects may address more than one sector.

Coastal livelihoods and fisheries	• Decline in fish catch in inland and coastal fisheries due to change in sea temperature and hydrological changes in major river systems	• Various actions under the coastal zone management plan, including livelihood support to coast-dependent communities • Proposed new mission on coastal resources under the NAPCC	14%
Mountain systems	• Temperature changes will result in snow melting and glacier retreat in many parts of the Himalayas	• Specific mission on sustaining the Himalayan ecosystem and other programs	8%

Particularly vulnerable regions	**Particularly vulnerable groups**	**Status of climate governance (policies, institutions)**
• Himalayas in the north and northeast regions • Snow- and glacier-fed river basins of the Ganges, Indus, and Brahmaputra • Arid and semi-arid regions, mostly those of western India • Coasts and coastal regions • Deltas • Island ecosystems	• Small and marginalized farmers • Different groups of tribal populations, who are primarily resource dependent • Women and children, because of existing socio-political structures	• Sector- and region-specific adaptation action plan in place since 2008 • Highest political priority accorded to India's climate change action plan • Subnational climate change action plan prepared and endorsed by the federal agency • Establishment of the National Adaptation Fund for Climate Change (July 2014)

Introduction

India, the seventh largest country in the world in terms of geographical area, is home to more than 1.21 billion people. Its geographical location in the subtropics, surrounded by the Himalayas in the north, the Indian Ocean on the south, the Arabian Sea in the west, and the Bay of Bengal in the east, leads it to experience a wide variety of climatic conditions and have a diverse biogeography. This unique geography also exposes the country to a range of extreme climatic events, such as cyclones, floods, and droughts, which have put lives at risk, damaged infrastructure, and slowed economic and social progress. These hazards are expected to become more pronounced as climate change increases exposure to risks such as changing and extreme weather, sea-level rise, glacier retreat, and snow melt.

The vulnerability of India to climate change is further driven by underlying socio-economic concerns of poverty and inequality, the resource needs of an ever-increasing population, and the development priorities of an emerging economy. Although India is currently ranked as the third-largest economy in the world (World Bank, 2014), the benefits of recent decades of economic growth have not been experienced equally. Millions of Indians continue to live in poverty, have inadequate access to key resources such as productive land, water, and energy, and depend on climate-sensitive livelihood systems such as agriculture, livestock production, and fisheries. This situation increases India's vulnerability to climate variability and change. Recognizing this risk, India has initiated a variety of climate change adaptation plans and programs. Such initiatives are diverse, both in context and content, are widespread in scale, and involve a broad spectrum of stakeholders, from national governments to donor-supported community-based actions.

It is within this context that this report reviews the climate change adaptation policies, programs, and projects, both ongoing and planned, in India. It aims to provide a clear and concise account of adaptation planning and actions in the country based on in-depth analysis of secondary information sources and key informant interviews. The report is one of a series intended to support the work of the Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA). Jointly funded by the U.K. Department for International Development (DFID) and the International Development Research Centre (IDRC), CARIAA aims to help build the resilience of poor people to climate change in three hot spots in Africa and Asia: semi-arid areas, deltas in Africa and South Asia, and glacier- and snow-fed river basins in the Himalayas. To achieve this goal, it is supporting four consortia to conduct high-calibre research and policy engagement activities that will inform national and subnational planning processes in 17 countries, including India.

The paper begins by summarizing current understanding of existing and projected climate risks and vulnerabilities in India and priority adaptation needs as identified by the national government. It then provides an overview of the critical policies and plans shaping India's efforts to address climate change adaptation at the national and subnational levels. To assess the extent to which efforts to address the country's critical adaptation priorities are

presently under way, section 5 paints a general picture of the scale, type, and focus of current and planned adaptation-focused programs and projects under way in India, as well as the level of adaptation finance flowing into the country. Section 6 provides a profile of in-country efforts to advance adaptation learning and knowledge sharing through networks and communities of practice. The paper concludes with an assessment of the general status of adaptation planning at the national and subnational levels in India.

1. Current climate and projected changes

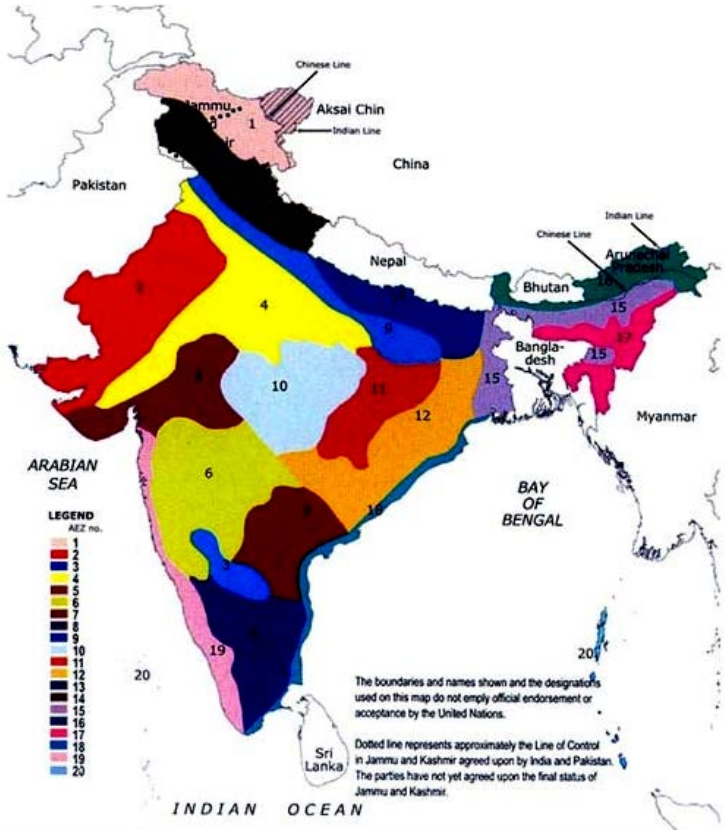
India's geographic location makes it one of the most climate-sensitive regions in South Asia, and contributes to its existing high degree of climatic variability and diversity of agro-ecological regions. As presented in Figure 1, the National Bureau of Soil Survey and Land Use Planning, under the Indian Council of Agricultural Research, has divided India into 20 agro-ecological regions (details of which are provided in Annex C), which are further classified into 60 agro-ecological subregions. These range from the cold arid ecoregion in the northern high mountain areas to the warm and humid areas along the coast of Bengal.

The country's climate is largely influenced by the Indian monsoon, which in turn is linked to seasonally reversing open-ocean currents that flow between the Arabian Sea and the Bay of Bengal, the two wings of the north Indian Ocean (Shankar, Vinayachandran, & Unnikrishnan, 2002). Better understanding of the monsoon's variability is emerging with improved modelling and simulation procedures (Turner & Annamalai, 2012). The monsoon contributes more than 85% of India's annual precipitation and is critical for the country's agriculture and water resources. The relationship between the El Niño-Southern Oscillation (ENSO) patterns and the Indian summer monsoon is well established (Christensen et al., 2007), with ENSO conditions influencing monsoon variability (Wu, Chen, & Chen, 2012). The inter-annual variability of Indian monsoon rainfall historically has been quite significant, with many instances of excessive as well as deficient rainfalls in the country, leading to both floods and droughts. Notably, 10 out of the 13 droughts in India since 1951 were in an El Niño year (Singh, 2014).

India's climate has experienced a number of changes in recent decades. Mean temperature increased across the subcontinent by about 0.2°C per decade for the period 1971–2007, although an overall cooling trend has been observed for the northwestern region of the country. ENSO events have had a significant influence on temperature anomalies during some seasons. With respect to precipitation, observed changes in rainfall patterns are quite different across various areas of India, and there is an increasing trend in the number of one-day extreme rainfall events in many parts of the country (Government of India [GOI], 2012). Additionally, a comprehensive statistical analysis of precipitation observations (1951–2011) reveals changes in wet and dry extremes during the monsoon season. The study found statistically significant decreases in peak-season precipitation simultaneously occurring with an increase in daily-scale precipitation variability. It also found statistically

significant increases in the frequency but decreases in the intensity of dry spells, and increases in the intensity of wet spells (Singh, Tsiang, Rajaratnam, & Differnbaugh, 2014).

These climatic trends are projected to continue in the future. Most of the climate change projections for India are based on the second-generation Hadley Centre Regional Climate Model and the most recent PRECIS model. NATCOM-II, India's Second National Communication to the United Nations Framework Convention on Climate Change (UNFCCC), which is based on PRECIS simulations for the 2020s, 2050s, and 2080s, projects a rise of 3.5°C to 4.3°C in India's annual mean surface temperature by the end of the century. The spatial distribution of this projected temperature change varies between regions (GOI, 2012).



1	Cold arid ecoregion with shallow skeletal soils
2	Hot arid ecoregion with desert and saline soils
3	Hot arid ecoregion with red and black soils
4	Hot semi-arid ecoregion with alluvium-derived soils
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Figure 1 – India's agro-ecological zones (Food and Agriculture Organization [FAO], n.d.; reprinted with permission)

One of the primary meteorological phenomena affected by climate change will be India's monsoon patterns, including the timing and distribution of rainfall, which may continue to affect the region's entire hydrological cycle and in turn its agriculture sector. An increase in rainfall intensity for most of India has been projected, with few exceptions in the eastern peninsular region. According to the regional model simulations, a decrease in frequency but increase in the intensity of cyclonic disturbances in the Indian Ocean region has been projected (GOI, 2012). India is also at risk from other climate change–related phenomena. For example, India's vast coastline of more than 7,500 km and the vital infrastructure and resources along it are at greater risk of climate-linked hazards such as tropical cyclones, sea-level rise, coastal flooding, and erosion. The Hindu Kush–Himalayan regions in the north and northeast are extremely sensitive to temperature and precipitation changes that result in snow melt and glacier retreat. Changes in ENSO patterns could bring additional climate risks in the future.

The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) further corroborates these projected climate changes for India. It observes an increasing trend in mean annual temperature and a significant increase in temperature extremes and heat wave frequency in India (Christensen et al., 2013). For example, recent heat waves in India, with recorded daytime temperatures of more than 46.6°C, claimed more than 1,800 lives (Inani, 2015). In addition to such temperature extremes, the report also projects more frequent and heavy rainfall days by the middle of the 21st century under a high-emissions scenario and states that an increase in extreme rainfall events related to monsoons will be very likely in many parts of India. The IPCC projects a global mean sea-level rise of 26 cm to 55 cm under a low-emissions scenario, and 45 cm to 82 cm under a high-emissions scenario (IPCC, 2013); both scenarios present significant risk to the vast stretch of India's densely populated coastal areas and their economies.

These projected climate changes and the resulting impacts are likely to cost India almost 1.8% of its GDP annually. In the absence of any longer-term adaptation or mitigation actions, the cumulative economic loss is projected to be more than 8.7% of India's GDP by 2100 (Ahmed & Suphachalasai, 2014).

2. Vulnerability to climate change

Vulnerability to climate change is multi-dimensional and dynamic in nature (Adger, 1999). Existing socio-economic, cultural, and political factors act as key drivers that further amplify the vulnerability of a system to climatic variability and extreme weather phenomena, as well as influence its capacity to deal with such changes. For example, research on farmers' resilience in semi-arid Ghana demonstrates how long-term historical processes, patriarchy, and local culture are shaping the present context of vulnerability (Nyantakyi-Frimpong & Bezner-Kerr, 2015). Thus, insights into some of these non-climatic drivers are essential to developing a comprehensive picture of vulnerability to climate risks and help set the stage

for future discussions on the vulnerability of different sectors, regions, and groups to the impacts of climate change.

2.1 Current drivers of vulnerability

India's vulnerability to climate variability and change is shaped by a mix of non-climatic drivers, including those related to its economy, social development, governance, and environmental sustainability. Some of the key development indicators of the country presented in Table 1 provide a snapshot of some of the various socio-economic and political factors that are essential to understanding the vulnerability context of the country. These indicators highlight the continued high incidence of poverty in the country. Poverty and inequality are two of the key underlying socio-economic drivers that increase the vulnerability of a given society, such as India's, to climate risks (Rao, Riahi, & Grubler, 2014).

Table 1 – Key indicators of development progress for India

Category	Indicator	Year	Value	Source
Human development	Human Development Index (score[d]/rank[d] out of 187 countries)	2013	0.586/135	United Nations Development Programme [UNDP] (2014)
	Population in multi-dimensional poverty (%)	2013	55.3%	
	Under-five mortality rate (per 1,000 live births)	2013	56	
	Adult literacy rate (15 years of age and above)	2013	62.8[c]	
	Improved water source, rural (% of population with access)	2012	91%	World Bank (2015)
	Improved sanitation facilities (% of population with access)	2012	36%	
	Access to electricity (% of population)	2010	75%	
Gender	Gender Inequality Index (value[e]/rank[d] out of 187 countries)	2013	.5631/135	UNDP (2014)
Demographics	Total population (in millions)	2013	1,252.139[a]	UNDP (2014)
	Average annual population growth rate	2010	1.5%	
	Population, urban (% of population)	2011	32.0% [b]	

Economic development	GDP (in current $US, millions)	2013	1,876,797.199	World Bank (2015)
	GDP growth (annual %) (average of period of 2010 to 2013)		6.7%	
	Agricultural land (% of land area)	2012	60.3%	
Governance	Corruption Perceptions Index (score[f])	2014	38	Transparency International (2014)
	Corruption Perceptions Index (rank[d] of 174 countries)	2014	85	
	Fragile States Index (score out of 120 points[e])	2014	76.9	Fund for Peace (2014)
	Fragile States Index (status)	2014	High warning	
	Expenditure on education, public (% of GDP)	2012	3.3%[c]	UNDP (2014)
	Expenditure on health (% of GDP)	2011	3.9%	
Environment	Population living on degraded land (%)	2010	9.6%	UNDP (2014)
	Change in forest area, 1990/2011	2013	7.3%	

[a] Projections based on medium-fertility variant

[b] Because data are based on national definitions of what constitutes a city or metropolitan area, cross-country comparison should be made with caution

[c] Data refer to the most recent year available during the period specified

[d] Where 1 or first is best

[e] Where 0 is best

[f] Where 0 is highly corrupt and 100 is very clean

India is an emerging economy, and the country has seen significant economic improvement in recent decades. The economy has grown on average almost 8% per year for the last couple of years (Organisation for Economic Co-operation and Development [OECD], 2014); according to the International Monetary Fund's latest GDP growth forecast, the country is likely to witness a growth of 7.2% in the current fiscal year (Zhong, 2015). Moreover, due to major structural reforms it undertook in the last couple of decades, including greater investments in economic and social development programs, India has been successful in reducing the number of people living below the poverty line. The number of poor declined from 407 million in 2004–2005 to 269 million in 2011–2012 (Anand, Tulin, & Kumar, 2014). However, such a strong rate of economic growth and decline in poverty persists alongside increasing income inequality in the country (Bandyopadhyay, 2013) and India continues to rank only 135th on the overall Human Development Index (UNDP, 2014). The

large proportion of its population, almost 53.75%, that remains multi-dimensionally poor and dependent on climate-sensitive livelihood systems such as agriculture and allied sectors accentuates India's climate vulnerability (Oxford Poverty and Human Development Initiative, 2015).

The level of economic growth across Indian states also is significantly different. Incidences of poverty and the extent of inequality are quite high in the central, northeastern, and eastern parts of India, and in the states of Assam, Madhya Pradesh, Odisha, Uttar Pradesh, and West Bengal. These regions are also highly exposed to multiple hazards of extreme rainfall, temperature anomalies, and sea level–related changes. There have been persistent efforts to alleviate this regional inequality in the country (Kundu & Verghese, 2010). Such socio-economic inequality is more pronounced among marginalized communities (such as Scheduled Castes, Scheduled Tribes, and Other Backward Classes)[2] and religious minorities. These disparities across scales have given rise to discontent and discord among many sections of society and in a few instances have resulted in armed conflicts and violence against the state. For example, more than 173 districts in eight states of India are affected by left-wing extremism. The government of India has been implementing a special Integrated Action Plan in these regions to deliver better infrastructure and more development investments (Ministry of Home Affairs, 2015).

Population growth is a further source of vulnerability for the country. India accounts for 2.4% of total world surface area but supports and sustains more than 17.5% of the world's population. India's current population of around 1.21 billion is likely to overcome China's by 2028, which will make it the world's most populous country (United Nations, 2012). India's population density has gone up from 267 persons per km^2 (1991) to more than 382 persons per km^2 (2011), and this higher concentration of people further exacerbates their level of exposure to climate-related hazards such as extreme precipitation, tropical storms, or heat waves.

Additionally, the Indian economy has witnessed a significant shift from being predominantly agrarian and agriculture-based to being more focused on service and manufacturing. For example, the share of India's GDP belonging to agriculture and its allied sectors declined from 51.9% in 1950–1951 to 13.7% in 2012–2013 ("Agriculture's share in GDP declines," 2013). As well, over a period of five years (2007–2012), agriculture employment fell by almost 37 million people (OECD, 2014). Declining agricultural productivity and new opportunities for wages in non-agricultural sectors have been the underlying drivers for this shift. The shift has also partly fuelled a large-scale rural-urban migration; more than 600 million people, or 40% of India's total population, are likely to live in its cities and urban centres by 2031 (The Global Commission on the Economy and

[2] These categories of economically and socially disadvantaged groups are formally identified in India's constitution, which conveys a responsibility on the GOI to promote their social and educational development.

Climate, 2014). Managing these economic and demographic transitions in a country of more than 1.25 billion people is a key challenge for the government.

While India has undertaken many reforms to diversify its key economic sectors by opening up new avenues in the manufacturing and services sectors, agriculture is still the primary source of livelihood for a large part of its population. The economy's continued reliance on agriculture and allied sectors, which are highly sensitive to climatic variability, is another of the key drivers of India's vulnerability to climate change.

Low levels of investment, both public and private, in climate change preparedness and mitigation measures make the economy and its people less resilient to climate-induced shocks and stress. For example, India's insurance density[3] of 3.96% and penetration[4] of US$53.20 are both among the lowest in the world ("Insurance penetration in India," 2015), which makes a large section of its population, vital infrastructure, and investments less capable of recovering from external shocks and losses (Aon Benfield, 2014; Swain, 2014). India's latest National Communication to the UNFCCC, NATCOM-II, underscores the need for adequate and accessible insurance coverage for farmers and their assets, such as crops, livestock, and other agricultural machinery, to enhance their adaptation capacities (GOI, 2012).

Vulnerability of the poor and marginalized, mostly those engaged in agriculture and allied sectors, is complex and multi-layered and influenced by larger socio-economic and political factors. For example, Taylor (2015) identifies a complex set of socio-economic factors consisting of informal credit market and debt, which push many small and marginal farmers to become forced labourers in the semi-arid and drought-affected regions of central India. Such relational vulnerability and its outcomes are manifested in a variety of ways in the Indian context (Taylor, 2015). For example, unseasonal rains and hailstorms in many parts of India in early April 2014 forced more than 100 farmers to commit suicide (Sood, 2014). Most reported suicides are among male farmers, with empirical evidence pointing to climatic and economic shocks leading to a slight decrease in female suicides (Hebous & Klonner, 2014).

2.2 Vulnerability of key sectors, regions, and groups

India's history is replete with climate-related events that were instrumental in triggering large-scale socio-economic, ecological, and political transformations in the country. Two such incidents were the Great Bengal Famine of 1943–1944, which resulted in the deaths of more than 4 million people (Brooke, 2014), and the 1954 floods in the Kosi River basin in northern Bihar, which altered the entire hydrogeology and demography of the region (Salman & Uprety, 2002).

[3] Insurance density is calculated as the ratio of total insurance premiums (in U.S. dollars) to total population.
[4] Insurance penetration is calculated as the ratio of the percentage of total insurance premiums (in U.S. dollars) to GDP.

While India historically has been a climate-sensitive region because of its vast landmass, which is surrounded by oceans and mountains, over the years there has been a significant increase and shift in the pattern of climate risk in the country. As per the Notre Dame Global Adaptation Index (ND-GAIN), there has been a gradual decline in India's vulnerability score and simultaneous increase in its readiness score, although the latter remains low relative to other countries (as presented in Table 2) (ND-GAIN, 2015). The declining vulnerability score could be attributed to the gradual integration of the Indian economy to the larger processes of globalization and ways through which many global stressors, both climatic and non-climatic, shape the risk context at the national and local level in the country (O'Brien et al., 2004). Such multiple stressors, combined with erratic weather phenomena in the past, such as prolonged dry periods and extreme and untimely precipitation, have resulted in extensive loss and damage in many part of India. India is one of the 32 countries Maplecroft has classified as being at "extreme risk" to climate change, ranking 13 on its 2015 Climate Change Vulnerability Index (Maplecroft, 2015). Maplecroft notes the potential for food production, poverty alleviation, migration patterns, and social stability to be adversely affected by climate change in India and other vulnerable countries. Table 3 presents other indices that highlight India's climate risk context.

In addition to its erratic weather phenomena, India is also one of the most multi-hazard-prone countries in South Asia. These hazards include earthquakes, cyclones, droughts, extreme heat, landslides, and floods, and have resulted in large economic losses and sociocultural disruptions. On average, such natural disaster–related events cost the country almost 2% of its GDP per year and 12% of its annual revenue (Lester & Gurenko, 2003). High levels of poverty further increase the exposure of India's population to many climatic hazards (Shepherd et al., 2013). India was one of the top 10 countries affected by extreme weather events in 2013, with a total absolute economic loss of about US$15.147 billion (Kreft, Eckstein, Junghans, Kerestan, & Hagen, 2015).

Table 2 – Global Adaptation Index rank and scores for India in 2013 (ND-GAIN, 2015)

	World rank	Score	Trend
Vulnerability	117 (of 180)	0.414*	↓
Readiness	162 (of 184)	0.389**	↑
Overall	117 (of 178)	48.7	↑

*Lower score indicates lower vulnerability. The vulnerability score is determined based on indicators of exposure, sensitivity, and adaptive capacity, taking into consideration indicators related to six life-supporting sectors: food, water, health, ecosystem services, human habitat, and infrastructure.

**Higher score indicates higher degree of preparedness. The readiness score takes into account measures of economic readiness, governance readiness, and social readiness to pursue adaptation actions.

Table 3 – India's ranking on different climate risk indices		
Index	**Rank/score**	**Source**
Climate Change Vulnerability Index	13 (among 32 "extreme risk" countries)	Maplecroft (2015)
Climate Risk Index	3 (among the 10 most affected countries)	Kreft et al. (2015)
Women's Resilience Index (in South Asia)	42.2 (out of 100)	The Economist (2015)
One of the top five countries by number of people affected by natural disasters in 2013	16.7 million	United Nations Office for the Coordination of Humanitarian Affairs (2015)

Among the major climate-induced hazards, flooding poses a significant threat to large parts of India and its population. Flood hazards are frequent and widespread in many parts of India; more than 40 million hectares (ha) of India's total geographical area of 329 million ha is prone to floods (National Disaster Management Authority, 2008). Flooding-related loss and damage are on the rise as more people and properties are exposed to these hazards because of poor planning and lack of access to flood-resilient infrastructure and other resources. Recent examples of severe floods include the following:

- The Jammu and Kashmir flood in October 2014, the deadliest flood to hit the region in the last 60 years, which caused an economic loss of US$16 billion and insurance payouts of more than US$150 million (Aon Benfield, 2014).
- The Uttarakhand flood in the climate-sensitive Himalayan regions of northern India, which claimed more than 6,500 human lives, was the second deadliest hydrometeorological disaster worldwide in 2013, after Typhoon Haiyan in the Philippines (Aon Benfield, 2013). Caused by severe precipitation, it is evidence of the increased probability of climate extremes in the region (Singh et al., 2014).

In central India, many of the arid and drought-prone regions have witnessed a drastic shift in their rainfall and temperature regimes. Erratic weather, such as untimely rainfall, prolonged dry spells, and hailstorms, has resulted in crop failure and loss of livelihoods for many poor, marginalized, and debt-ridden farmers in the dry regions of Vidarbha and Marathwada in Maharashtra. For example, more than 24,000 villages lost 50% of their crop in the 2014 drought, the worst to hit the state since 2012 (India Water Portal, 2014). In order to manage the drought, the India Ministry of Agriculture released its (Drought) Crisis Management Plan 2014, which recognized that annually more than 50 million people in India are exposed to drought (GOI, 2014).

The coastal regions of India are also at risk from cyclones. For example, Cyclone Phailin, the second strongest tropical cyclone after the 1999 Orissa Super Cyclone, hit coastal India in October 2013. The cyclone and the flooding it induced destroyed more than US$4 billion worth of crops (Kreft et al., 2015) and triggered large-scale forced migration from disaster-affected coastal communities in the region (Barik, 2013). Similarly, the coastal city of Visakhapatnam along the Bay of Bengal was hit by Cyclone Hudhud in October 2014—becoming the first coastal city in the India Meteorological Department's history to be hit by a cyclone (Rao, 2014). The impact was unprecedented, and the total economic loss, as per official estimates, was INR 1 trillion, or US$15 trillion (Rajani Kanth & Rama Raju, 2014).

Climate change impacts are likely to be most pronounced, with far-reaching consequences in some of India's key sectors, such as water, agriculture, forests and other land ecosystems, coastal and marine resources, human health, and energy. Table 4 presents a brief overview of the climate vulnerabilities of some of these sectors in India.

Table 4 – Key vulnerable sectors in India

Sector	Likely impact
Water resources	• Increased rainfall will result in increased water yield for all the river systems, but changes in precipitation are highly variable across river basins • Higher temperatures and increased precipitation will also increase evapotranspiration in all major river systems. • These changes will cause a significant shift from moderate to extreme drought severity in many river basins. • Changes in annual stream discharge are likely to increase the risk of floods in basins. • Because of changes in hydrological cycles in river basins, there will be a significant gap in water availability versus water demand. India's water demand of 634 billion m^3 in 2000 has been projected to go beyond 1447 billion m^3 by 2050. • Groundwater resources will be affected primarily through a change in the hydrodynamics of the unconfined aquifer systems of different geological formations, and this may further affect the storage potential. • Temperature changes will result in snow melting and glacier retreat in many parts of the Himalayas. For example, a joint Indian Space Research Organisation and Ministry of Environment and Forests assessment revealed that almost 76% of glaciers have shown a retreat in area, 7% have advanced, and 17% are static (GOI, 2012).
Forest	• A change in the distribution of forests is projected. For example, the tropical evergreen forests in the eastern India plateau are expected to expand. • Net primary productivity and soil organic carbon will increase. • The habitats of many species will move poleward, resulting in changes in

	species composition and biodiversity. • Vegetation will change across major forest types in the country.
Agriculture	• Crop diversity in many regions will decrease. • The impact on crop productivity will be different across regions. For example, the production of wheat, one of the major cereal crops, is negatively affected by increases in temperature. Similarly, yield of fruits and vegetables are likely to go down because of weather anomalies and extreme events. • Coastal inundation will lead to salinization, which makes agricultural land unsuitable for cereals and grains. • Livestock productivity is projected to go down. For example, milk production in India has been estimated to suffer a loss of almost 1.8 million tonnes because of climate stresses.
Fisheries	• Fisheries, both inland and coastal, are likely to suffer huge losses because of declines in fish catch due to changes in sea temperature and hydrological changes in major river systems.
Health	• Direct impact will be through heat stress-related sickness, injury, and stress. • Water-borne diseases are likely to become widespread because of water stress–related issues such as lack of clean water or outbreaks of diarrhea after floods. • The incidence of vector-borne diseases such as malaria and dengue will increase. • Seasonal transmission and distribution patterns of many disease-transmitting vectors such as mosquitoes and ticks will be altered.
Energy	• Energy production and supply systems will suffer negative effects. For example, hydro-power generation will suffer a great deal because of changing river-flow discharge and glacier melting. • Rising temperatures and extreme cold conditions will increase energy demand and consumption. • Energy security is a key concern, especially for the vast majority of people in India who are not able to access or afford clean and reliable energy.
Infrastructure Systems	• Climate change–induced natural disasters pose serious threats to infrastructure development and investments. The risks could be physical, technological, supply chain–related, or regulatory in nature (Naswa & Garg, 2011). For example, a study by the Indian Institute of Management (2007) found that 20% of repair and maintenance expenses on tracks, tunnels, and bridges on the Konkan Railways (a 760 km line connecting Maharashtra, Goa, and Karnataka) were due to climatic reasons. • Natural resource–based infrastructure, such as hydro-power projects in the Himalayas, are at greater risk of cloudbursts, flooding, and landslides. • Critical infrastructure in coastal regions, including power transmission, telecommunications, roads and railways, and health care facilities, is at

	higher risk of cyclones and sea level–related changes (Bach, Gupta, Nair, & Birkmann, 2013). For example, Cyclone Hudhud, which hit the east coast of India on October 10, 2014, was the costliest natural catastrophe globally in 2014. Its estimated cost is US$7 billion, largely due to infrastructure damage along India's coasts (Munich Re, 2015).

Of particular concern is the potential for India's water resources to be hard hit by climate change impacts (IPCC, 2014). The National Water Mission (NWM), part of the National Action Plan on Climate Change (NAPCC)), identifies the following threats to the country's water resources (Ministry of Water Resources [MOWR], 2011:

- expected decline in glaciers and snowfields in the Himalayas
- increased drought-like situations due to the overall decrease in the number of rainy days over a major part of the country
- increased flood events due to overall increase in rainy day intensity
- influence on groundwater recharge due to changes in precipitation and evapotranspiration
- increased saline intrusion of coastal and inland aquifers due to rising sea levels

As highlighted in NATCOM-II, water availability will be differently affected in various river basins, with most projected to become highly vulnerable (Table 5). Likewise, while some areas, such as the arid and semi-arid regions of western India, will become water-stressed, many regions in the northern and northeastern regions will witness abnormally high precipitation leading to water logging and floods. Over-exploitation of groundwater in water-stressed regions, changes in water quality because of floods and droughts, and increasing salinity in coastal aquifers due to saline intrusion induced by sea-level rise have also been identified as key impacts of concern in the NWM.

Table 5 – Vulnerability scale of water availability, by basin, under the A1B scenario (a medium-high emissions scenario) for 2040, 2070, and 2100 (GOI, 2012)

Water availability	**A1B scenario**		
River basin	Year		
	2040	2070	2100
Ganges, upstream	SV	V	V
Ganges, downstream	HV	HV	HV
Mahanadi	SV	V	SI
Brahmani	V	V	SI
Brahmaputra	HV	HV	HV
Surma Imphal	HV	HV	HV

Key:	V = Vulnerable SV = Semi-vulnerable HV = Highly vulnerable SI = Semi-invulnerable

As India has a predominantly agrarian economy, impacts on the agriculture sector are also of critical concern. More than 60% of India's population depends on agriculture and its allied sectors for its livelihoods and survival. Agriculture contributes more than 18.5% of the country's GDP. Almost 68% of total net sown area in India is rainfed, and the rainfed agro-ecologies contribute to 60% of the country's livelihood, income, employment, and environmental security (National Rainfed Area Authority, 2014). This critical economic sector's high dependency on monsoon rains makes it more vulnerable to climatic impacts.

Moreover, because of declining agricultural productivity and other socio-economic drivers, more than 37 million farmers and agri-workers have abandoned agriculture to seek employment opportunities in the construction and manufacturing sectors (OECD, 2014). As more and more men move out of the traditional agricultural and allied sectors, the share of women in the workforces of these sectors is steadily increasing. This "feminization of agriculture," in addition to prevalent discrimination in relation to land ownership, control, and access, has further reinforced the vicious cycle of marginalization, poverty, hunger, and malnutrition in many parts of rural India. Part of this is attributed to the fact that women in rural India, by virtue of the social structure, lack adequate access to and benefit from resources such as credit and land.

A majority of those who move out of agriculture end up in informal settlements and slums in India's rapidly growing urban centres and cities. India's rising urban poverty, coupled with a lack of adequate climate-resilient infrastructure and social services planning, makes its cities among the most vulnerable to climate risk. For example, a recent vulnerability assessment of 20 Indian cities revealed that their infrastructure and inhabitants are highly exposed to multiple climate hazards and their level of preparedness is quite limited (Parikh, Jindal, & Sandal, 2013).

In addition to these sectoral vulnerabilities, there is a clear distinction in the vulnerabilities of various agro-climatic regions in the country. The Hindu Kush–Himalayan region is one of the areas of India most at risk from climate change. Changing temperature and precipitation patterns in the region have resulted in large-scale snow and glacial melt and retreat, which in turn have affected water availability and livelihoods in the Himalayan basins (Moors & Stoffel, 2013). This has further increased the risk of flash floods, including that of glacial lake outburst floods in the region (Worni, Huggel, & Stoffel, 2013).

Climate hazards along India's coasts, such as tropical cyclones and sea-level rise, are likely to become intense (GOI, 2012). The rate of global sea-level rise is occurring faster than previously projected (Hay, Morrow, Kopp, & Mitrovica, 2015), putting development investments, infrastructures, and livelihood assets of tens of thousands of coastal and coast-

dependent communities at greater risk. This includes some of the coastal megacities like Mumbai, Kolkata, and Chennai, which are at severe risk of coastal flooding (The Energy and Resources Institute [TERI], 2014b). For example, an assessment of flood risk in the megacity of Mumbai revealed that the total losses (direct plus indirect) associated with a 100-year flood event could triple compared with the current situation (to US$690–US$1,890 million) due to climate change alone, and adaptation could significantly reduce future losses (Ranger et al., 2011). Similarly, millions of people living in the river deltas, such as the Sundarbans delta (4.5 million) and the Mahanadi delta (6 million) remain vulnerable to sea-level rise, storm surges, and cyclones. Such climate-induced vulnerabilities have resulted in unforeseen human suffering, including a flourishing network of human trafficking in the Sundarbans (Ghosh, 2015).

Arid and semi-arid regions, which make up almost 53.4% of India's land area, face a unique set of climate vulnerabilities because of their different ecological, cultural, and livelihood contexts. Reduction in monsoon rainfall and increasing temperature have resulted in acute water insecurity, crop failure, land degradation, and desertification in many parts western Gujarat and Rajasthan. Erratic and extreme weather phenomena have often resulted in unexpected events in these regions, such as the 2006 floods in the drought-prone regions of Barmer in Rajasthan. Pastoralism, a significant livelihood system in these arid and semi-arid regions, is at greater risk because of dwindling livestock base and degradation of grazing lands (Convention on Biological Diversity, 2010).

The existing socio-economic and political inequalities in some parts of India render many poor and marginalized communities and certain social groups more vulnerable to shocks and stress, including those related to climate variability and climate change. For example, women in rural India spend almost 60% of their time in agriculture-related activities and are much more vulnerable than men to climate change impacts. These differential vulnerabilities along gender lines are more pronounced among women-headed families with inadequate access to and rights over productive assets such as land and water (Agarwal, 2003). Children in many marginalized locations are particularly vulnerable to climate-induced stress and shocks, and there is growing evidence that climate change impacts are one of the key drivers of child slavery and exploitation in India (Bhalla, 2015).

The other social group that is particularly vulnerable to climate change risks in India is the large section of the tribal and indigenous population whose entire livelihood systems and sociocultural organizations are natural resources–based. Climate change is affecting such tribal societies through a variety of ways, including through declining ecosystem services and gradual erosion of their traditional knowledge systems (Minj, 2013). Coping capacities among many such forest-dwelling tribal communities are on the decline because of growing alienation from land and productivity in some of the most climate-sensitive and economically challenged regions in India, such as Odisha (Datta, Pradhan, & Chhotaray, 2015). Many such tribal communities in India are also encountering climate risks and threats with which they do not have any previous experience. For example, during Cyclone

Hudhud in October 2014, the endangered *Bonda* tribes living in the high mountain regions of Odisha were evacuated for the first time in their living memory ("Cyclone Hudhud," 2014).

3. Adaptation planning context

Until recently, policies in India aimed at mitigating the floods, droughts and cyclones that are recurring natural hazards in many parts of India focused on investments in physical infrastructure and other financial measures such as post-disaster compensation and relief. With emerging knowledge of human-environment interactions, and more specifically around human-induced climatic changes and their influence on various natural hazards, greater policy attention to climate change issues has been triggered in the country. Over time, the adaptation planning context in India has grown from a purely environmental and stand-alone sectoral initiative into a more integrated and multisectoral development planning process.

A critical step in advancing adaptation planning in the country was the release of the NAPCC in 2008, which was a watershed in India's efforts to design, plan, and implement climate change adaptation and mitigation actions across sectors and regions. The NAPCC has been successful in presenting a clear climate action roadmap for the country, facilitating similar actions at the subnational level and mobilizing greater resources and partnerships. India's adaptation planning context has further been shaped by its engagement in UNFCCC processes as well as greater needs at the domestic level to ensure that its economic growth and development gains are more sustainable and climate sensitive. Greater interest and investments in adaptation planning are also linked to the emergence of new opportunities for international cooperation and business investments in climate mitigation projects in sectors such as transport, renewable energy, and infrastructure. Although adaptation planning in India, as elsewhere in the world, is interlinked with mitigation planning and financing, a detailed discussion of the mitigation planning context in India is beyond the scope of this paper. Table 6 presents a snapshot of the summary of India's progress in establishing the policies and institutions to support adaptation planning.

Table 6 – National adaptation planning context: Summary of progress as of May 2015

Indicator	Progress
Climate change recognized in country's guiding development vision/plan	Yes, in the *Twelfth Five Year Plan (2012–2017)* and the recent *Economic Survey 2015–2016* as part of the annual Union Budget.
National-level coordinating entity for climate change established and active	Yes, the Prime Minister's Council on Climate Change, chaired by the prime minister; it was established in 2008 and reconstituted in November 2014.
Climate change policy or law in	Not present

place	
Climate change strategy published	Although no specific national or subnational climate change strategies have been prepared, the *Report of the Expert Group on Low Carbon Strategies for Inclusive Growth* (April 2014) highlights sectoral adaptation and mitigation needs (Planning Commission, 2014), and many strategies are being prepared at the city level (ACCCRN, n.d.).
Climate change action plan published	Yes, the NAPCC and a series of State Action Plans on Climate Change. The National Action Plan is being expanded to include four new missions: wind energy, health, coastal resources, and waste-to-energy (Sinha, 2015).
National adaptation plan published	In development; sector/region-specific adaptation plans are under way.
Climate change fund or national adaptation fund operational	Yes. The National Adaptation Fund for Climate Change was launched in the 2014 Union Budget and received additional funds in the 2015–2016 Union Budget.
Climate change units established in key ministries at the national level	In some of the key ministries such as the Ministry of Science and Technology's Climate Change Programme and a Climate Change Cell within the Ministry of Agriculture
Climate change cells established at the subnational levels (state, local bodies etc.)	Yes. Many provincial states, including the states of Jharkhand, Himachal Pradesh, and Madhya Pradesh, have established and operational State Climate Change Cells. The Surat Municipal Council was the first urban local body to establish the Urban Health and Climate Resilience Center in 2013.
Degree to which climate change integrated into national sectoral policies	Mainstreaming of climate change into key sectoral development policies such as agriculture, fisheries, rural development, health, urban development, and water resources development is ongoing and planned.

3.1 National-level development policy context

India's overall development planning, programming, and financing is outlined in and implemented through its five-year plans. The five-year plans set out an overarching development vision for the country and lay the broader framework for sectoral policies and planning in order to achieve a specific set of economic, social, and environment goals. India's current *Twelfth Five Year Plan (2012–2017)* has a vision of "faster, sustainable, and more inclusive growth" (Planning Commission, 2013a). The plan emphasizes sustainable development as a key policy objective and recognizes the adverse impacts of climate change

on the Indian economy. It recommends implementation of the NAPCC (described below) as an "integral part" of the Twelfth Plan. It also identifies a Mitigation and Adaptation Strategy for Climate Change as one of the strategy challenges.

Climate change has emerged as a key policy priority for India's newly elected government, which made an administrative decision in May 2014 to rename the Ministry of Environment and Forests (MOEF) as the Ministry of Environment, Forests and Climate Change (MOEFCC) ("Ministry of environment and forests," 2014). Adaptation planning efforts in the country have gained new momentum as adaptation actions have become a key component of India's national development agenda. This situation was made explicit by the Minister for Environment, Forests and Climate Change at the UNFCCC Conference of the Parties (COP) 20 Summit held in Lima, Peru in December 2014 (Press Information Bureau, 2014), who, in regard to the need for such planning, stated, "I have always put our country's views at all available global platform that the world wants to discuss only about mitigation. But we want to discuss along with mitigation, more on adaptation. Because we are at the receiving end" (DNA India, 2014).

With this categorical emphasis on adaptation as a key mandate of its climate change policies and programs, both at the domestic and global levels, the GOI also aims to include adaptation as part of its Intended Nationally Determined Contributions (INDCs) to be presented prior to the next UNFCCC COP Summit (COP21) in Paris in December 2015. The MOEFCC, as part of the INDC preparation process, has so far completed two rounds of consultations with other ministries and intends to have two open sessions with civil society and think tanks (Gupta, 2015). Such a transparent and inclusive process has opened up new opportunities to further strengthen the climate change adaptation agenda and policy engagement process in India. This emerging adaptation policy context in India is also aligned with the some of the government's recent initiatives (such as 100 Smart Cities) and other policy priorities (such as the Low Carbon Strategies for Inclusive Growth).[5] Such country-level alignment of aims and priorities driven by a strong political will, as suggested by Conway and Mustelin (2014), is critical to improving adaptation practice.

Some of India's recent national policy initiatives are of significant relevance to climate change planning and implementation at the subnational level. Primary among these is the recommendation of India's Fourteenth Finance Commission to raise the tax share of provincial governments from the current 32% to 42%. This has further strengthened fiscal federalism, and every provincial government will have access to additional revenue to meet their development priorities and needs (Ministry of Finance, 2015).

[5] The Expert Group on Low Carbon Strategies for Inclusive Growth submitted its Interim Report in May 2011.

3.2 National-level climate policy context

As outlined below, India has made significant progress in establishing the policy and institutional framework needed at the national and subnational levels to advance its efforts to adapt to climate change. Among these initiatives are the establishment of the Prime Minister's Council on Climate Change in June 2007 and development of the NAPCC and (as described in section 4.5) State Action Plans on Climate Change.

India's overarching adaptation policy framework is the NAPCC of 2008, prepared under the guidance of the Prime Minister's Council on Climate Change. The NAPCC recognizes that effective and appropriate climate change adaptation and mitigation planning would yield "co-benefits" that could further strengthen the country's overall development objectives (MOEF, 2008a). Implementation of various sector-specific and region-centric climate change actions was designed through eight National Missions, as presented in Table 7. The government has very recently decided to add four new missions to the existing ones: wind energy, human health, coastal resources, and waste-to-energy (Sinha, 2015). An evaluation of the NAPCC in 2012 identified inadequate inter-ministerial coordination and lack of clarity on climate change co-benefits as some of the implementation challenges that various missions and the responsible ministries were facing (Byravan & Rajan, 2012).

While India's NAPCC recognized the gender dimensions of climate change impacts, the plans and proposed missions were not clear on implementation of this aspect at the national and provincial levels. A project supported by the Climate and Development Knowledge Network (CDKN), Gender and State Climate Change Action Plans in India, has been successful in helping a few state governments (Uttarakhand, Uttar Pradesh, and Madhya Pradesh) identify institutional opportunities for mainstreaming gender into their respective State Action Plan on Climate Change (SAPCC) (CDKN, 2013). But there are still significant gaps, both in policy and practice, with regard to further strengthening the climate and disaster resilience of women in the country, as reflected in India's Women's Resilience Score of 42.2 (out of 100) in the South Asia region (The Economist, 2015).

Table 7 – India's NAPCC progress (MOEFCC, 2014)

National mission under NAPCC	Mission objective	Implementation status	Budgetary allocation (2012–2017)
	Mitigation-focused		
Jawaharlal Nehru National Solar Mission	To establish India as a global leader in solar energy	Installed 2.970 MW of grid-connected solar generation capacity Installed 364 MW of off-grid solar generation capacity Installed 8.42 million m^2 of	US$1.4 billion

		solar thermal collectors	
National Mission for Enhanced Energy Efficiency	To achieve growth with ecological sustainability by devising cost- effective and energy-efficient strategies	Perform, Achieve and Trade cycle-1 launched and expected to be completed successfully by March 2015 Distributed 2.58 million LED bulbs	US$31 million
National Mission on Sustainable Habitat	To promote sustainability of habitats through improvements in energy efficiency	Made Energy Conservation Building Code 2007 mandatory Prepared long-term transport plan for cities Sanctioned 760 water supply projects	US$153 million
Adaptation-focused			
NWM	To conserve water, minimize wastage, and ensure equitable distribution	Revised National Water Policy (2012) Created 1,082 new groundwater monitoring wells	US$31.6 million
National Mission for Sustainable Agriculture	To transform agriculture into an ecologically sustainable, climate-resilient production system	Developed 11,000 ha of degraded land Brought 1 million ha of land under micro-irrigation Created 5.4 million tonnes of agricultural storage capacity	US$2.1 billion
National Mission for Sustaining the Himalayan Ecosystem	To evolve management measures for sustaining and safeguarding the Himalayan glaciers and mountain ecosystem	Established six new centres relevant to climate change in existing institutions in Himalayan states Created an observational network to monitor the health of the Himalayan ecosystem	US$81 million
Both mitigation- and adaptation-focused			
National Mission for a Green India	To use a combination of adaptation and mitigation measures to enhance carbon sinks in sustainably managed	Planned preparatory activities under way in 27 Indian states Received perspective plans from 11 states	US$2.1 billion

	forests and other ecosystems	Finalized implementation guidelines	
National Mission on Strategic Knowledge for Climate Change	To identify the challenge and the responses to climate change through research and technology development	Established 12 thematic knowledge networks Developed three regional climate models Trained 75 high-quality climate change professionals	US$403 million

In recent times India also has taken up climate change issues and opportunities as part of its larger diplomatic engagements at the regional and global levels. Two such recent efforts are likely to further strengthen climate change adaptation and mitigation actions in India:

- During U.S. President Barack Obama's 2015 state visit to India, both countries agreed to "enhance their bilateral cooperation on adaptation" and achieve greater Indo-U.S. collaboration to facilitate the crucial climate change agreement at COP21 in Paris (Press Information Bureau, 2015).
- Through the Indo-German Ministerial Level Dialogue (January 28, 2015), Germany confirmed its support of India's efforts to achieve a balance between mitigation and adaptation, and ensured its long-term cooperation to help India meet its adaptation financing needs ("Germany supports India's bid," 2015).

Through these agreements, India is gaining greater international support and recognition for its planned climate change adaptation and mitigation needs, including financial and technological needs. India, which aims to gain additional financial flow through the Green Climate Fund, has been reiterating the need for early financial contribution from developed countries to meet the agreed-upon US$100 billion target ("India for early financing," 2014).

The convergence of many such policies, programs, and sectoral plans is one of the key institutional innovations that the GOI has been undertaking to ensure synergy and effective use of resources. A GOI–UNDP Joint Programme on Convergence (2008–2012) helped facilitate this process at the national, state, and district levels (UNDP, 2012). Although climate change adaptation or mitigation issues were not part of this program, some of the key learnings around convergence have been instrumental in the design and development of the recent MOEFCC Convergence Guidelines related to the Green India Mission (GIM), the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) Convergence Guidelines (March 3, 2015), and the GIM-Compensatory Afforestation Fund Management and Planning Authority (CAMPA) Convergence Guidelines (May 1, 2015). The GIM is part of the NAPCC and aims to increase the quality of forest cover and enhance ecosystem services in the country, whereas CAMPA was established for compensatory afforestation, penal compensatory afforestation, and so on, in lieu of forest land diversion for various non-forestry activities/projects. Such convergence of a climate change–focused program with a wage employment program (MGNREGS) and a forest sector development program

(CAMPA) highlights efforts for greater institutional coordination and integrated planning across levels, working toward mainstreaming climate change issues as part of standard and popular development programs in the country (Aggarwal, 2015). Such convergence efforts by key nodal ministries at the federal level are also likely to further strengthen greater coordination in planning and implementation at the subnational level.

3.3 Institutional structure for climate governance

To facilitate its efforts to take action on climate change, the GOI has established a comprehensive institutional structure addressing this issue, as reflected in Figure 2. At the apex of this structure is the Prime Minister's Council on Climate Change, a high-level advisory panel with India's Prime Minister as its chairperson. It was originally established in 2007 and reconstituted in November 2014, when its objectives were revised to the following:

a) Coordinate a national action plan for assessments, adaptation, and mitigation of climate change.
b) Advise government on proactive measures that India can take to deal with the challenge of climate change.
c) Facilitate inter-ministerial coordination and guide policy in relevant areas.

The first meeting of the reconstituted Council was held on January 19, 2015, in the wake of U.S. President Barack Obama's state visit to India, and focused on identifying potential areas of Indo-U.S. collaboration on climate change (Goswami, 2015).

Day-to-day management of climate change issues is led, as previously noted, by the MOEFCC, which is the nodal federal agency responsible for climate change policy and planning in the country, including adaptation planning. The Ministry of External Affairs takes the lead in international climate negotiations and other processes such as negotiations under the UNFCCC. Housed within the MOEFCC is the Climate Change Division, the Expert Committee on Climate Change, and the National Steering Committee on Climate Change. While the Expert Committee looks after the overall technical and financial assessment of the State Action Plans, the National Steering Committee has the final authority to endorse the plans.

The new government, as part of Union Budget 2014, established the National Adaptation Fund for Climate Change in July 2014, with an initial allocation of INR 1.0 billion (US$20 million) to further scale up adaption actions in the country, especially in regions most at risk from climate change. Budgetary allocation for the Fund increased to US$16.67 million under the Union Budget 2015. Simultaneously, the government has made a proposal to establish the National Centre for Himalayan Studies in Uttarakhand, with a special focus on undertaking advanced scientific research on climate change adaptation issues in the fragile and climate-sensitive Himalayan regions.

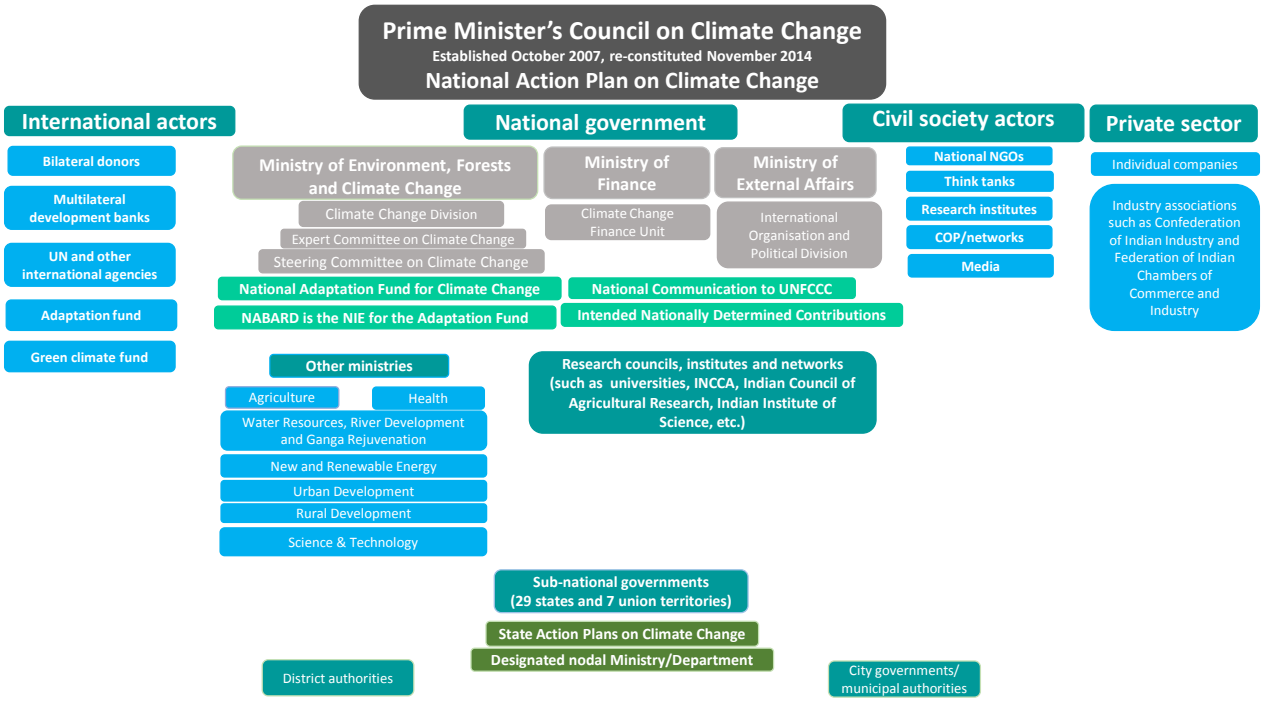

Figure 2 – Institutional arrangement for climate change adaptation policy planning and implementation in India

3.4 National-level sectoral policies

India's five-year plan and the NAPCC provide a framework for guiding adaptation action in different sectors. While concern has been expressed that these frameworks have not been clear and consistent in their approach to facilitating relevant and required changes in sectoral policies and planning (Dubash, Raghunandab, Sant, & Sreenivas, 2013), a number of India's major sectoral policies recognize climate change as a potential risk and have identified adaptation measures of various kinds. As described below, among these policies are the *National Water Policy*, the *Agricultural Policy Vision 2020*, and the *National Policy for Disaster Risk Management*. The progress India has made in integrating climate change concerns into these and other sectoral policies provides the basic institutional framework required to further refine and improve the strategies for more effective mainstreaming of climate change adaptation measures.

The *National Water Policy* (MOWR, 2012) recognizes climate risks and their differential impacts across India's diverse agro-climatic regions and states, and as part of the basic principles of public policy, states that "The impact of climate change on water resources availability must be factored into water management related decisions. Water using activities need to be regulated keeping in mind the local geo-climatic and hydrological

situation" (MOWR, 2012, p.3). The policy further cites better demand management, particularly through the adoption of compatible agricultural strategies, cropping patterns, and improved water application methods as means to enhance water use efficiency and capacity to cope with increased climate variability. Similarly, the document states industrial processes should be made more water efficient.

India's *National Environment Policy* (MOEF, 2006a) focuses on ensuring that people whose livelihoods are dependent on the sustainability of natural resources realize that a greater purpose will be served from conservation of these resources. Major objectives of the document include improving the livelihood security of the poor, integrating environmental concerns into economic and social development, maintaining efficiency in environment resources use, seeking good governance in management and use of environmental resources, and conserving critical environmental resources. The *National Environment Policy* recognizes climate change as a significant threat leading to possibly catastrophic disruptions to livelihoods, economic activity, living conditions, and human health. It identifies specific adaptation measures for freshwater resources (river systems, groundwater), mountain ecosystems, and coastal resources.

The *National Biodiversity Action Plan* (MOEF, 2008b) draws from the *National Environment Policy*'s principle that human beings are at the centre of concerns for sustainable development and they are entitled to a healthy and productive life in harmony with nature (MOEFCC, 2015). The objectives of the *National Biodiversity Action Plan* are expected to be realized through strategic implementation by the local, state, and central governments of India. Particular measures relevant to climate change adaptation include assessing the vulnerability of various important key sectors, implementing necessary adaptation actions, and identifying the scope for incorporating the outputs of these actions into relevant programs, including watershed management, coastal zone planning, infrastructure planning, agriculture, biodiversity, forestry, and health programs.

The *Agricultural Policy Vision 2020* (Indian Agricultural Research Institute, n.d.) aims to double India's present production of food and agricultural products by 2020. Remarkably, given that climate change has emerged as a significant factor influencing agricultural production in India, the policy does not specifically mention climate change as a potential risk. However, it does take note of degradation of natural resources and water scarcity as recurring and emerging issues that sustainable agricultural development must consider. It has a specific paragraph on water for sustainable food security that suggests that potential policy reforms may include the establishment of secure water rights to users, the decentralization and privatization of water, pricing reforms, and the introduction of appropriate water-saving technologies. The vision document further identifies the need for available dry-land technologies and technology-based agricultural growth. These measures are consistent with efforts to increase climate resiliency within the agriculture sector. The *National Policy for Farmers* (Ministry of Agriculture, 2007), an earlier document aiming to improve the economic viability of farming, acknowledges the adverse impacts climate

change will have. It cites that proactive measures to reduce vulnerabilities will be taken, particularly the development of contingency plans and alternative land-use and water-use strategies, along with providing experienced farmers with training in the management of drought, flood, and aberrant monsoons.

The *National Agroforestry Policy* (Ministry of Agriculture, 2014) recognizes the potential of agroforestry to become an important tool for building the resilience of farmers and rural people against the threats of climate change. One of the basic objectives of the policy is to protect and stabilize ecosystems, and promote resilient cropping and farming systems to minimize risk during extreme climate events. Specific measures outlined in the strategy to facilitate agroforestry include giving incentives to farmers for adopting agroforestry and promoting sustainable agroforestry for renewable biomass-based energy. Contract farming, public-private partnerships, and special purpose vehicle mechanisms may also be explored to promote and upscale agroforestry.

India's *National Policy for Disaster Management*, formulated in 2009, recommends that synergies in approach and strategies for climate change adaptation and disaster risk reduction be encouraged and promoted to meet the challenges of climate risk in a sustained and effective manner (Ministry of Home Affairs, 2009). In addition, the National Disaster Management Authority set up a core group of experts from scientific and technical institutions to identify broad research needs in disaster risk reduction, with emphasis on climate change and global warming relevant to India.

Surprisingly, climate change as a potential risk to health appears to be absent from the draft *National Health Policy* (Ministry of Health and Family Welfare, 2014). It does make mention of an expected stronger focus on preventive and promotive health addressing the wider social and environmental determinants of health, along with improved action to reduce air pollution.

To improve the sanitation situation in urban areas, the Indian government prepared the *National Urban Sanitation Policy* (Ministry of Urban Development, 2008). The overall goal of this policy is to transform urban India into community-driven, totally sanitized, healthy, and livable cities and towns. The policy requests that all states consider the impacts of climate change within any municipal, regional, or ward-wide sanitation plan development.

As laid out in the country's *Integrated Energy Policy* (GOI, 2006), a low domestic resources base and the large energy requirements needed to meet India's development goals pose a key challenge for the country's ability to maneuver on the energy front. The document recognizes climate change as a serious threat that may have severe impacts on livelihoods, economic activity, water resources, forests, agricultural activity, and health, requiring large-scale resources for adaptation measures. However, the policy calls exclusively for initiatives focused on mitigation efforts, suggesting a number of specific measures to reduce the greenhouse gas intensity of the economy by as much as one-third. It does not address the potential vulnerabilities of India's energy sector to the impacts of climate change. India's

Integrated Energy Policy is complemented by the *Strategic Plan for New and Renewable Energy Sector for the Period 2011–2017* (Ministry of New and Renewable Energy, 2011), which identifies climate change as an external factor that will drive the development of the country's renewable energy sector. The plan further emphasizes the positive environmental impact of renewable energy technologies and their contribution to a lower carbon footprint, but does not acknowledge the potential risk that climatic change poses to energy production.

Table 8 provides an overall assessment of the extent to which climate change has been integrated into these key sectoral policies and strategies. It demonstrates that India has begun to integrate climate change into a number of national and sectoral policies and plans, largely driven by concerns such as poverty, livelihood protection, and vulnerability. It also suggests, though, that greater progress will be needed in the future to better enable the country to adapt to the impacts of climate change.

Table 8 – Integration of climate change into national sectoral strategies, polices and plans: An assessment of progress

Policies	Absent	Climate change mentioned as potential risk	Possible actions for reducing risk identified	Targets identified for specific adaptation measures
National Water Policy (2012)		✓	✓	—
National Environment Policy (2006)		✓	✓	—
National Biodiversity Action Plan (2008)		✓	✓	—
Agricultural Policy Vision 2020		—	✓	—
National Policy for Farmers (2007)		✓	✓	—
National Agroforestry Policy (2014)		✓	✓	—
National Policy for Disaster Management (2009)		✓	—	—
National Health Policy (Draft) (2015)	✓	—	—	—
Integrated Energy Policy (2006)		✓	—	—
New and Renewable Energy Sector for the Period 2011-2017	✓	—	—	—

National Urban Sanitation Policy (2008)		✓	✓	—

3.5 Subnational policies

In an effort to make climate change planning more inclusive and needs-based, in 2009 the GOI requested that states develop their respective SAPCCs. The MOEF (now the MOEFCC) developed a common framework document with an overall objective to help the states identify and plan their adaptation and mitigation priorities and ensure those actions are aligned to the stated missions of the NAPCC. Because of a lack of both adequate climate change vulnerability data and requisite scientific capability at the subnational level, states encountered many challenges in preparing their action plans. Technical support from external donors and consultants sought to help bridge this gap in many cases (Dubash & Jogesh, 2014).

Draft SAPCCs, once submitted to the MOEFCC, go through a two-stage consultation process: the drafts are reviewed by the Ministry's Expert Committee on Climate Change for their technical feasibility, and based on the committee's recommendations the plans are subsequently endorsed by the National Steering Committee on Climate Change in the MOEFCC. To date, 30 states have prepared their SAPCC (MOEFCC, 2014) and, as of January 2015, 19 of these have been endorsed and 3 are under consideration by the National Steering Committee on Climate Change (MOEFCC, 2015). The overall budgetary requirement for implementation of these SAPCCs is around US$188.66 billion over a period of five years (2012–2017) (MOEFCC, 2014). While budgetary constraints and inadequate institutional capacities are some of the major challenges that states encounter as part of SAPCC implementation, the overall approach to and perception of these action plans as stand-alone implementable actions, rather than as opportunities for climate resilience development, have been the key deterrents (Dubash & Jogesh, 2014).

Provincial governments, because of their other development priorities, are often not in a position to allocate the required financial resources for implementing their SAPCCs. To address some of these resource gaps, the Working Group on Environment and Climate Change, established during development of the current Twelfth Five-Year Plan,[6] recommended, among other suggestions, additional financial allocation from the national government as central assistance (Planning Commission, 2013b). Recently, there has been a significant increase in federal assistance to provincial states for implementation of the 66 Centrally Sponsored Schemes,[7] rising from US$27.2 billion (INR 1.36 trillion) in 2013–2014 to US$67.6 billion (INR 3.38 trillion) in 2014–2015 ("PM Modi forms 3 sub-groups," 2015). This is in addition to the increased share of taxes states receive under the Fourteenth

[6] The Planning Commission established the Working Group on Environment and Climate Change for support in development of the Twelfth Five Year Plan on July 17, 2011 (Planning Commission, 2011).
[7] For a complete list of all 66 Centrally Sponsored Schemes in India, see Parliament of India (2013).

Finance Commission. Such a substantial increase of financial resources, along with major institutional changes to foster and strengthen "cooperative federalism" with greater devolution of power and decision-making to provincial governments, will help provinces meet the financial requirements to fund adaptation activities.

The National Fund for Climate Change Adaptation, established in July 2014, is meant to mobilize the greater amount of funding required to meet adaptation planning and implementation needs at various levels. The other key decision of the national government that will give further autonomy to the provincial governments for development planning and resource allocation is the newly established National Institute for Transforming India (NITI Aayog), which replaced the Planning Commission of India. In its first governing body meeting, on February 7, 2015, chaired by the prime minister and attended by chief ministers, each state was asked to establish two task forces on poverty alleviation and future development of agriculture. This renewed focus on poverty alleviation and agriculture development at the subnational level will help states better integrate their adaptation and mitigation needs and plans into these larger development plans and priorities. These initiatives have further bolstered the efforts of subnational governments to design and implement adaptation planning. Along with increased access to additional revenue through the planned increase in transfer of tax revenue to the provinces, subnational governments will be in a stronger position to allocate the required financial resources for their adaptation needs.

Over and above these provincial government initiatives, there are many climate change adaptation initiatives being undertaken at the city level. The Rockefeller Foundation–supported Asian Cities Climate Change Resilience Network (ACCCRN) program, launched in 2008, helped city governments and stakeholders in the cities of Gorakhpur, Indore, and Surat. The initiatives have since been scaled up to include 30 other Indian cities.[8] A CDKN-supported Future Proofing Indian Cities (2013–2014) project[9] aimed to help cities develop climate risk plans, facilitated urban diagnostic assessments of 59 Indian cities, and helped cities develop a robust evidence base for future planning and investments. The Union Cabinet of India has recently approved two urban missions: the Smart Cities Mission and the Atal Mission for Rejuvenation and Urban Transformation, with an initial budgetary allocation of INR 480 billion (US$9.6 billion) and INR 500 billion (US$10 billion) respectively ("100 smart cities," 2015). The Union Cabinet envisages building 100 "smart" cities[10] and rejuvenating another 500 cities under the Atal Mission for Rejuvenation and Urban Transformation program. Both of these programs have specific focus on integrating climate change adaptation and measures into their planning and design.[11] Many municipal

[8] Further information about this project may be found at ACCCRN (n.d.).
[9] For further information, see CDKN (n.d.).
[10] Although there is no single definition of what constitutes a "smart" city, the general objective of India's initiative is to promote cities that provide core infrastructure (e.g., clean water, sanitation, public transit), provide their citizens with a decent quality of life, and use modern technologies and solutions (including e-government).
[11] Additional information is available at Ministry of Urban Development (n.d.).

authorities, as part of their Smart City planning and preparation, are undertaking very specific sectoral adaptation planning and have come up with innovative adaptation plans. One such example is the Municipal Corporation of Shimla in the Himalayan State of Himachal Pradesh, which was one of the six cities selected for the United States Agency for International Development (USAID)-funded Climate Adaptation Partnership Program managed by the International City/County Managers' Association (ICMA International, 2015). As part of this program, the Municipal Corporation of Shimla, in association with the city of Boulder, in the United States, is preparing an adaptation plan for its water sector (Lohumi, 2015).

4. Current and planned adaptation programs and projects

Climate change adaptation programs in India have been growing in scale and across sectors. This expansion has been enabled by financing received through India's national budget and the support of some bilateral donors and international research organizations. Diverse actors at various levels are leading and supporting adaptation projects and programs initiated in India. Given the size of the country, it is not feasible to identify and document every adaptation project, and hence this section presents a snapshot of selected projects to provide a representative sample of some of the current adaptation efforts in the country. A discussion of financing for adaptation project and programs then follows.

4.1 Adaptation projects and programs

As part of this study, we used online resources to identify adaptation programs and projects in India with a specific focus on supporting climate change adaptation, as reflected in their title and/or objectives. We captured identified projects in a database and classified them by their type and area of focus. Annex A provides details on the methodology used within this component of the review. The review process identified more than 30 internationally funded adaptation projects, spanning diverse sectors, as summarized in Table 9 and presented in more detail in Annex B.

A wide range of adaptation programs and projects are under way in India, addressing needs in different sectors, in different regions, and from the local to the national levels. As summarized in Table 9, agriculture, water, and disaster risk reduction are some of the key sectors where the numbers of adaptation projects are comparatively high. While the NATCOM-II analysis, as well as many climate change research findings, present basin-wide climate change impacts in some of the major basins in the country, our research did not come across any adaptation project at the basin level. Many of the adaptation projects are located in the climate-sensitive Himalayan and coastal regions. A larger number of these projects focus on climate risk assessment and adaptation planning at the community level. There are very few adaptation projects and initiatives in the climate-sensitive regions in the

northeast of India and the islands in the Indian Ocean and the Sundarbans region. Two areas that have so far received relatively little attention are gender dimensions and health issues. Adaptation needs of some marginalized groups, such as small and marginal farmers, tribal communities, and nomadic tribes (such as those in the arid and semi-arid regions of western India and in the Himalayas), do not appear to be adequately studied and addressed so far.

Adaptation projects and programs in India are supported through some existing government programs as well as through stand-alone initiatives. For example, some of India's flagship social sector development programs, such as the MGNREGS, the National Rural Livelihoods Mission,[12] and the National Urban Livelihoods Mission,[13] have been identified as crucial programs for effectively implementing large-scale community-level adaptation actions. Work by MGNREGS, for instance, has resulted in increased environment benefits (such as for land, water, and crop systems) and reduced risks of climate vulnerabilities among communities (Indian Institute of Science, 2013).

Table 9 – Sector of focus of current adaptation projects and programs identified in India

Sector of focus	India's priority sectors for adaptation	Number of projects[a]	Percentage of total projects[b]	Geographical scale	
Agriculture	✓	9	30%	National projects	15
Forestry	✓	1	3%	Regional projects	10
Freshwater fisheries	✓	2	7%	Global projects	5
Freshwater supply	✓	5	17%	Total	30
Watershed management	✓	5	17%		
Coastal zone management	✓	3	10%		
Ecosystem conservation		3	10%		
Disaster risk management	✓	7	23%		
Gender		2	7%		
Insurance		2	7%		
Energy	✓	1	3%		

[12] For more information visit National Rural Livelihoods Mission (n.d.).
[13] For more information visit National Urban Livelihoods Mission (n.d.).

Urban areas	✓	4	13%
Human health	✓	1	3%
Climate information	✓	4	13%
Government		10	33%
Civil society		3	10%
Multisectoral		3	10%
Other[c]		4	13%

[a] Individual projects may address one or more sectors.

[b] Calculated by the number of projects active in this sector relative to the total number of projects identified, reflecting the potential for a single project to be addressing adaptation needs in more than one sector.

[c] For each of the following categories, one project was identified as addressing needs pertaining to the sector: biodiversity protection, migration, transportation, and social protection.

Agriculture is one of the key sectors that has attracted significant climate change investments in India, for both mitigation and adaptation. Domestically financed projects include the National Initiative in Climate Resilience Agriculture, which was launched in 2011 with the overall objective to enhance the resilience of Indian agriculture (crops, livestock and fisheries) to climate change and climate variability through strategic research, technology demonstration, and capacity building. The program has been successful in demonstrating and promoting farm-level, easy-to-adopt climate-resilient technologies such as improved crop varieties, crop diversification, and other agricultural practices (Central Research Institute for Dryland Agriculture, 2014).

Many adaptation efforts in the Indian agriculture sector are under way with support from international initiatives such as the Climate Smart Agriculture initiatives of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) and a special program on the gender dimensions of agriculture and climate change in India through a joint Food and Agriculture Organization (FAO)-CCAFS initiative under the Mitigation of Climate Change in Agriculture Program (FAO, 2013). CCAFS, in association with many subnational governments, is piloting the Climate Smart Village approach in different agro-climatic regions across the country to improve food security and resilience among farming and farm-dependent communities. Similarly, building on the opportunities through the National Rural Livelihood Mission, a national program of the Ministry of Rural Development, the World Bank is supporting an innovative Sustainable Livelihoods and Adaptation to Climate Change project in 200 villages in the states of Madhya Pradesh and Bihar.

Such livelihood diversification and efficient natural resource use initiatives have also promoted private enterprise and corporate participation with farmer groups and civil society organizations to build the adaptive capacities of farmers through technological and

financial innovation. For example, Jain Irrigation System, a leading manufacturer of irrigation systems, has been promoting the micro-drip system in many water-stressed regions of India and helping farmers better adapt to climate-related stress and water shortage. In an effort to further scale up these climate adaptation technologies for farmers, in 2014 Jain Irrigation System entered into a memorandum of understanding with TERI, India's leading climate change research and policy institute (TERI, 2014a).

Many adaptation measures in the water sector have capitalized on the existing institutions of water resource use and access. For example, the traditional participatory watershed development approach, promoted by the GOI as part of its Drought Prone Area Program, has proven to be an effective platform to mobilize community-based climate change adaptation action in the drought-prone regions of Maharashtra (Gray, 2013). This project is being implemented by the Watershed Organization Trust in association with the World Resources Institute (WRI) and the Swiss Development Corporation (SDC). This approach has been successful in supporting community-led water-budgeting, agro-meteorology installations, livelihood diversification, and biodiversity and ecosystem conservation in the region.

Climate change impacts on the hydrological cycle and water resources in the mountain regions of the Himalayas are likely to result in erratic flow in glacier- and snow-dependent river systems and negatively affect the livelihoods of tens of millions of people dependent on these rivers. The National Mission for Sustaining the Himalayan Ecosystem, under the NAPCC, aims to support effective adaptation actions in the Indian Himalayan Region through the use of robust scientific evidence and multistakeholder partnerships across the region. Some of the major policy-oriented climate change research initiatives in this region are the Himalayan Climate Change Adaptation Programme, led by the International Centre for Integrated Mountain Development, and the joint SDC–Ministry of Science and Technology (GOI) Indian Himalayas Climate Adaptation Programme. Climate change impacts on ecosystem services in the mountains and ways to strengthen communities' adaptive capacity have been the focus of many recent initiatives. One such initiative is the Himalayan Adaptation, Water and Resilience project being implemented as part of the CARIAA program.

Coasts and coastal regions are particularly vulnerable to climate change impacts such as sea-level rise, coastal flooding, and cyclonic storms. The National Cyclone Risk Mitigation Project, support by the World Bank, is one of the most comprehensive programs in the coastal states of Andhra Pradesh, Odisha, and Gujarat. In addition to cyclone risk mitigation infrastructures, this project is also facilitating community-based risk management plans and capacity building of line departments. Similarly, a European Commission–funded and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)-managed program on Strengthening Adaptation Capacities and Minimizing Risks of Vulnerable Coastal Communities in India was implemented between 2011 and 2013 in the coastal regions of Andhra Pradesh and Tamil Nadu.

4.2 Climate finance

Financing for adaptation action in India is derived primarily from national budgets. Table 10 demonstrates the significant budgetary allocation in 2015–2016 to various national government programs that are directly or indirectly contributing to climate change adaptation and resilience across sectors. A systematic analysis of India's budgetary allocation for climate change adaptation programs found that the allocation has grown from 1.7% of GDP in 2006–2007 to 2.68% of GDP in 2009–2010 (Ganguly & Panda, 2010). As reflected by the presented 2015–2016 budgetary allocations, most of these allocations were through traditional development programs of poverty alleviation, natural resources management, health and sanitation, education, and disaster management. Of this 2.68% of budgetary allocation, around 2.2% of GDP was allocated toward adaptation programs aimed at building human capabilities and their assets (such as poverty alleviation, livelihood stabilization, and food security) and 0.46% of GDP to natural resources management (Ganguly & Panda, 2010). This low level of integration (2.68%) highlights some of the gaps in existing policy and practice, which have yet to internalize the development-adaptation continuum and the opportunities for climate-proofing the country's development investments and gains.

Table 10 – Financial allocation for national government programs contributing to climate resilience in India

National Government Programs contributing to climate change resilience in India	Budgetary allocation (2015–2016) in INR crores*	Equivalent in US million dollars**
MGNREGS	34,699.00	5,443.16
Prime Minister's Employment Generation Programme	1,050.00	164.71
Pradhan Mantri Krisj Sinchai Yojana (includes watershed development and micro-irrigation facilities)	5,300.00	831.40
Krishyonnati Yojana	3,257.00	510.92
Rashtriya Krishi Vikas Yojana (integrated pest management, soil health, seed farms, market development, etc.)	4,500.00	705.91
National Crop Insurance Programme	2,588.00	405.97
Dairy Vikas Abhiyaan	481.50	75.53
Blue Revolution	410.69	64.42
National Rural Livelihood Mission	3,343.00	524.41
Forestry (National Afforestation and Eco-Development)	688.00	107.93
Urban Rejuvenation Mission	6,000.00	941.21

Ruban Mission***	300.00	47.06

*Based on Major Programmes under Central Plan, Union Budget 2015–2026 (Ministry of Finance, 2014). http://indiabudget.nic.in/ub2015-16/bag/bag42.pdf. 1 crore = 10 million.

**Conversion rate of US$1 = INR 63.74.

*** The mission is to "improve the quality of life standard of living in Rurban clusters to bridge the rural urban divide and to reduce migration from rural to urban areas and facilitate reverse migration" (Ministry of Finance, 2014, p. 20).

In addition to its own budgetary allocation, India is also a top recipient of international financial assistance for climate change adaptation and mitigation planning and programs. While most international financing supports national and subnational governments, specific information pertaining to fund disbursements, sectors, regions, and timelines is very often difficult to obtain. Some clarity is provided through the OECD's Rio Markers system. Its data for bilateral development aid for India for which adaptation is a principal or significant component is presented in Figure 3. These findings suggest that relatively little of the official development assistance flowing to India specifically aims to support adaptation. The OECD's reporting also indicated that the bulk of bilateral support for adaptation in India is directed to the water supply and sanitation sector, followed by banking and financial services (OECD, 2015).

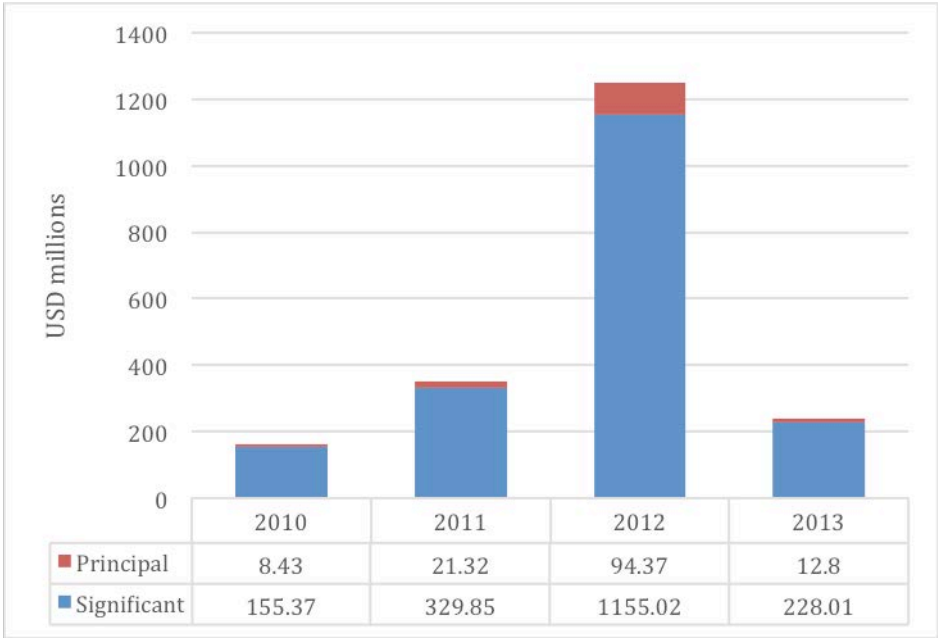

Figure 3 – Bilateral development aid in India identified as having adaptation support as its principal or significant objective,[14] 2010 to 2013, constant 2012 prices (based on OECD, 2015)

[14] Based on the definitions used by the OECD Rio Markers system, activities are considered to have supporting adaptation as their "principal" objective "when promoting the objectives of the UNFCCC is stated in the activity documentation to be one of the principal reasons for undertaking the activity. In other words, the activity would not have been funded but for that objective.

A different perspective on climate financing in India is provided through a review of the findings of the Climate Funds Update, which tracks financing allocated from dedicated multilateral and bilateral climate funds since 2003. Based on their data, as presented in Figure 4, India has been the top recipient of financing through climate funds in comparison to its neighbours in South Asia. The vast majority of these funds, however, have been directed toward mitigation-focused activities (US$611.7 million) as opposed to adaptation (US$18.8 million) (as of April 2015). When funding for adaptation only is considered, India receives significantly less support from dedicated climate funds compared to Bangladesh and Nepal. Adaptation initiatives in India have not received adequate financing through these bilateral and multilateral climate funds, and adaptation remains an underfunded domain.

	South Asia			
	Bangladesh	India	Nepal	Pakistan
Adaptation	$134.5	$18.8	$106.4	$7.3
Mitigation - General	$7.1	$611.7	$45.9	$13.5
Mitigation - REDD*	$2.3	$0.0	$4.4	$0.0
Multiple Foci	$9.1	$22.8	$0.0	$0.0

*Reducing emissions from deforestation and forest degradation

Figure 4 – Comparison of approved funding from designated multilateral and bilateral climate funds to countries in South Asia since 2003, as of April 30, 2015 (based on Climate Funds Update, 2015)

Activities marked "significant" have other prime objectives, but have been formulated or adjusted to help meet climate concerns" (OECD, 2011, p.3).

5. Networks and communities of practice

Communities of practice and networks can play a critical role in facilitating the exchange of information, tacit knowledge, and expertise regarding adaptation needs, options, and priorities between civil society, governments, and the private sector. Through their actions at the local, subnational, and national levels, they can also help shape the policy debate around climate adaptation. In India, a few active and prominent networks are engaged in these activities.

Amongst these are research-focused networks such as the Indian Network for Climate Change Assessment (INCCA), launched by the MOEF in October 2009. It was conceptualized as a network-based scientific program designed to assess the drivers and implications of climate change through scientific research and to build capacity toward management of climate change–related risks and opportunities. One of the two assessments completed by INCCA so far is a regional analysis of climate change in the 2030s. It formed part of the scientific basis for the design of India's climate change planning, including the NAPCC (2008) and its National Communications to the UNFCCC

At the national level, India's newly established NITI Aayog, which replaced the Planning Commission, has become prominent in initiating multistakeholder discussions on key national development agenda items that have great scope in influencing specific sectoral policy. For example, the NITI Aayog, in association with the International Energy Agency, recently organized such a stakeholder discussion to feed into the National Energy Policy ("NITI Ayog in talks," 2015).

Other networks have been established with the support of international organizations. For example, the Rockefeller Foundation–supported ACCCRN is one of the most active and visible network in urban adaptation planning and policy engagement in India. Launched in 2008, the network involves about a dozen cities in India and works at the nexus of climate change, vulnerable and poor communities, and urbanization. The Climate Change Knowledge Network in Indian Agriculture (CCKN-IN) has been established with the support of GIZ. It seeks to support the establishment of knowledge networks that will bring together national-, state-, and district-level agricultural actors to access and share information. Similarly, the Watershed Organization Trust and WRI, as part of the SDC-supported Scaling Up Good Adaptation Practice in India project, have proposed establishing the India Adaptation Learning Hub, a platform to share climate change adaptation practices, insights, and technologies and to support policy engagement at various levels (WRI 2014). Along with these networks, many practitioners, mostly from civil society organizations and development agencies, are involved in Climate Action Network South Asia.

Along with networks such as these, India is home to a number of prominent research institutes that influence the national discussion on climate change adaptation. Some of the key research institutes instrumental in informing climate change adaptation policy and

practice in India are the Indian Agricultural Research Institute, the G.B. Pant Institute of Himalayan Environment and Development, WRI-India, TERI, the Indian Institute for Human Settlement, the Council on Energy, Environment and Water, the Centre for Policy Research, and the Center for Science and Environment. Most of these institutes provide research-based inputs to designated ministries at the national and subnational levels.

As well, there are many NGOs actively engaged in adaptation practice and innovation at the community level. Organizations such as the M. S. Swaminathan Research Foundation, Watershed Trust Organization, Development Alternatives, and WWF-India have been at the forefront of adaptation practice and on-the-ground implementation in various parts of India. For most of these agencies and networks, a key challenge in the present context is the GOI's recent decision to strictly monitor various agencies supported by external donors through the Foreign Contribution Regulation Act (Singh, 2015).

6. Conclusions

India's climate change vulnerability context is changing as many life-supporting economic sectors and ecosystems are becoming more exposed to climate risks. Climate-related stress and shocks have negatively affected agriculture, forest, and water resources, which are key to the livelihood security of tens of millions of people. Multi-level interaction of these stresses with the country's existing socio-economic and political factors has given rise to new forms of vulnerabilities among many resource-dependent but marginalized sections in Indian society. Emerging socio-economic conditions, such as increased rural-urban migration and feminization of agriculture, are further reinforcing the vicious cycles of marginalization, poverty, and vulnerability in both urban and rural regions in the country. Many climate-related extreme weather phenomena, such as cloudbursts, heavy precipitation, and heat waves, are on the rise in many parts of India. The resulting economic loss and socio-ecological damages have negatively affected the state of the economy, including years of investment and development gains. Climate change adaptation research and on-the-ground initiatives in India have not only built an evidence base of the country's vulnerabilities, but have also highlighted the capacities of various stakeholders and other institutional opportunities to facilitate effective adaptation planning and implementation at various levels.

For an emerging economy like India, such climate change impacts pose additional development and governance challenges. India has been proactive in identifying its climate change priorities and established the NAPCC in 2008. This action plan consists of eight missions, addressing both the adaptation and mitigation needs of the country. Climate change also figures high on the political agenda of the current Indian government, which came into power in June 2014. Climate change issues in general, and those relating to adaptation in particular, are gaining new ground in policy planning and public discourse in India, as reflected by the series of policy initiatives and institutional restructuring in the recent past. The new government has been undertaking definite policy decisions to further

strengthen climate change adaptation actions in India; primary among these decisions was the establishment of the National Adaptation Fund for Climate Change in June 2014.

India's federal structure of governance very often poses institutional and financial challenges to the planning and implementation of regular development programs. To deal with such challenges in climate change adaptation and mitigation planning, the national action plan provided a common framework for the subnational governments to prepare their respective SAPCCs. The entire process of preparing such action plans and their subsequent endorsement by the federal ministry of environment was initially plagued by a lot of confusion and a lack of clear understanding. But continuous engagement between the federal government and subnational governments has been instrumental in developing clarity of purpose on climate change actions. Many external agencies have facilitated these processes through technical and financial support to the subnational governments and in turn have enhanced their capacities for planning and implementation of adaptation actions.

India's adaptation needs are diverse, as reflected in its NATCOM-II, released in 2012, and also in recent engagements, both at the international and domestic levels. India reiterated the need for greater support for and investment in adaptation at the 2014 UNFCCC Climate Conference in Lima and has been actively pursuing climate change issues at the domestic level. As highlighted earlier, it plans to include climate change adaptation in its INDC to be submitted prior to the UNFCCC Climate Conference in Paris in December 2015.

One of the key challenges around adaptation planning and implementation in India has been lack of adequate financial resources, meaning that a majority of adaptation needs remain unmet. Efforts to mainstream climate change adaptation and disaster risk reduction into sectoral development plans and infrastructure development have addressed some of these gaps. Recent policy initiatives around fiscal federalism have substantially increased financial allocation to subnational governments. This could help subnational governments better manage their resources by meeting their identified development priorities, including climate change adaptation. Additionally, the government has decided to develop four new missions (on wind energy, human health, waste-to-energy, and coastal areas) in addition to the existing eight missions under the NAPCC (Sinha, 2015). This decision reflects the government's continuous efforts in ensuring improved integration of climate change issues, both adaptation and mitigation, into the country's larger development policy and priorities.

International adaptation finance also has been able to fill some of these resource gaps. India has been one of the top recipients of climate change–related aid from bilateral and multilateral sources, but much of this funding has gone toward mitigation projects. In recent years, though, through its strategic diplomatic engagements, India has been successful in mobilizing international support for its adaptation priorities over its mitigation and greenhouse gas emission reduction targets. As well, India is one of the leading advocates for early operationalization of the Green Climate Fund and aims to gain additional external financial support for adaptation programs through it.

As mentioned earlier, most of these actions are going to be implemented at the subnational level through SAPCCs, and this presents newer opportunities for subnational governments to take a lead in adaptation planning and implementation. Communities of practice and networks of organizations that actively engage in adaptation planning could build on these opportunities at the subnational level.

More importantly, there is a growing interest among the subnational governments to further refine and reorient their SAPCCs to capitalize on climate change adaptation and mitigation opportunities and climate-proof their development investments and infrastructure planning. Needs, as well as opportunities, are very context specific, but many commonalities exist. Primary among them is the need for a robust scientific evidence base on climate change impacts at the subnational and district levels. For example, the Indian Sundarbans Delta Vision prepared by WWF-India in 2011 identifies a number of climatic and non-climatic drivers of vulnerability in the delta and proposes suitable adaptation and disaster risk reduction measures (Danda, Sriskanthan, Ghosh, Bandyopadhyay, & Hazra, 2011). Such micro-level climate change impact assessments and the requisite capacity to undertake them are very limited at the moment. Clarity of issues at the micro-level is essential to help decision-makers and adaptation planners better understand the process and prioritize their actions.

In addition to the community of researchers and practitioners in India, the private sector is emerging as a key player in adaptation planning, mostly through partnership in research and development of technologies and business innovation for climate change adaptation. For example, the GOI's new initiative of 100 Smart Cities has opened up avenues for the private sector to help build climate-smart and inclusive cities.

Through many such innovative initiatives, India has been making significant progress in climate change adaptation planning and implementation. This has led to a shift in perception and practice of adaptation planning from being a stand-alone initiative toward being an integrated process of climate-resilient development planning.

7. Annexes

Annex A: Methodology

This section presents the research parameters established to guide development of the standardized reviews of current adaptation action in the CARIAA program's countries of engagement. It sets forward definitions used in this study, particularly with respect to the identification, selection, and classification of programs and projects considered in the review. This methodology was previously developed by the International Institute for Sustainable Development to support a review of current and planned adaptation action in 12 regions, which was completed in 2011 for the Adaptation Partnership. Modest updates to this original methodology were made to support the current review undertaken for the CARIAA program. For more information, see Adaptation Partnership (2015).

A.1 Adaptation actions included in the review

Within the review, adaptation action was defined as "policies, programs, and projects designed and implemented specifically to address the current and projected impacts of climate change." Therefore, the review focused on examining policies, programs, and projects in which specific reference has been made to supporting adaptation to climate change or climate risk reduction.

Consistent with this definition, the review gave attention to discrete, time-bounded programs and projects designed and implemented specifically to support preparation for or implementation of practical adaptation actions within the broader context of achieving development objectives. Therefore, at least one of the following terms appeared in the title, goals statement, or objectives statement of each program or project included in the review: "adaptation," "climate change adaptation (CCA)," "climate risk management," or "climate vulnerability reduction."

Based upon these parameters, the following types of programs and projects were not included in the review: disaster risk reduction, prevention, or management projects, unless they specifically reference that this activity is being undertaken in support of CCA; primary scientific research studies (for example agrology, botany, or meteorology) on the potential impacts of climate change (for example on changes in crop production, glacial melt rates, or typhoon patterns); long-term monitoring efforts (whether climatic or socioeconomic) needed to inform decision-making; stand-alone workshops, conferences, and training programs; and capacity building to support participation in processes related to the UNFCCC (such as training for negotiators, enabling activities to prepare reports).

The following additional parameters were established to guide the selection of programs and projects incorporated in the study:

- *Official start date.* To ensure that only "current" projects were included in review, selected projects needed to have begun on or after January 1, 2012, with the exception of projects that began before this date but were still ongoing as of January 1, 2015.
- *Official end date*. Ongoing projects are those who official completion day is on or after January 1, 2015. Projects completed after January 1, 2012, were classified as completed.
- *Funding characteristics*. Projects with a value of US$100,000 or more were included in the study. However, reflecting the greater level of adaptation action underway in Bangladesh and India, the minimum value of projects included in the reviews for these two countries was raised to US$250,000. Projects financed by international and domestic sources of funding were considered.

Additionally, identified projects were classified by geographical scale in accordance with the following definitions:

- Global: Projects involving countries throughout the world, including the profiled country.
- Regional: Multi-country projects within a particular subregion, be it a continent or subcontinental area (such as South Asia or West Africa), that includes the profiled country.
- National: Projects occurring within one country.

A.2 Type of project being undertaken

To better understand the orientation of the projects underway in the countries examined as part of the review, projects were classified by type using the following definitions:

- *Research*. Encompassing efforts to develop new knowledge or organize existing information so as to increase understanding of the links among climate change, human society, and ecosystems and inform adaptation decision-making.
- *Assessment*. Encompassing risk, impact, and vulnerability assessments, as well as monitoring of ecological and societal trends.
- *Capacity building*. Encompassing the provision of technical training, technical assistance, institutional strengthening, and education.
- *Knowledge communication*. Encompassing efforts to share information, knowledge, and practices related to CCA, including awareness raising and engagement of media.
- *Policy formation and integration*. Encompassing efforts to inform, develop, and implement CCA plans, strategies, frameworks, and policies at the local, subnational, national, and international levels.
- *Field implementation*. Encompassing physical measures to reduce vulnerability to the impacts of climate change, including the implementation of pilot projects, construction of infrastructure, development and modification of technologies, and management of physical resources.

- *Community-based adaptation*. Encompassing actions that directly engage community members in efforts to understand, plan for, and respond to the impacts of climate change.

A.3 Sector or area of focus

To further inform analysis of the range of adaptation action taking place in each country reviewed, programs and projects examined in the study were classified by sector using the following definitions:

1. **Food, fibre, and forests**. Defined as the management and use of terrestrial natural resources to directly improve human well-being. Its subcategories are:
   - *Agriculture*. Encompassing subsistence agriculture, commercial agriculture, and the rearing of confined domestic animals.
   - *Pastoralism*. Encompassing the use of domestic animals as a primary means for obtaining resources from habitats (UNEP, 2007), particularly in nomadic and semi-nomadic communities.
   - *Forestry*. Encompassing afforestation, reforestation, agroforestry, commercial forestry, community-based forest management, and woodland management.
   - *Fire management*. Encompassing monitoring, planning, and management to address the impact of fires on settlements and ecosystems, including forested and grassland ecosystems.
   - *Aquaculture.* Food production through the rearing of aquatic animals, such as fish, crustaceans, and molluscs, or the cultivation of aquatic plants in natural or controlled marine or freshwater environments.

2. **Ecosystems**. Defined as a system of living organisms interacting together and with their physical environment, the boundaries of which may range from very small spatial scales to, ultimately, the entire Earth (IPCC, 2001). Its subcategories are:
   - *Biodiversity protection*. Encompassing activities related to the maintenance of living organisms at various spatial scales, including the establishment and protection of parks and bioreserves.
   - *Ecosystem conservation*. Encompassing efforts to *maintain* the health of particular ecosystems, such as wetlands, grasslands, forests, mangroves, and coral reefs.
   - *Ecosystem restoration*. Encompassing efforts to *restore* the health of particular ecosystems, such as wetlands, grasslands, forests, mangroves, and coral reefs.

3. **Freshwater resources**. Defined as the management and use of freshwater contained in terrestrial ponds, lakes, rivers, and watersheds, among others. Its subcategories are:
   - *Freshwater fisheries*. Encompassing the catching, packing, and selling of fish and shellfish derived from lakes, rivers, and ponds, as well as through freshwater aquaculture.

- *Watershed management*. Encompassing management of the basins that supply water to different streams, rivers, lakes, and reservoirs, including integrated watershed management.
- *Freshwater supply*. Encompassing efforts to access and preserve freshwater for human consumption and use, including drinking water sources, groundwater resources, rainwater harvesting, and water infrastructure such as wells, dams, and dikes.

4. **Oceans and coastal areas**. Defined as the management and use of coastal areas and oceans. Its subcategories are:
   - *Coastal zone management*. Encompassing the management of land and water resources in coastal areas, including through integrated coastal zone management and the establishment and maintenance of coastal infrastructure.
   - *Marine management*. Encompassing the management and use of offshore ocean and sea resources.
   - *Marine fisheries*. Encompassing the catching, packing, and selling of fish, shellfish, and other aquatic resources found in the oceans and seas, including through marine and coastal aquaculture.

5. **Disaster risk management**. Defined by the United Nations International Strategy for Disaster Reduction (2009) as the "systematic process of using administrative directives, organizations, and operational skills and capacities to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster" (p. 10). It includes emergency response measures, preparation for extreme events and early warning systems. No sub-categories were established in relation to this macro project category.

6. **Migration and security**. Defined as efforts to support the movement of people and maintain their personal security in the face of incremental climate changes or climate shocks.
   - *Migration*. Encompassing preparations for and responses to the potential movement of people from one location to another due to climate change impacts.
   - *Security*. Relating to personal security and freedom from violence, crime, and war due to natural and human-induced disasters (UNEP, 2007) and encompassing peace building, conflict reduction, and conflict avoidance.

7. **Gender**. Defined as the social attributes and opportunities associated with being male and female and the relationships between women and men, and girls and boys, as well as the relations among women and among men. These attributes, opportunities, and relationships are socially constructed and are learned through socialization processes (United Nations Entity for Gender Equality and the Empowerment of Women, n.d.). This category includes efforts to understand the vulnerability of women to the impacts of climate change, gender-sensitive adaptation strategies, and measures to improve the

situation of women at the local and policy level, including through gender mainstreaming. No subcategories were established in relation to this macro project category.

8. **Business**. Defined as the purchase and sale of goods and services with the objective of earning a profit. Its subcategories are:
   - *Tourism*. Encompassing the adjustment and development of tourist facilities and operations to account for current and future vulnerabilities, including these actions in relation to ecotourism.
   - *Private sector*. Encompassing potential impacts of climate change and potential adaptation strategies on the diverse activities underway in the portion of the economy in which goods and services are produced by individuals and companies including industry, mining, and other economic sectors.
   - *Trade*. Encompassing the exchange of goods and services within and between countries.
   - *Insurance*. Encompassing the development, testing, and adjusting of insurance and risk-management schemes, including weather-based index systems.

9. **Infrastructure**. Defined as the basic equipment, utilities, productive enterprises, installations, institutions, and services essential for the development, operation and growth of an organization, city or nation (IPCC, 2001). Its sub-categories are:
   - *Energy*. Encompassing energy-related systems and infrastructure, including small-scale and large-scale energy generation through hydroelectric power generation, wind, solar, and other forms of traditional and new energy sources, as well as transmission networks.
   - *Transportation*. Encompassing the components of the system required to move people and goods, including roads, bridges, railway lines, shipping corridors, and ports.
   - *Waste management*. Encompassing sanitation, sewage systems, drainage systems, and landfills.
   - *Buildings*. Encompassing actions related to built structures such as houses, schools, and offices, including changes to building codes, building practices, and green ways of construction.

10. **Human settlements**. Defined as a place or area occupied by settlers (IPCC, 2001). Its subcategories are:
    - *Peri-urban areas*. Encompassing the outskirts of urban centres and the transition zones between rural and urban areas.
    - *Urban areas*. Encompassing municipalities, towns, and cities, as well as areas in these centres (such as slums).
    - *Rural areas*. Encompassing villages and other small settlements, as well as rural landscapes and integrated rural development.

11. **Human health**. Defined as a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity (WHO, n.d.). It includes efforts to assess vulnerabilities to and the impacts of climate change on human health directly and indirectly, and the development and implementation of appropriate adaptation strategies at the local, regional, and national levels. No subcategories were established in relation to this macro project category.

12. **Climate information services**. Defined as the production and delivery of authoritative, timely, and usable information about climate change, climate variability, climate trends, and impacts to different users at the local, subnational, national, regional, and global levels. It includes efforts to develop, adjust, and provide short- and long-term climate forecasts, including climate change projections, to different audiences. No subcategories were established in relation to this macro project category.

13. **Governance**. Defined as the institutions (laws, property rights systems, and forms of social organization) through which societies define and exercise control over resources (UNEP, 2007). Its subcategories are:
    - *Government*. Encompassing efforts to build the capacity of government officials, either at the national or subnational level, to prepare for and facilitate adaptation to climate change, including through the development of policies, plans, frameworks, and strategies, as well as the establishment and operation of climate change trust funds.
    - *Civil society*. Encompassing efforts to build the capacity of the public, including NGOs, to understand, prepare for, and respond to climate change.

14. **Social protection**. Based on DFID's definition of social protection, projects within this category focus on three sets of instruments to address chronic poverty and vulnerability:
    - *Social insurance*. Referring to "the pooling of contributions by individuals in state or private organizations so that, if they suffer a shock or change in circumstances, they receive financial support."
    - *Social assistance*. Encompasses "non-contributory transfers that are given to those deemed vulnerable by society on the basis of their vulnerability or poverty."
    - *Workplace safety*. Involves the "setting and enforcing of minimum standards to protect citizens within the workplace" (DFID, 2006, p. 1).

    Adaptation projects that focus on labour market interventions and social assistance would be included in this category. No subcategories were established in relation to this macro project category.

15. **Multisectoral**. Defined as actions that simultaneously address more than one sector in one or multiple locations. It includes efforts that address more than one sector, which are challenging to tease apart, and in the context of this review includes large, multi-

country projects in which the specific sector of focus is nationally determined and, therefore, varies from country to country. No subcategories were established in relation to this macro project category.

16. **Other**. To capture areas of focus not clearly identified in the previous categories.

Annex B: Projects and programs

Projects working to address vulnerability to the impacts of climate change in India are presented alphabetically in the table below.

Name of project	Objectives	Funder(s) and budget	Implementing agencies	Type of project	Sectors	Duration	Scale and location(s)
Adaptation at Scale in Semi-Arid Regions	This project will enable proactive, longer-term approaches to climate change adaptation in semi-arid regions, while supporting the management of current risks. It draws on a number of disciplines to address the complex interactions among climate, biophysical, social, political, and economic dynamics. Research on each of these aspects will be integrated through transformative scenario planning, involving stakeholders throughout. The project will generate credible information that decision-makers and others can use to develop robust adaptation strategies.	DFID and IDRC through CARIAA CAD$13.5 million	University of East Anglia; International START Secretariat; Oxfam; Indian Institute for Human Settlements; University of Cape Town, South Africa	Research; capacity building; knowledge communication	Multi-sectoral	2014 – 2019	Global India, Ethiopia, Kenya, Uganda, Ghana, Mali, Botswana, Namibia, South Africa, Niger

Building Adaptive Capacities of Small Inland Fishers for Climate Resilience and Livelihood Security, Madhya Pradesh	The objective of the project is to showcase climate-resilient pond designs, institutional arrangements between farmers and traditional fishermen, and insurance schemes that will provide farmers with options for adapting more effectively to climatic variability. The project focuses on implementing and testing adaptive strategies that aim to prevent risk (e.g., modification of pond design for larger and longer water retention), transfer risk (e.g., weather-based insurance that absorbs losses from climate change), and terminate risk (e.g., changing fish species or by introducing alternative technological options).	Adaptation Fund US$1,790,500	National Bank for Agriculture and Rural Development	Field implementation; community-based adaptation; knowledge communication	Freshwater fisheries; watershed management; insurance; climate information	2013–unknown	National
Building Climate Change Awareness in the South Asian Media	This initiative aims to improve media coverage and public debate around climate and development in South Asia by strengthening the capacity and understanding of journalists and other members of the media.	DFID; the Netherlands through CDKN £250,000	International Centre for Integrated Mountain Development; Panos	Capacity building	Other: Communications and media	May 2012–March 2014	Regional Bangladesh, India, Nepal, Pakistan, Bhutan, Sri Lanka

Building the Capacity of Civil Society Organizations in Africa and Asia	The project aims to strengthen the effectiveness of civil society organizations to work with communities to adapt to climate change and ensure food security, to test innovative approaches that improve livelihood opportunities, and to support gender equality.	Canadian Department of Foreign Affairs, Trade and Development and the Aga Khan Foundation Canada, through the Partnership for Advancing Human Development in Africa and Asia CAN$100 million ($75 million from Government of Canada; $25 million from Aga Khan Foundation)	Aga Khan Development Network agencies	Capacity building; knowledge communication	Civil society	June 2012–December 2017	Global Bangladesh, India, Pakistan, Tajikistan, Kenya, Tanzania, Uganda, Mali, Egypt, Afghanistan, Kyrgyzstan, Madagascar, Mozambique

Climate Change: Addressing Heat-health Vulnerability in Rapidly Urbanizing Regions of Western India	Implemented in the city of Ahmedabad, the first phase of this project focused on developing a comprehensive early warning system and preparedness plan for extreme heat events. Through research, engagement, and awareness-raising, Ahmedabad's Heat Action Plan was created. It includes three key strategies: building public awareness, initiating a simple early warning system, and building the capacity of medical and community health professionals. The ongoing second phase focuses on firmly embedding the action plan in the government systems by supporting an assessment of implementation of the plan to date, updating and refining policies, and helping to build a strong surveillance and monitoring system for extreme heat. It is also reaching those that are most at risk by working with sectors and groups that directly affect the vulnerable (e.g., construction industry, police) and further operationalizing the early warning system.	CDKN Phase 1: £200,000 Phase 2: £300,000	Natural Resources Defense Council; the Indian Institute of Public Health Gandhinagar; the Public Health Foundation in India	Research; assessment; knowledge communication; policy formation and integration	Human health; government	Phase 1: March 2012–August 2013 Phase 2: September 2014–September 2016	National

CCKN-IN	Using a multi-level and multi-actor approach, the project is piloting climate change knowledge networks by a variety of state and non-state actors at the district, state, and union levels. Additionally, the project will systematically record and process lessons learned and best practices to support upscaling to other states and finally to the national level.	GIZ €1,405,099	Ministry of Agriculture; GOPA Consulting Group; Watershed Organisation Trust	Knowledge communication	Agriculture	September 2013–April 2017	National
Climate Proofing Growth and Development in South Asia	This project seeks to integrate climate change (adaptation and mitigation) into development planning, budgeting, and delivery in national and subnational governments in Afghanistan, Bangladesh, India, Nepal, and Pakistan, by strengthening planning, budgeting, and delivery mechanisms; building awareness and capacity of stakeholders; providing technical and some implementation support; helping leverage domestic finance; and actively sharing knowledge.	DFID £28.5 million	UNDP; Oxford Policy Management	Capacity building; knowledge communication; policy formation and integration	Government	October 2012–2019	Regional Bangladesh, India, Nepal, Pakistan, Afghanistan

Climate Resilience through Risk Transfer	Pioneering an innovative community-based insurance scheme that will offer composite insurance—covering health, crops, livestock, and natural disasters—to directly meet the needs of vulnerable communities affected by climate change.	Embassy of Switzerland in New Delhi £167,530	Micro Insurance Academy; BASIX Consulting and Training Services Ltd.; Nidan; Vaishali Small Farmers Association; Sampada Trust	Field implementation	Insurance	2014–unknown	National
Climate Risk Management in Urban Areas through Disaster Preparedness and Mitigation	The main objectives of the project are (1) to reduce disaster risk in urban areas by enhancing institutional capacity to integrate climate risk reduction measures into development programs and undertake mitigation activities based on scientific analyses and (2) to enhance community-level capacity to manage climate risk in urban areas by increasing preparedness.	US Agency for International Development US$1.21 million	GOI; UNDP	Assessment; capacity building; knowledge communication; policy formation and integration	Disaster risk management; urban areas	2012–2015	National
Conservation and Management of Coastal Resources as a Potential Adaptation Strategy for Sea Level Rise	The project aims to overcome the consequences of salinization and other impacts on coastal areas due to sea-level rise and seawater inundation caused by increased cyclonic storms and storm surges. This goal will be achieved through appropriate adaptation strategies, such as the restoration of degraded mangroves and demonstration of the Integrated Mangrove Fishery Farming System.	Adaptation Fund US$689,264	M. S. Swaminathan Research Foundation	Field implementation	Ecosystem conservation; coastal zone management	2013–unknown	National

Deltas, Vulnerability and Climate Change: Migration and Adaptation	This project aims to understand adaptation choices in delta regions with a strong focus on the role of migration as an adaptation strategy, including temporary, periodic, or permanent migration. Working with stakeholders and key decision-makers, and taking gender into account, the project will integrate climate and socio-economic data for each delta to assess when migration might be appropriate for the most vulnerable, compared with other adaptation options.	DFID and IDRC through CARIAA CAD$13.5 million	University of Southampton; Bangladesh: Institute of Water and Flood Management, Bangladesh University of Technology and Engineering; India: Jadavpur University; Egypt: National Authority for Remote Sensing and Space Sciences; Ghana: University of Ghana	Research; capacity building; knowledge communication	Migration; multisectoral	February 2014–November 2018	Global Bangladesh, India, Ghana, Egypt

Enhancing Adaptive Capacity and Increasing Resilience of Small and Marginal Farmers in Purulia and Bankura Districts of West Bengal	The proposed project aims at developing climate-adaptive and resilient livelihood systems through diversification, technology adoption, and natural resource management for rural small and marginal farmers associated with agriculture and allied sector in the Lateritic Zone of West Bengal, India. Specifically, it would seek to enhance the adaptive capacity of vulnerable farm families in semi-arid regions of Purulia and Bankura districts of West Bengal by introducing measures to alleviate the adverse impacts of climate change on their food and livelihood security.	Adaptation Fund US$2,510,854	Development Research Communication and Services Centre	Field implementation; community-based adaptation	Agriculture; freshwater fisheries; disaster risk management	2014–2018	National
Enhancing Institutional and Community Resilience to Disasters and Climate Change	The project will support efforts to strengthen the capacity of governments, communities, and institutions to accelerate implementation of disaster risk reduction and climate change adaptation plans.	UNDP; US Agency for International Development US$6.235 million	Disaster Management Division; Ministry of Home Affairs	Capacity building,; knowledge communication; community-based adaptation	Agriculture; freshwater supply; disaster risk management; government	September 2013–December 2017	National

Future Proofing Indian Cities	The project aims to support the development of urban development strategies and investment plans in Bangalore and Madurai that are future proofed. The longer-term objective is to reduce urban poverty and catalyze economic development in both cities. This will be accomplished by supporting the identification and implementation of investments that generate environmental, social, and economic benefits.	CDKN £450,000	Atkins Indian Institute for Human Settlements; University College London; the Dhan Foundation; Indian Institute of Human Settlements	Assessment; capacity building; policy formation and integration	Urban areas; government	September 2013–October 2014	National

Gender and State Climate Change Action Plans in India	The project aimed to (1) influence governments in four states to mainstream and articulate gender and inclusiveness in their SAPCCs, (2) demonstrate that adaptation policies need to promote climate-resilient low-input agricultural practices and address gender-based differences, and (3) examine adaptation-related gender budgeting. Activities implemented included analysis of draft SAPCC, meeting with state- and national-level bureaucrats, attending policy roundtables involving collaborating departments working in the area of agriculture, preparing policy briefs, and producing a gender framework for the SAPCCs.	CDKN £150,000	Alternative Futures	Research; capacity building; policy formation and integration; field implementation	Agriculture; gender; government; civil society	February 2012–December 2013	National

Groundwater Resilience to Climate Change and Abstraction in the Indo-Gangetic Basin	The project aimed to develop a strategic overview assessment of the occurrence and status of groundwater resources in the Indo-Gangetic basin and strengthen the evidence base linking groundwater resources, climate and abstraction, and emerging policy responses.	DFID £565,200	British Geological Survey; Indian Institute of Technology Kharagpur; Institute for Social and Environmental Transition–Nepal; ISET-International; MetaMeta; National Institute of Hydrology, Roorkee (India); Overseas Development Institute; University College London; University of Dhaka	Research; knowledge communication	Freshwater supply; climate information	June 2012–September 2014	Regional Bangladesh, India, Nepal, Pakistan

Himalayan Adaptation, Water and Resilience	Its overall goal is to contribute to enhanced climate resilience and adaptive capacities of the poor and vulnerable women, men, and children living in these river basins by leveraging research and pilot outcomes to influence policy and practice to improve their livelihoods.	DFID and the IDRC through CARIAA CAD$13.5 million	International Centre for Integrated Mountain Development; Bangladesh Centre for Advanced Studies; TERI; Climate Change, Alternate Energy and Water Resources Institute of the Pakistan Agricultural Research Council; Alterra; Wageningen University and Research Centre, the Netherlands	Research; capacity building; knowledge communication	Watershed management; multisectoral	2014–2019	Regional Bangladesh, India, Nepal, Pakistan

Himalayan Climate Change Adaptation Programme	The program aims to (1) increase understanding of the uncertainties influencing climate change scenarios and water availability and demand projections for parts of major river basins in the region, and to encourage use of the knowledge thus created; (2) enhance capacities to assess, monitor, communicate, prepare for, and undertake actions to respond to challenges and opportunities from impacts of climate change and other drivers of change; and (3) make concrete and actionable proposals on strategies and policies (with particular reference to women and the poor) for uptake by stakeholders, including policy makers.	Norwegian Ministry of Foreign Affairs; Swedish International Development Cooperation Agency	Center for International Climate and Environmental Research–Oslo; International Centre for Integrated Mountain Development; GRID-Arendal	Research; assessment; knowledge communication; community-based adaptation	Watershed management; climate information	September 2011–December 2017	Regional Bangladesh, India, Pakistan, China
Increasing Resilience and Reducing Risk of Coastal Communities to Climate Change and Natural Hazards in the Bay of Bengal	The overall objective of the project is to contribute to poverty alleviation amongst the poor communities of coastal areas of the Bay of Bengal, with a focus on reducing their risk to the impacts of hazards and climate change.	European Union	Concern Worldwide; Jagrat Juba Sangha and Sushilan (Bangladesh); Regional Centre for Development Cooperation (India)	Capacity building; knowledge communication; community-based adaptation	Coastal zone management; disaster risk management; government; civil society	February 2011–January 2016	Regional Bangladesh, India

Indian Himalayas Climate Adaptation Programme	The project aims to ensure that the resilience of vulnerable communities in the Himalayas is strengthened, and that the knowledge and capacities of research institutions, communities, and decision-makers are connected and enhanced.	Swiss Agency for Development and Cooperation CHF3,720,000	GOI; Government of Himachal Pradesh; G.B. Pant Institute for Himalayan Environment and Development; Consortium of Swiss Universities (Geneva, Bern, Fribourg, Zurich), Consortium of Indian Universities	Assessment; capacity building; knowledge communication; policy formation and integration; community-based adaptation	Freshwater supply; climate information; government	2012–2015	National
Mainstreaming Agrobiodiversity Conservation and Utilization in Agricultural Sector to ensure Ecosystem Services and Reduce Vulnerability	This project aims to "mainstream the conservation and use of agrobiodiversity for resilience agriculture and sustainable production to improve livelihood and access and benefit sharing capacity of farmer communities across four agro-ecoregion of India" (Global Environment Facility, 2013, p.1).	GEF Trust Fund US$11,801,100	Indian Council of Agricultural Research; Bioversity International, Office for South Asia	Field implementation; community-based adaptation	Agriculture; ecosystem conservation	2013–2018	National

Managing Climate Risk for Urban Poor	This program will help cities plan for and invest in reducing the impacts of weather-related changes and extreme events on 2 million urban poor and vulnerable people in 25 medium-sized cities in six Asian countries (initially Pakistan, Bangladesh, India, Vietnam, Indonesia, and the Philippines). The project aims to improve planning processes by 2018 so that they consider climate change risks, for developing and funding new investment and infrastructure opportunities, and for knowledge and lesson sharing. The project will focus on physical investments such as housing, drainage, flood protection, and wastewater systems, and systemic improvements (e.g., improving building codes).	DFID; Asian Development Bank; Rockefeller Foundation US$140 million (DFID: £85.0 million; Rockefeller Foundation: US$5 million)	Unknown	Research; capacity building; knowledge communication; policy formation and integration; field implementation	Urban areas	September 2013–December 2017	Regional Pakistan, Bangladesh, India, Vietnam, Indonesia

National Cyclone Risk Mitigation Project (Phases I and II)	The project mainly aims to (1) minimize risk and vulnerabilities to cyclones, (2) strengthen structural and non-structural cyclone mitigation efforts, and (3) build the capabilities and capacities of people to engage in cyclone risk mitigation in harmony with the conservation of coastal ecosystems in coastal cyclone hazard prone states and union territories.	Phase 1: US$319 (World Bank: US$255 million; State Governments of Andhra Pradesh and Orissa: $US64 million) Phase 2: US$387 (World Bank: US$308.40 million)	National Disaster Management Authority	Assessment; policy formation and integration; field implementation	Coastal zone management; disaster risk management; transportation; buildings	Phase 1: 2011–2017 Phase 2: unknown–March 2021	National
Operational Research to Support Mainstreaming of Integrated Flood Management under Climate Change	In the first phase of this intended two-phase project, scoping and planning studies were done to review lessons learned from the integration of structural and non-structural components of flood management in India and globally, identify the scope and location of the research activities, and engage in preliminary data collection. The project's second phase comprised operational research to support the mainstreaming of integrated flood management in a way that took into account projected future conditions and climate change uncertainties.	DFID £800,000	Asian Development Bank	Research; assessment	Watershed management; disaster risk management	July 2012–July 2014	National

Partners for Resilience	The goal of this project is to increase the resilience of citizens against natural disasters, climate change, and the deterioration of ecosystems through various intervention strategies: (1) stimulating sustainable economic developments; (2) strengthening the capacity of local organizations and local authorities by, among other things, undertaking a risk assessment and developing natural disaster risk management plans and warning systems; and (3) advocating for and stimulating knowledge sharing between governments, civil society, knowledge institutes, and the private sector in the field of natural disaster reduction and climate adaptation.	Netherlands €40 Million	Dutch Red Cross (secretary); Red Cross Climate Centre; CARE Netherlands; Cordaid; Wetlands International	Capacity building; knowledge communication; policy formation and integration; field implementation	Agriculture; freshwater supply; disaster risk management; government; civil society; social protection	2011–2015	Global India, Ethiopia, Kenya, Uganda, Mali, Guatemala, Nicaragua, Indonesia, Philippines
Sheltering from a Gathering Storm	This research program focused on peri-urban areas of India, Vietnam, and Pakistan facing risks from typhoons, floods, and extreme heat. It tested the hypothesis that most investments in climate-resilient shelter designs can have a positive benefit to cost ratio accruing to vulnerable populations over a 30-year design life.	DFID; the Netherlands though CDKN £800,000	ISET-International in partnership with Hue University (Vietnam); Gorakhpur Environmental Action Group (India); ISET-Pakistan; ISET-Nepal	Research	Buildings; urban areas	April 2012–March 2014	Regional India, Pakistan, Vietnam

South Asia Water Initiative	This project supports countries to improve and deepen transboundary dialogue, enhance the basin and water resources knowledge base, strengthen water institutions, and support investments that lead to sustainable, fair, and inclusive development, including through the integration of climate change adaptation into integrated water resource management.	United Kingdom through the South Asia Water Governance Programme (£11.5 million); Australian Department of Foreign Affairs and Trade's South Asia Sustainable Development Investment Strategy; Norway	World Bank	Research; capacity building; knowledge communication; policy formation; and integration	Watershed management; energy	2013–2017	Regional Bangladesh, India, Nepal, Afghanistan, China, Bhutan
Sustainable Livelihoods and Adaptation to Climate Change	The project's objective is to improve the adaptive capacity of rural poor with farm-based livelihoods. It will help them cope with climate variability and change through activities focused on (1) risk assessment, planning, service provision, and implementation of climate adaptation interventions; (2) scaling up and mainstreaming climate adaptation interventions; and (3) investing in the establishment of climate adaptation units in participating states and establishing monitoring and evaluation systems.	World Bank US$10.17 million	Ministry of Rural Development, GOI	Assessment; capacity building; policy formation and implementation; field implementation; community-based adaptation	Agriculture; forestry; government	December 2014–June 2018	National

Water-Agriculture-Livelihood Security in India	The program will help improve farmers' livelihoods and food security in Punjab, Gujarat, and either Bihar or Jharkhand—all significant contributors to India's overall food security. Public and private sector collaboration coupled with innovation are key elements of this new program.	US Agency for International Development US$1.7 million	Centers for International Projects Trust in partnership with state governments, agricultural universities, and research institutes; the Indian Council for Agricultural Research; Columbia University; agri-businesses such as Field Fresh Del Monte	Research	Agriculture; freshwater supply	2012–2017	National

Annex C: India's agro-ecological regions

AEZ No.	Agro-ecological region	Geographical area (million ha) (% of total area)	Gross cropped area (million ha)	Physiography	Precipitation (mm)
1	Cold arid ecoregion with shallow skeletal soils	15.2 (4.7%)	0.07	Western Himalayas	<150
2	Hot arid ecoregion with desert and saline soils	31.9 (9.7%)	20.85	Western Plain and Kutch Peninsula	<300
3	Hot arid ecoregion with red and black soils	4.9 (1.9%)	4.18	Deccan Plateau	400–500
4	Hot semi-arid ecoregion with alluvium-derived	32.2 (9.8%)	30.05	Northern Plain and Central Highlands	500–800
5	Hot semi-arid ecoregion with medium and deep black soils	17.6 (5.4%)	11.04	Central Highlands	500–1,000
6	Hot semi-arid ecoregion with shallow and medium black soils	31.0 (9.5%)	25.02	Deccan Plateau	600–1,000
7	Hot semi-arid ecoregion with red and black soils	16.5 (5.2%)	6.19	Deccan Plateau and Eastern Ghats	600–1,000
8	Hot semi-arid ecoregion with red loamy soils	19.1 (5.8 %)	6.96	Eastern Ghats and Deccan Plateau	600–1,000
9	Hot subhumid (dry) ecoregion with alluvium-derived soils	12.1 (3.7%)	11.62	Northern Plain	1,000–1,200
10	Hot subhumid ecoregion with red and black soils	22.3 (5.8%)	14.55	Central Highlands	1,000–1,500
11	Hot subhumid ecoregion with red and yellow soils	11.1 (4.3%)	6.47	Eastern Plateau	1,200–1,600
12	Hot subhumid ecoregion with red and lateritic soils	26.8 (8.2 %)	12.09	Eastern Plateau and Eastern Ghats	1,000–1,600
13	Hot sub humid (moist) ecoregion with alluvium-derived soils	11.1 (3.4%)	10.95	Eastern Plains	1,400–1,600
14	Warm subhumid to humid with inclusion of perhumid	18.2 (5.6%)	3.20	Western Himalayas	1,600–2,000

	ecoregion				
15	Hot subhumid to humid ecoregion with alluvial-derived soils	12.1 (3.7%)	8.99	Bengal basin and Assam plain	1,400–2,000
16	Warm perhumid ecoregion with brown and red hill soils	9.6 (2.9%)	1.37	Eastern Himalayas	2,000–4,000
17	Warm perhumid ecoregion with red and lateritic soils	10.6 (3.3%)	1.56	North-Eastern Hills	1,600–2,000
18	Hot subhumid to semi-arid ecoregion with coastal alluvium-derived soils	8.5 (2.6%)	6.12	Eastern Coastal Plains	900–1,600
19	Hot humid perhumid ecoregion with red, lateritic and alluvium-derived soils	11.1 (3.6%)	5.70	Western Ghats and Coastal Plains	2,000–3,200
20	Hot humid/perhumid island ecoregion with red loamy and sandy soils	0.8 (0.3%)	0.05	Islands of Andaman & Nicobar and Lakshadweep	1,600–3,000

Source: National Institute of Hydrology (2015)

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