Impact of Climate Change on Indian Economy

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According to 'United in Science Report 2020', the 5-year period from 2016-2020 is expected to be the warmest on record with an average global mean surface temperature of 1.1°C above pre-industrial era. The raging climate crisis is catalyzing the incidence, intensity and impact of extreme weather events including floods, droughts, cyclones, extreme precipitation and wildfires. Such erratic weather instances have seen a dramatic rise over the last decade, resulting in economic losses of over USD 1 trillion. The clock is fast ticking and experts suggest that we only have a decade to avoid this climate catastrophe. This clarion call to limit the global temperature rise has indeed spurred a sense of urgency to tackle climate crisis, demonstrated through the landmark Paris Agreement and the adoption of 2030 Agenda for Sustainable Development. We have witnessed unprecedented level of ambition and collaborative action from the stakeholder spectrum, who have joined forces to display exemplary political will, drive on-ground action through technology transfer and mobilize finance to address this emergency. Even though this is a step in the right direction, a lot more still needs to be done!

While the world is grappling with the challenges posed by climate change, developing economies like India are particularly vulnerable. Since 2004, the country has experienced 11 of its 15 warmest recorded years. As per 'Brown to Green report 2019' by the Climate Transparency, India has lost maximum number of lives and is amongst the top 5 countries in terms of economic losses due to extreme weather events within G20 nations (between 1998 and 2017). The country stares at losing 10% of its economy by 2100 if climate change remains unabated. Therefore, a systemic response to climate change is not only essential but is eventually slated to be an obligation. An important starting step in the right direction is to contextualize, assess and quantify the impact of Climate-related risks and the emerging opportunities arising out of low carbon growth trajectory.

YES BANK is pleased to collaborate with the Department of Science and Technology (DST) Centre of Excellence in Climate Modeling at IIT Delhi for the knowledge report ***'Impact of Climate Change on Indian Economy'***. The report captures the impact of climate change on critical sectors of Indian economy including agriculture, energy, tourism, insurance and infrastructure and quantifies the adverse effects on the overall health, human productivity and the critical ecosystem services. The study further corroborates the importance of cutting-edge research in developing an India-centric climate model to ensure reliable short, medium and long term projections, which can feed into formulation of relevant policies, driving corporate action on climate change and reorient the flow of capital to fuel sustainable development and economic growth.

I am confident that this report will not only serve as a repository of succinct and action-oriented case studies, but also stimulate relevant stakeholders including policy makers, regulators, academicians, financial institutions and the corporate sector to devise an orchestrated climate action strategy, that will help India glide on a sustainable and resilient development pathway.

Thank you.
Sincerely,

Prashant

Prashant Kumar
Managing Director & CEO

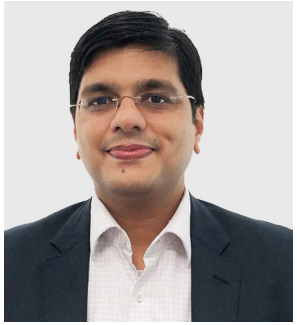
YES BANK

PREFACE

Climate is changing and global warming is happening. Its effects will likely to be large and serious, and can be dangerous. Not only it has become a serious threat to the planet and to people, it is also threatening the global economy, and taking its centre stage in the models of today's economists. The Nobel Prize for Economics in 2018 was awarded for integrating climate change into long-term macroeconomic analysis — this highlights the influence of climate change on economy. The COVID-19 life-threatening pandemic, we are facing today, is a harbinger of climate disasters to come. It is high time we take bold steps and make our systems climate resilient. We have already seen the economic impacts of climate change; for example, according to Morgan Stanley, climate change disasters have cost North America more than 400 billion USD over the last three years. There are numerous ways climate change will affect our economy — agriculture, energy, financial-markets, health, infrastructure, insurance, power, and tourism — some of which are presented in great detail on the Indian context in this report. The issue in question is quite complex, and hence needs multi pronged approach through close collaborations of the public and private sectors. Along this direction, IIT Delhi and YES Bank have signed an MoU to promote research on climate change on the Indian context. The DST Centre of Excellence in Climate Modeling is a major initiative taken at IIT Delhi to tackle some these pressing issues of climate change in India. The centre of excellence is developing a modeling framework for the Indian region, which can simulate the regional climate of India and can be used for future climate projections at district level to assess the impacts of climate change on the aforementioned sectors. This report signifies the impact of the research carried out in the Centre of Excellence, and will be very useful for private and public sectors, policy and decision makers and scientists. I am pleased with the report and congratulate the authors and contributors for bringing out the same.

Prof. V. Ramgopal Rao
Director
IIT Delhi

EXECUTIVE SUMMARY



Impact of Climate Change on Indian Economy

There is a mounting global consensus that climate change is putting a stress on the growth trajectory of nations worldwide, with evident economic, social and environmental implications. According to the World Economic Forum's Global Risks Report 2020, top five risks over the coming decade, in terms of likelihood, are all Climate-related including human-made environmental disasters, climate action failure, natural disasters, biodiversity loss and extreme weather. The manifestation of these risks is already underway and is witnessed through the rise in sea levels, intense wildfires, extreme climate events and extinction of the rich flora and fauna species. Looking at the grim situation, McKinsey Global Institute has estimated loss of trillions of dollars to the global economy with billions of lives at risk. Closer to home in India, climate change could shave off 2.5% - 4.5% of India's GDP annually if not tackled timely. Clearly the cascading and multiplier effect of climate change is jeopardizing the economic growth, with unprecedented repercussions on governments, businesses and individuals alike.

Appreciatively, the growing awareness, snowballing scientific evidence and heightened conversations have ushered an ***'Era of Implementation'***, with climate change viewed from an 'opportunity' lens by diverse stakeholders. Governments have not only adopted Nationally Determined Commitments under the Paris Agreement, but are also leveraging their economic stimulus packages, meant to tackle COVID-19, to spur green growth and build back better. Businesses are adopting science-based targets and driving strategies to address climate change. As per Carbon Disclosure Project, 225 of the world's 500 biggest companies believe climate change could generate over USD 1.2 trillion in new business opportunities. Positive developments are seen in the financial sector, with France, UK and the Netherlands emerging as the frontrunner in integration of climate risk into financial supervision. More than 70 Central Banks and supervisors have come together to mainstream climate and environmental issues into financial system through the Network of Greening the Financial System (NGFS). 199 signatories have signed up for the Principles for Responsible Banking and 1,600 organizations have endorsed their support for the Task Force on Climate-related Financial Disclosures (TCFD).

In a similar stride, India, which faces acute vulnerabilities due to the changing climate, has emerged as a strong force in the global fight against climate change. The country has not only committed ambitious targets under the Paris Agreement, but is the only major country in the world where the commitments are compatible with the goal of limiting global warming to an average of 2°C *(as per Climate Action Tracker)*. Recently, the country has set up a committee to oversee the implementation of climate change targets committed under the Paris Agreement. The Government is introducing enabling policy frameworks to promote growth and mobilize investments in sectors like renewable energy and e-mobility. In order to leverage the *'Power of Collective'*, India is fostering international cooperation through collaborative platforms including the International Solar Alliance and the International Coalition for Disaster Resilient Infrastructure. While the stage is set to seize the moment and champion the low carbon transition, there is a lot more that needs to be done.

Given the strategic importance and criticality of climate change in Indian context, YES BANK partnered with the Department of Science and Technology (DST) Centre of Excellence in Climate Modeling at IIT Delhi, which is working towards developing an India-Centric Climate Model for reliable projections. The joint knowledge report ***'Impact of Climate Change on Indian***

Economy' assess the impact of climate crisis on certain key economic sectors, with India-specific cases from agriculture, health and ecosystem sector to substantiate significant adverse impacts. Further, the report also elucidates the challenges involved in assessment of climate change impact including limitation of current economic models in incorporating climate change considerations, lack of research and quality data, limited capacity to assess Climate-related risks, to name a few. Given the magnitude of the challenges posed by climate crisis, the report suggests a collaborative approach involving blended expertise from governments, civil society, academia, businesses and the financial sector. The report captures the critical role played by these stakeholders in mainstreaming climate change in the form of case studies from leading national and international experts.

Thus, climate risk as a material aspect is going to play a critical role in charting out national-level policies, business strategies and reorientation of finance in an emerging economy like India. This report may serve as a blueprint to trigger conversations, share best practices and foster collaborations to drive accelerated climate action.

Niranjan Banodkar
Group President & Head - Strategy, Sustainability & Investor Relations

YES BANK

SPECIAL MESSAGE

The present state of the planet, with the rapid changing of climate, and global warming becoming more apparent around the world, is one of the most worrying concerns the mankind has today. Being a young and developing country, India, at the crossroads of development and sustainability, will find it much more challenging in times to come. In order to achieve the ambitious economic goal of five trillion USD, while it takes the reforms that were long promised i. e., relaxation in regulations and controlling, reformation of labour laws, privatisation of state entities, and investment in infrastructure development, it should make sure it is achieved not at the cost of its climate — a highly complex and tough task that needs the cooperation of the private and public sectors. In this regard, to address certain pressing issues of climate change in India, IIT Delhi has taken a major initiative and created the DST Centre of Excellence in Climate Modeling with the support of the DST, GoI.

The country needs reliable climate projection for future planning and policy making to make informed decisions against the backdrop of global warming and climate change. This is deliverable only when we have reliable models - models successful in capturing the present-day climate of India. However, all the available climate models possess unacceptably large biases, especially with rainfall and temperature over India, but they are doing reasonably good over the other regions and at the global scale. The Centre of Excellence is in the process of developing an India Centric Climate Model, which can simulate the regional climate of India and can be used for future climate projections at district level to assess the impacts of climate change on agriculture, energy, health, human resource, water resource, and ultimately on the economy of India. This report is offered illustrating the impacts of climate change on Indian economy. I am grateful to all the members of the DST CoE in Climate Modeling at IIT Delhi, Climate Change Programme of the DST, Financial and Investor Strategy Division of the Yes Bank, and especially to Head CAS Prof. AchutaRao, Head CCP Dr. Gupta, and Director IIT Delhi Prof. Rao.

Prof. S. K. Mishra
Principal Investigator, DST CoE in Climate Modeling
IIT Delhi

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- ✓ **David Carlin**, Program Lead for UNEP-FI TCFD Banking Lead, UNEP FI
- ✓ **Dr. Maxime Souvignet**, Team Lead, Munich Climate Insurance initiative (MCII) / United Nations University (UNU-EHS)

Section I

Introduction

Session I - Introduction

CLIMATE CHANGE – THE GAME CHANGER

The world is witnessing one of the biggest threats ever in the form of climate change, with unprecedented impacts on societies, nations and economies. From unpredictable weather patterns, to extreme climate events including floods, droughts and cyclones, to rise in sea levels, the potential impact of climate change on the planet are unparalleled. California, Oregon and certain other parts of the western United States (US) have experienced worst wildfires in the last 18 years, with their frequency and impact catalysed by climate change[1]. Recent estimates by NASA-led study has indicated that if greenhouse gas emissions (GHG) continue swiftly, Greenland and Antarctica's ice sheets could together contribute more than 15 inches (38 centimetres) of global sea level rise, which is beyond the amount that has already been set in motion by Earth's warming climate[2]. Thus, it is evident that climate change, exacerbated by emissions from anthropogenic activities, is making the world warmer, disrupting weather patterns and increasing the frequency and intensity of extreme climate events. While extreme weather events may be the most noticeable and immediate impact of climate change, another more intense, long-term and equally hazardous effect is rising mean temperatures[3]. The periodic assessment reports by the Intergovernmental Panel on Climate Change (IPCC) irrefutably substantiates the role of anthropogenic forces in driving the observed warming of the Earth's surface by about 1°C during the last 150 years[4]. As per the recent report 'United in Science 2020', the five year period from 2016-2020 is expected to be the warmest on record, with an average global mean surface temperature of 1.1°C above pre-industrial era (1850-1900).

It is established that climate change and global warming could seriously disrupt economies if timely adequate action is not taken. The dire consequences of climate change will not only have an impact on critical natural capital, infrastructure, human health and productivity but also negatively affect sectors such as agriculture, forestry, fisheries, ecosystem, tourism, to name a few. Hence, climate change has not only direct but also many indirect implications that can have a domino effect on the rise or fall of any economy around the world. Research indicates that insistent rise in average global temperature by 0.04°C per year, barring major policy breakthroughs, is set to reduce world real Gross Domestic Product (GDP) per capita by 7.22% by 2100[5]. The impact of climate change will not be uniform across the world, and developing nations are more vulnerable and are at a higher risk of experiencing the negative effects of global warming. This is substantiated by Standard and Poor's research on the influence of climate change on sovereign risk, as shown in the Figure 1.

[1] *The Visual and Data Journalism Team (2020). California and Oregon 2020 wildfires in maps, graphics and images. https://www.bbc.com/news/world-us-canada-54180049.*

[2] *Ramsayer, K. (2020). Emissions Could Add 15 Inches to 2100 Sea Level Rise, NASA-Led Study Finds. NASA's Goddard Space Flight Center, Greenbelt Maryland. https://www.nasa.gov/feature/goddard/2020/emissions-could-add-15-inches-to-2100-sea-level-rise-nasa-led-study-finds.*

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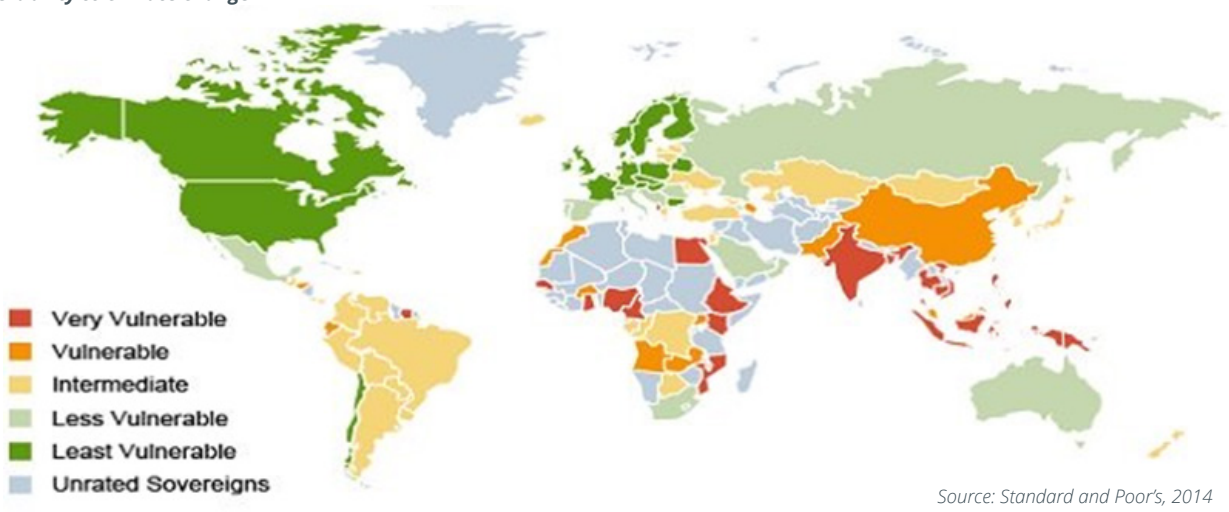
[5] *Franck, T. (2019). Climate change to slow global economic growth, new study finds, Economy. https://www.cnbc.com/2019/08/20/climate-change-to-slow-global-economic-growth-new-study-finds.html.*

RESEARCH INDICATES THAT INSISTENT RISE IN AVERAGE GLOBAL TEMPERATURE BY 0.04^{0}C PER YEAR, BARRING MAJOR POLICY BREAKTHROUGHS, IS SET TO REDUCE WORLD REAL GDP PER CAPITA BY 7.22% BY 2100

Figure 1: Sovereign risk to climate change

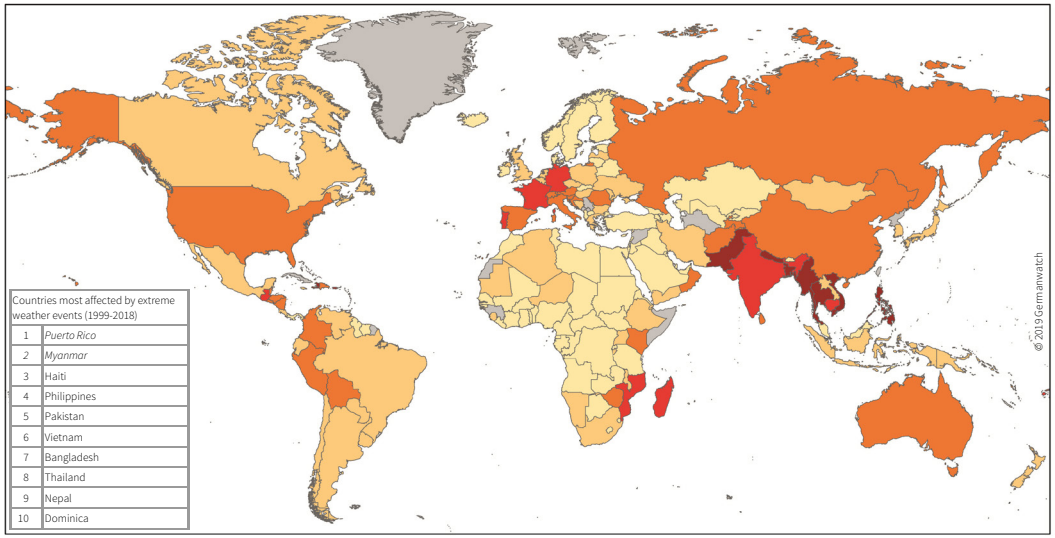
Potential vulnerability to climate change



Source: Standard and Poor's, 2014

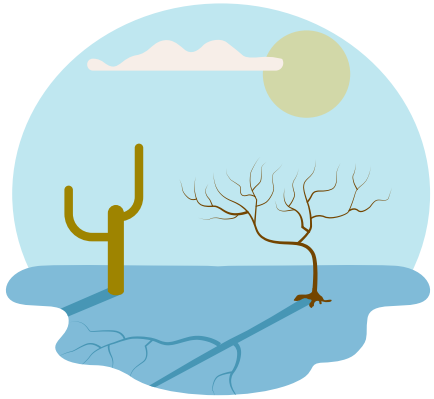
The Germanwatch's coveted study 'Global Climate Risk Index 2020' also indicated that of the ten most affected countries in the period 1999 to 2018, seven were developing countries. as shown in Figure 2 below:

Figure 2: Global Climate Risk Index



Italics: Countries where more than 90% of the losses or deaths occurred in one year or event

Source: Global Climate Risk Index 2020, Germanwatch



CLIMATE EMERGENCY – INDIAN CONTEXT

As evident from the studies mentioned in the previous section, India is particularly vulnerable to the growing threats of climate change, even though the impact may differ from one region to the other, on account of the complex geographical spread. A recent study titled 'Assessment of Climate Change over the Indian Region' by the MoES, Government of India has concluded that since the middle of 20th century, India has witnessed a rise in average and extreme temperature, decrease in monsoon precipitation, rise in sea levels and increased instances of droughts and cyclones. According to El Dorado, in May 2020, 10 out of the 15 hottest cities in the world were in India[6]. Germanwatch ranked India as the fifth most vulnerable country in terms of extreme weather events. Basis Climate Risk Index 2020, it is evident that India is specially affected by heatwaves and is among those countries particularly affected by extreme heat in both 2018 and 2019. The increase of global mean surface temperature by the end of the 21st century (2081–2100) relative to 1986–2005 is likely to be 0.3°C to 1.7°C under Representation Concentration Pathways (RCP2.6), 1.1°C to 2.6°C under RCP4.5, 1.4°C to 3.1°C under RCP6.0 and 2.6°C to 4.8°C under RCP8.5[7]. Tropical areas including India are going to face this warming that will have severe impact on agriculture, sea level, global hydrological systems, health and ecosystems[8,9&10].

When it comes to climate change, another important aspect that is closely monitored is the Indian Summer Monsoon (ISM) rainfall, which plays a critical role in deciding the fate of the Indian economy[11&12]. ISM rainfall has a remarkable influence on the agriculture, water resources, human health and ecosystems. Good monsoons bring prosperity, and bad ones cause damage and result in loss of livelihood. Keeping this in mind, the scientific community has made significant efforts to understand the fundamental mechanisms, past evolution and trend and possible future projections of the summer monsoon rainfall. Recent studies reveal that ISM has undergone significant changes during the last half century. The seasonal mean ISM rainfall has weakened[13,14,15&16] and the temporal distribution of rainfall within the season has become more extreme[17 & 18].

Global warming has caused the Indian economy to be 31% smaller[19]. Since past, India has suffered severe socio-economic losses due to recurring floods and droughts during boreal summer[20] and as per IPCC[7], India, like other developing nations, is likely to suffer losses in all major sectors of the economy including energy, transport, agriculture, and tourism. There are around 700 million people residing in rural areas, dependent on climate sensitive economic sectors like agriculture and forests, fisheries for food and livelihoods[21]. According to World Bank, central districts of India are the most susceptible to climate change damage owing to lack of infrastructure and agrarian nature[3]. The report by World Bank[22] states that 7 of the 10 severe hotspot districts are in the Vidarbha region of Maharashtra. The rest are in Chhattisgarh and Madhya Pradesh. In these severe hotspots, the GDP loss could be as high as 9.8% against the national average of 2.8%. The report estimated the overall loss in national GDP in actual terms could be USD 1,178 billion by 2050 under the carbon-intensive scenario. In many sectors, high temperatures can make life wretched for workers and decrease their productivity. According to the International Labour Organization, the loss in productivity by 2030 because

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[6] *Of the world's 15 hottest places, 10 are in India, Hindustan Times.*

[7] *IPCC. 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.*

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of heat stress could be equivalent to India losing 34 million full-time jobs (up from 15 million in 1995) - the highest among the world's most populous nations (ILO 2019)[23]. According to TERI, desertification, land degradation and drought cost around 2.5% of GDP in 2014-15[24].

Modeling Climate Change scenarios for India

India, being an agrarian country and sustaining the life of around one sixth of world population needs reliable climate projections for future planning, assessing impact on the economy, forecasting change in ISM and temperature, policy formulation and making informed decisions against the backdrop of global warming and climate change. This is possible only when there is a robust model, which is successful in capturing the present-day climate of India. Hence, it is extremely important to develop an India-Centric Climate Model (ICCM) for reliable short-term forecasts and long-term projections. The Department of Science and Technology (DST) Centre of Excellence (CoE) in Climate Modeling is a major initiative taken at IIT Delhi and funded by the DST, Government of India, to develop an ICCM to address certain pressing issues of climate change in India, and to educate manpower in numerical modeling of the Earth system and climate. Reliable future projections of climate, demand a reasonable numerical global model. However, all the available global climate models used in the IPCC Assessment Reports possess inadequately large biases, especially with precipitation over India, even though they are doing reasonably well over other regions and at global scale[25,26,27&28] (Figure 3 & 4). The DST CoE propose to perform the required upgrades to an existing climate model and build a better model for the Indian region through improved physical and computational implementations. The ultimate aim is to develop the ICCM through process improvements and region-specific customization that can simulate the regional climate.

Figure 3. June to September (JJAS) mean rainfall for the period 1975 to 2005 from India Meteorological Department (IMD) data and corresponding biases (model - observation) in some of the IPCC AR5 models

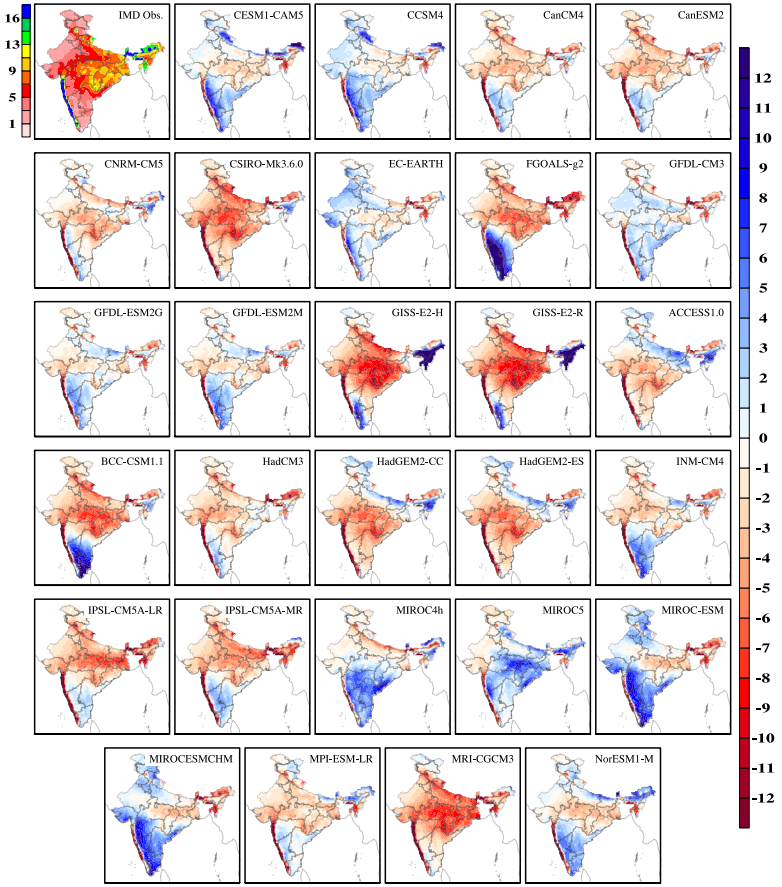

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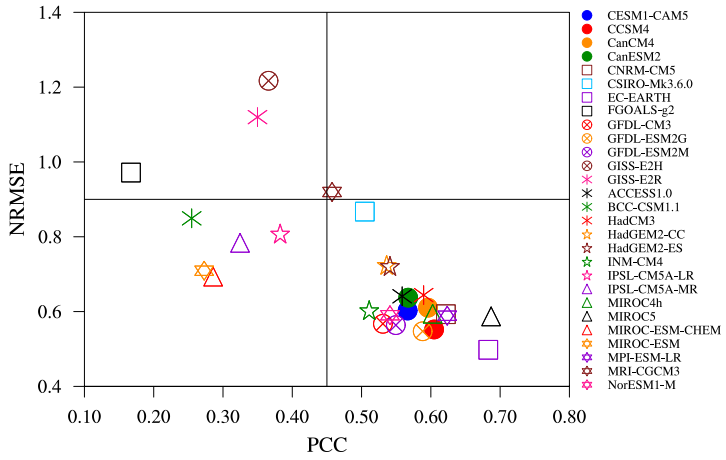
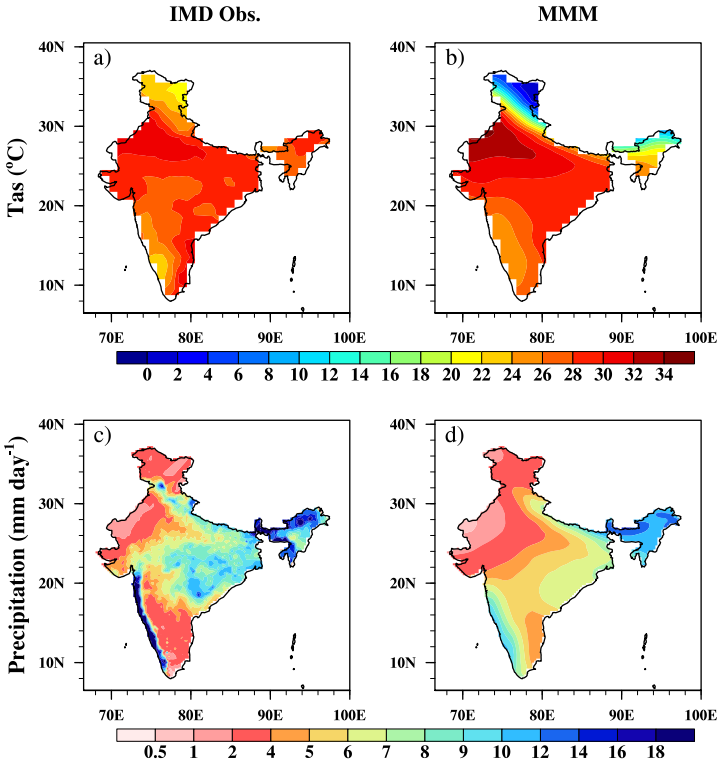
Figure 4: Pattern Correlation Coefficient and the normalized root mean square error (RMSE) in the IPCC AR5 models for JJAS rainfall (as compared to IMD)



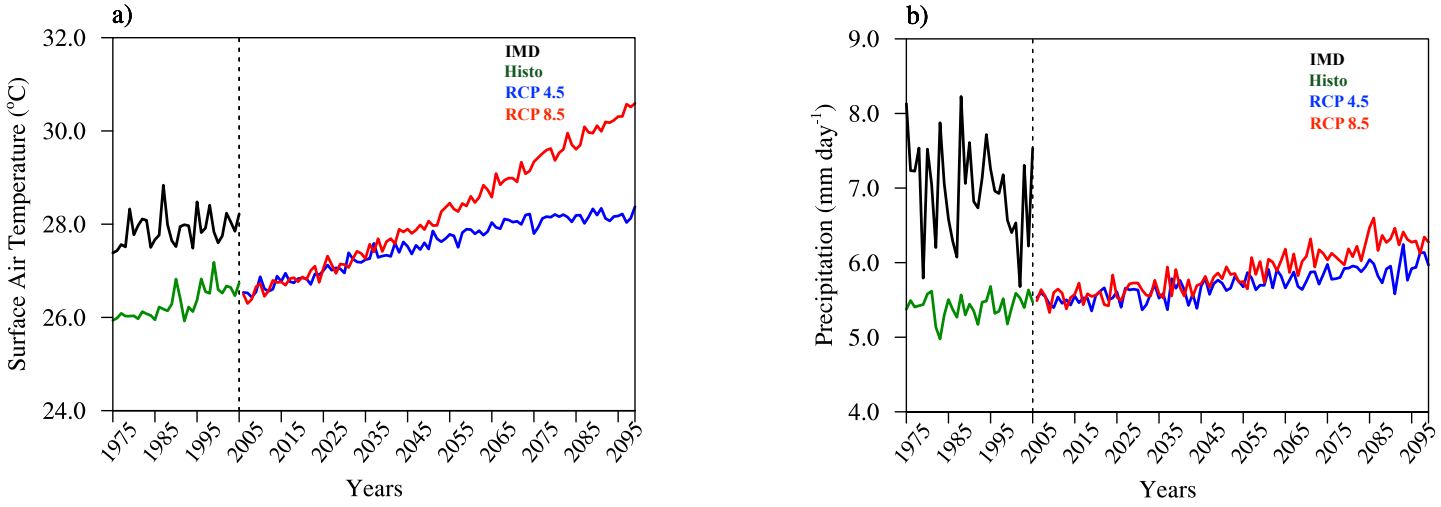
DST CoE studied the seasonal mean temperature (°C) and precipitation for summer monsoon (JJAS) from 1975 to 2005 over the Indian landmass from observation (IMD) and multi model mean (MMM) (Figure 5). The observed temperature is ~32°C over west India covering Rajasthan and Gujarat. Moderate to low temperatures observed over the Jammu and Kashmir, northeast India and west coast of India. It was found that there is underestimation in temperature over the Himalayan and northeast region (upto 16°C) and overestimation over most part of central India (upto 4°C) in MMM[26]. From rainfall analysis, some significant characteristic features of the ISM system such as rainfall maxima over northeast India, Western Ghats, and foothills of Himalayas; high rainfall over central and eastern states and the dry regions over northwest and peninsular India can be clearly seen in the IMD observations. There is severe dry bias over most parts of Indian land, especially over the Western Ghats (upto 8 mm/day), whereas there is a wet bias over the leeward side of Western Ghats (upto 4 mm/day) in MMM[26]. Figure 6 represents the time series of precipitation and surface air temperature from IMD observation, multi-model mean and projected under two representative concentration pathways i.e. RCP4.5 and RCP8.5. The IMD observed and MMM temperature both show increase in surface air temperature from 1975 to 2005. Projected temperature towards the end-of-century under RCP8.5 shows increase of about 4°C, however under RCP4.5, this increment is about 2°C.

Figure 5: Near-surface air temperature (oC) (a) IMD observation and (b) Multi-model Mean, and Precipitation (mm/day) (c) IMD observation and (d) Multi-model Mean



WINNERS OF THE 2018 NOBEL PRIZE FOR ECONOMICS, WILLIAM D. NORDHAUS AND PAUL ROMER, HAVE INTEGRATED CLIMATE CHANGE INTO LONG-TERM MACROECONOMICS BY DEVELOPING A QUANTITATIVE MODEL THAT CONSIDERS THE INTERACTION BETWEEN ECONOMIC DEVELOPMENT AND CLIMATE CHANGE ON A GLOBAL LEVEL.

Figure 6: Time series of (a) surface air temperature (b) precipitation from IMD, MMM for historical period from 1975-2005 and projected under RCP4.5 & RCP8.5



Going forward, these India-specific studies will play an instrumental role in assessing the impact of climate change on critical sectors of Indian economy such as agriculture, construction, human health, water resources and energy, to name a few.

CLIMATE CHANGE IMPACT ON ECONOMIES AROUND THE WORLD

It is evident that the temperature changes are increasing disparities amongst countries and have economic implications. Even though there is an enormous variance in the level of economic impact that climate change could have, depending on the geography and the kind of sectors that contribute to the GDP of a country, there usually are a few kinds of economic costs that are clearly visible[29]:

- ✓ Firstly, the long term impact, where climate change could reduce the productivity/crop yield of any region, which is usually irreversible
- ✓ Secondly, the temporary damage done to infrastructure *(in case of floods, cyclones, hurricanes)* which has huge costs for reconstruction
- ✓ Thirdly, rebuilding power grids that can't sustain the extreme weather events *(However, this could lead to positive impact in the long run as the focus shifts to increasing efficiency or finding alternative sources of energy).* These examples showcase the varying degrees of the effects climate change could possibly have

Winners of the 2018 Nobel Prize for economics, William D. Nordhaus and Paul Romer, have integrated climate change into long-term macroeconomics by developing a quantitative model that considers the interaction between economic development and climate change on a global level. A recent study[30] in the US has identified 22 sectors including healthcare, infrastructure and agriculture to have major impact of climate change and costed approximately USD 415 billion in the last few years. The effect of climate change on many sectors could result in around 10% shrinkage in the GDP which would in turn lead to a reduction by a tenth in everyone's income[29]. Owing to these adverse impacts, countries are committing to ambitious Nationally Determined Contributions (NDCs) under the Paris Agreement and adopting targeted approach to curb the effects of climate change. For instance, in UK, a special Committee on Climate Change[31], identified sectors and ways to mitigate the impact of climate change on the economy and is now working towards new emissions target, where annual costs of achieving net-zero emissions by 2050 are between 1-2% of GDP.

According to another study[32], the effects of global warming might vary from time, region, and economic sectors but overall tend to increase. They are relatively higher for poor African and Asian nations with low GDP. Over the medium term, despite some minor gains in a few European countries, the losses from global warming (at 3°C) will affect a major part of the world (Table 1). Using the value of GDP in 2017 from IMF[33] (2018) as the base year, the study results and economic growth forecasts approximate global loss to USD 9,593.71 billion or roughly 3% of the 2100 world GDP for 3°C global warming. At 4°C, losses from global warming increase to USD 23,149.18 billion. The largest losses for all temperature increases have an impact in Africa, India, and Southeast Asia (Figure 7).

[29] *Irwin, N. (2019). Climate Change's Giant Impact on the Economy: 4 Key Issues. The New York Times. https://www.nytimes.com/2019/01/17/upshot/how-to-think-about-the-costs-of-climate-change.html*

[30] *Martinich, J. and Crimmins, A. (2019). Climate damages and adaptation potential across diverse sectors of the United States. Nat. Clim. Chang., 9: 397–404, https://doi.org/10.1038/s41558-019-0444-6*

[31] *Committee on Climate Change (2019). Net Zero: The UK's contribution to stopping global warming. http://www.theccc.org.uk/publication/net-zero-the-uks-contribution-to-stopping-global-warming*

[32] *Kompas, T. et al. (2018). The effects of climate change on GDP by country and the global economic gains from complying with the Paris Climate Accord. Earth's Future, 6: 1153–1173, https://doi.org/10.1029/2018EF000922*

[33] *IMF (2018). World Economic Outlook, IMF Publication. Retrieve from https://www.imf.org/external/pubs/ft/weo/2018/01/weodata/ index.aspx.*

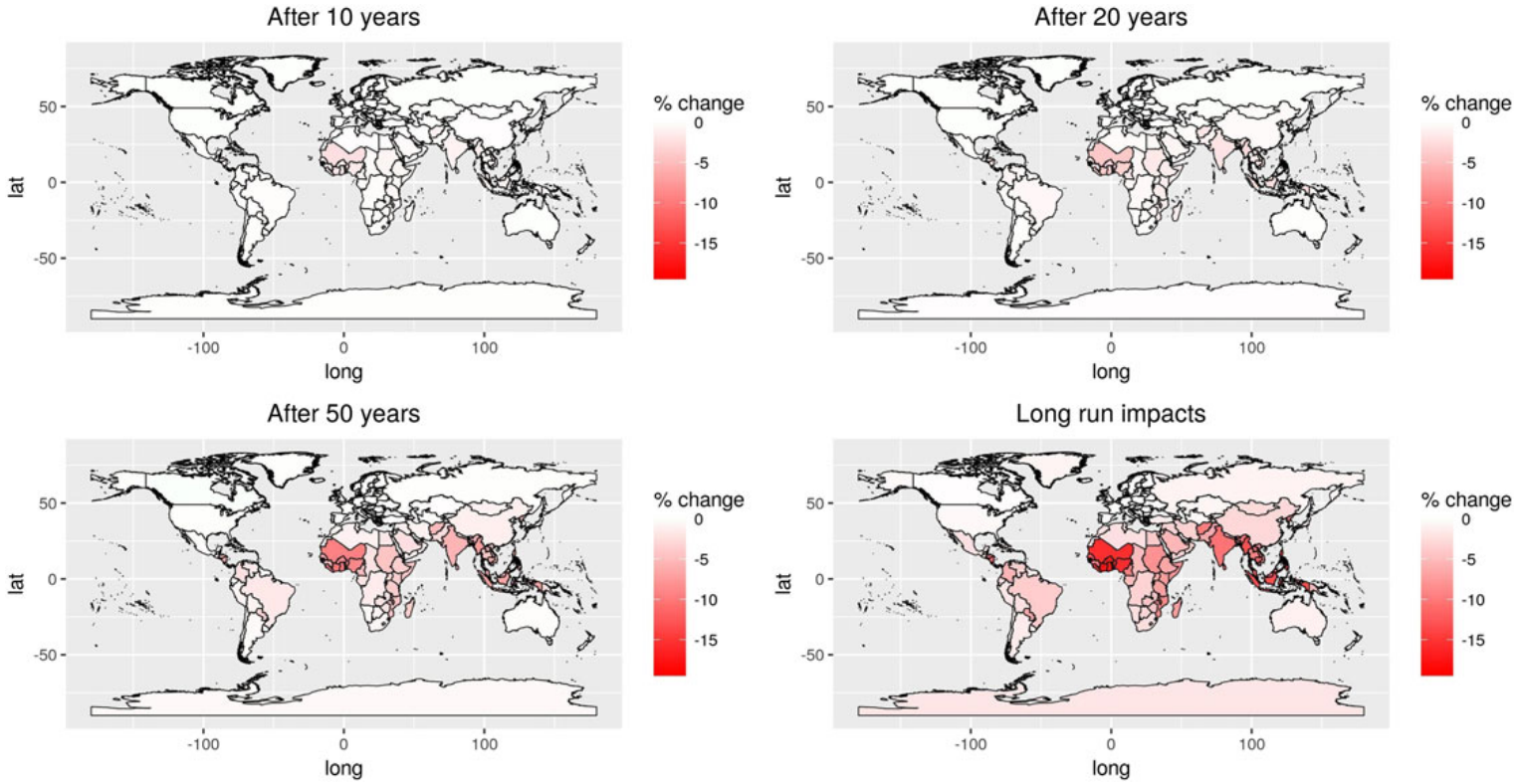
Table 1. Impacts of Global Warming (3°C) on the World GDP (% Change/Year)

Country	2027	2037	2047	2067	Long Run
Australia	-0.051	-0.107	-0.172	-0.326	-1.083
New Zealand	0.043	0.073	0.087	0.073	-0.798
Rest of Oceania	-0.452	-0.924	-1.422	-2.470	-5.171
China	-0.205	-0.438	-0.692	-1.247	-2.918
Hong Kong	-0.356	-0.765	-1.216	-2.205	-5.288
Japan	-0.042	-0.100	-0.173	-0.356	-1.335
South Korea	-0.025	-0.071	-0.136	-0.313	-1.498
Mongolia	-0.214	-0.415	-0.631	-1.105	-2.710
Taiwan	-0.535	-1.121	-1.740	-3.034	-5.978
Rest of East Asia	-0.819	-1.752	-2.752	-4.849	-9.490
Brunei Darussalam	-0.372	-0.815	-1.308	-2.385	-5.563
Cambodia	-1.175	-2.439	-3.758	-6.482	-12.101
Indonesia	-1.242	-2.594	-4.020	-6.973	-13.267
Laos	-1.039	-2.164	-3.342	-5.765	-10.621
Malaysia	-1.91	-2.293	-3.568	-6.229	-12.118
Philippines	-1.206	-2.592	-4.093	-7.275	-14.798
Singapore	-0.905	-1.958	-3.106	-5.562	-11.652
Thaland	-0.766	-1.605	-2.500	-4.401	-9.243
Vietnam	-0.802	-1.636	-2.500	-4.276	-7.959
Rest of Southeast Asia	-1.342	-2.767	-4.237	-7.234	-12.924
Bangladesh	-0.854	-1.671	-2.491	-4.142	-7.591
India	**-1.023**	**-2.099**	**-3.222**	**-5.532**	**-10.351**
Nepal	-0.505	-1.012	-1.537	-2.628	-5.731

(Source: Kompas et al. 2018)

AT 4^{0}C, LOSSES FROM GLOBAL WARMING INCREASE TO USD 23,149.18 BILLION. THE LARGEST LOSSES FOR ALL TEMPERATURE INCREASES HAVE AN IMPACT IN AFRICA, INDIA, AND SOUTHEAST ASIA (FIGURE 7).

Figure 7: Dynamic impacts of global warming (3°C) on the world GDP (% change/year)



Source: Kompas et al. 2018

The study also calculated the long-run impacts of different global warming scenarios (1–4°C), which correspond to different RCPs in Moss et al. (2010)[34] (Table-2).

Table 2. Long-run impacts of different global warming scenarios

Country	1°C	2°C	3°C	4°C
Australia	-0.287	-0.642	-1.083	-1.585
New Zealand	-0.144	-0.413	-0.798	-1.269
Rest of Oceania	-1.015	-2.627	-5.171	-8.553
China	-0.755	-1.694	-2.918	-4.597
Hong Kong	-1.314	-3.082	-5.288	-7.655
Japan	-0.182	-0.595	-1.335	-2.412
South Korea	-0.211	-0.731	-1.498	-2.666
Mongolia	-0.789	-1.664	-2.710	-3.981
Taiwan	-1.597	-3.560	-5.978	-8.552
Rest of East Asia	-2.389	-5.709	-9.490	-13.710
Brunei Darussalam	-1.202	-3.134	-5.563	-8.173
Cambodia	-3.509	-7.572	-12.101	-17.183
Indonesia	-3.347	-7.980	-13.267	-19.040
Laos	-3.369	-6.795	-10.620	-15.759
Malaysia	-3.084	-7.145	-12.118	-17.339
Philippines	-4.113	-9.185	-14.798	-20.986
Singapore	-2.729	-6.923	-11.652	-16.566
Thaland	-2.541	-5.749	-9.243	-13.269
Vietnam	-2.223	-4.862	-7.959	-11.641
Rest of Southeast Asia	-3.811	-8.110	-12.924	-18.573
Bangladesh	-2.285	-4.755	-7.591	-11.237
India	**-2.922**	**-6.434**	**-10.351**	**-14.622**
Nepal	-1.012	-2.881	-5.731	-9.859

Note. The numbers are calculated on the value of predicted GDP to 2100 from data in IMF (2018), International Institute for Applied Systems Analysis (2018), and Crespo Cuaresma (2017)

Source: Kompas et al. 2018

[34] *Moss, R. H. et al. (2010). The next generation of scenarios for climate change research and assessment. Nature, 463: 747–756*

INDIA'S CSCC IS THE HIGHEST (USD 86 PER TCO2 (49–157); 21% OF THE GSCC (20–30%)

As global warming increases, so does the frequency of extreme weather events and other natural disasters, and this would have a significant impact on emergency management responses and expenditures which might just double itself in a few years and add pressure on government budgets. Thus, taking a note of the losses in GDP and the gains from complying with the Paris Accord, it is imperative countries abide by their climate action targets or rather surpass them to bring about improvements.

Quantifying the Impact of Climate Change

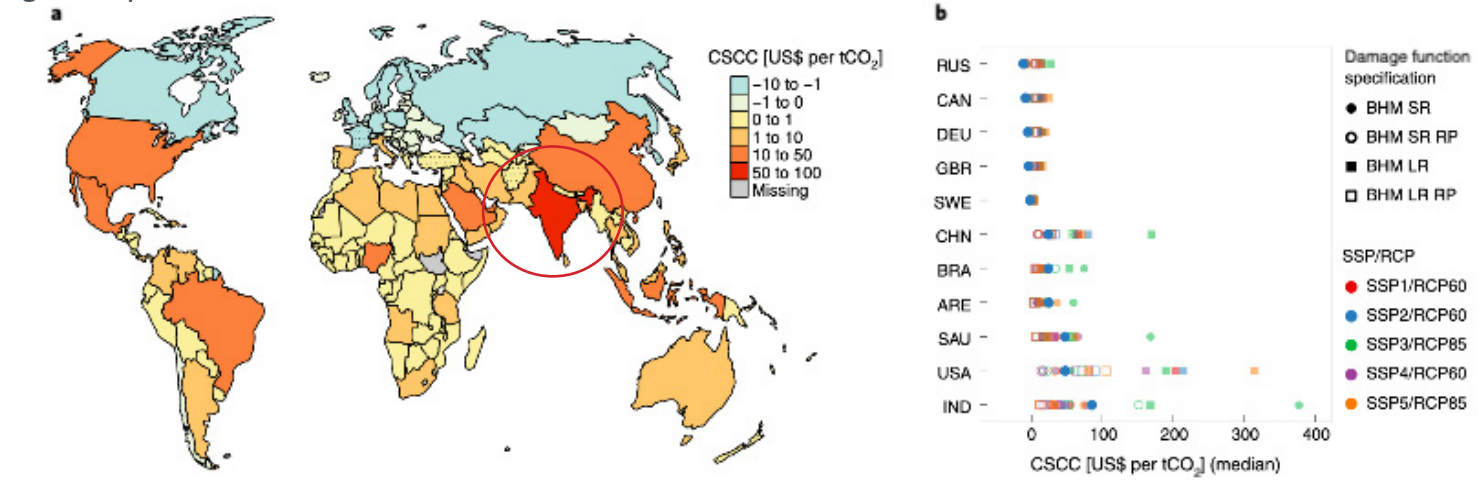
A very important starting step is to assess and measure the damage caused to the environment and one of the ways to do this is by calculating the Social Cost of Carbon (SCC), which serves as a metric to find the expected economic damages from carbon dioxide (CO_2) emissions in the environment. A study[35] has been conducted to estimate country-level contributions to the SCC using climate model projections, through a process with four distinct components:

- ✓ A socio-economic module that looks at the future evolution of the economy, highlighting the projected emissions of CO_2 *(this does not consider the impact of climate change)*
- ✓ A climate module wherein the earth system responds to emissions of CO_2 along with other anthropogenic factors
- ✓ A damages module, wherein the economy's response to changes in the Earth system are quantified
- ✓ A discounting module, wherein a time series of future damages is compressed into a single present value

In this analysis, uncertainties associated with each module at the global and country-level have been explored. The resultant empirical climate-driven economic damage estimations and socio-economic projections gave a relative ranking of countries that have been contributing to a high global SCC value, having a median of USD 417 per tonne of CO_2 (tCO_2). **The major contributors to global SSC that were found were India, China, Saudi Arabia, and the US.**

India's CSCC is the highest (USD 86 per tCO2 (49–157); 21% of the GSCC (20–30%); Confidence Interval are given in parentheses (Figure 8&9). It has been suggested that if the non-linear climate damages continue, the CSCC in 2020 which is negative for many northern countries will become positive if the countries continue to contribute CO_2 in the atmosphere at the same rate.

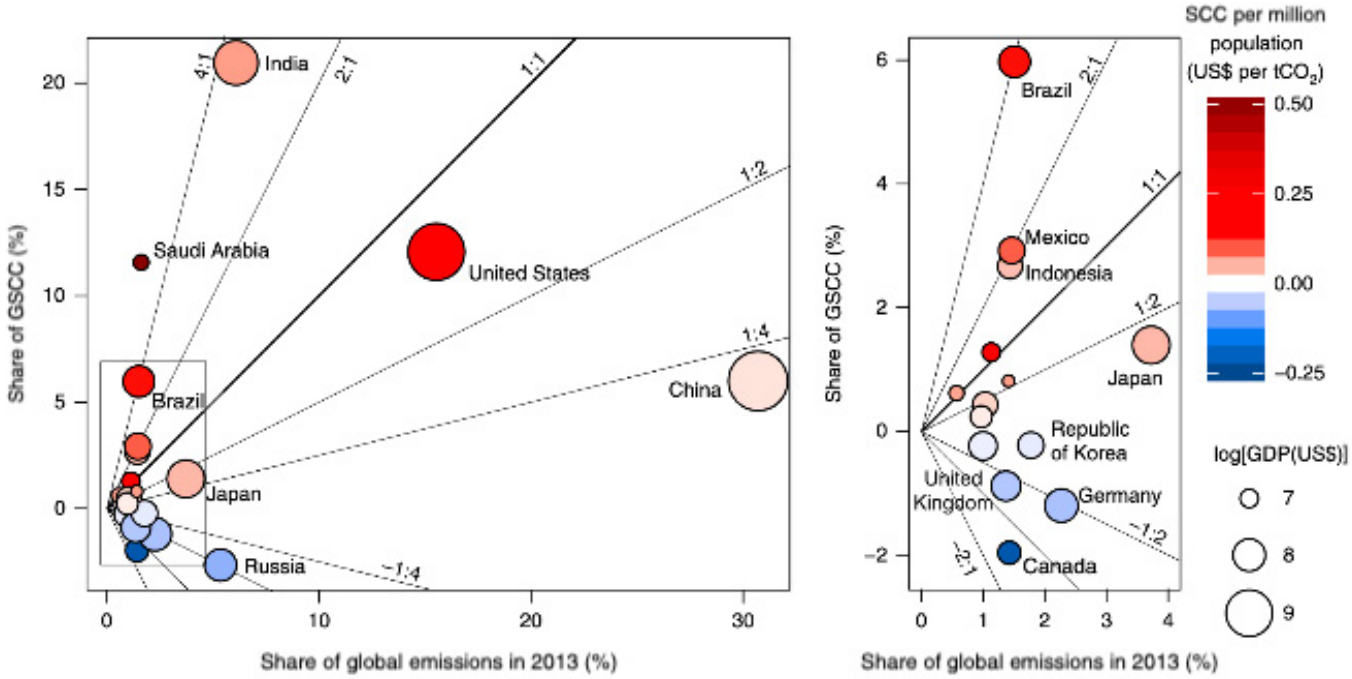
Figure 8: Spatial distribution of median estimates of the CSCCs (Ricke et al. 2018)



Source: Ricke et al. 2018

[35] *Ricke, K. et al. (2018). Country-level social cost of carbon. Nature Clim Change, 8: 895–900. https://doi.org/10.1038/s41558-018-0282-y.*

Figure 9: Winners and Losers of climate change among the G20 nations



Source: Ricke et al. 2018

All the above data, research and empirical findings point out that India is particularly vulnerable to climate change. The country needs to identify the critical sectors that are impacted by climate change and devise an orchestrated strategy to mitigate the risks and leverage the opportunities arising out of climate action, involving all the stakeholders.

Section II

Sectoral Analysis

Section II

SECTORAL ANALYSIS

In order to provide a perspective of impact of climate change on Indian economy, the study focuses on certain sectors including agriculture, energy, tourism, insurance, and infrastructure. The report attempts to quantify the effect of climate change on the health, human productivity and the ecosystem services. All these focus areas have been selected keeping in view their contribution to the GDP, livelihood generation potential, impact of climate change on those sectors and the sectoral impact on climate change. Even though COVID-19 has been the unprecedented health emergency faced by the world in 2020, the analysis and projections presented in this section does not take into account the effect of COVID-19 on the past and future sectoral growth perspectives.

Impact of Climate change on sectors of Indian economy

1) Agriculture

Agriculture in India accounts for a substantial share in GDP (14%), and an even larger share in employment (42%)[36]. The criticality of the sector can be judged from the fact that it has a direct bearing on the lives of 1.38 billion people. According to the 2011 census, 69% of the population remains rural and intimately connected to agriculture sector, which provides forward and backward linkages from the rest of the economy[37]. The share of agriculture in overall employment dropped to 42% in 2016 from 70% in 1981[38]. The sector's contribution has had drastic impacts for the past few years majorly due to unusual rains and frequent droughts. India has experienced 24 large scale droughts from 1891 to 2012 and the frequency has been ever since increasing[39]. Higher temperatures tend to reduce crop yields and favour weed and pest proliferation. Water is the most critical agricultural input but more than 50% of the total cultivated areas do not have proper irrigation facilities in place[40]. The negative effects of climate change impact the irrigated crop yields across agro-ecological regions both due to high temperature and changes in water availability.

Rainfed agriculture is also predominantly impacted due to rainfall variability and reduction in number of rainy days. In 2019, sugar output dropped to its lowest in three years due to delayed showers that shrivelled cane in Maharashtra[41]. A continuous shortfall in production will add to India's import costs which is another major concern for the country. Another concern is the excessive use of groundwater as opposed to the surface and sub-soil, causing the government to classify 30% of the development blocks as semi-critical, critical or overexploited[42].

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[36] *https://tradingeconomics.com/india/gdp-from-agriculture*

[37] *Gupta, S. et al. (2014). Impact of Climate Change in Indian Economy: Evidence from food grain yields. Climate Change Economics, 5(2): 1450001.*

[38] *India - Employment In Agriculture, Trading Economics (2020) https://tradingeconomics.com/india/employment-in-agriculture-percent-of-total-employment-wb-data.html*

[39] *NRAA (2013). Contingency and compensatory agriculture plans for droughts and floods in India—2012. Position Paper 6, National Rainfed Area Authority, 87 pp.*

[40] *Jitendra (2019). Growing gap in irrigation potential and usage major challenge, Down to Earth. https://www.downtoearth.org.in/news/agriculture/growing-gap-in-irrigation-potential-and-usage-major-challenge-66580*

[41] *Parija, P. (2019). India's sugar output plunges to 3-year low due to droughts, The Print. https://theprint.in/india/indias-sugar-output-plunges-to-3-year-low-due-to-droughts/256880/*

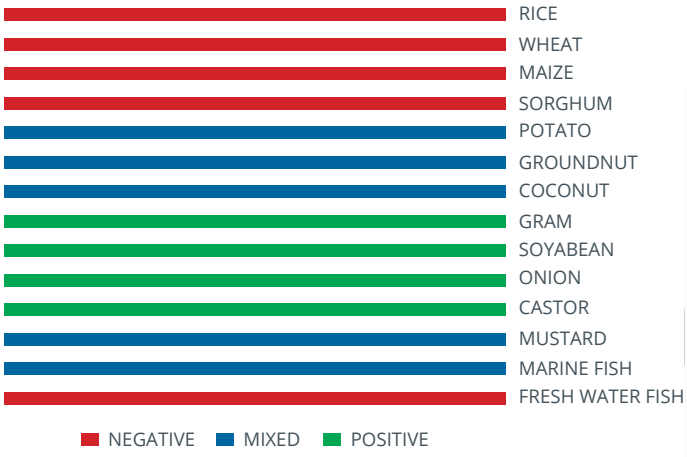
[42] *Revised Guidelines for Ground Water Extraction Notified, Ministry of Water Resources, River Development and Ganga Rejuvenation (2018) https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1555824*

IN ORDER TO MEET THE GROWING DEMAND FOR FOOD, THE FARMERS ARE EXPECTED TO PRODUCE 50% MORE GRAIN BY 2020 AS COMPARED TO 2014[36], ADDING A LOT OF PRESSURE ON THE RESOURCES.

As shown in projection of temperature and rainfall (Figure 6 a&b), there is an upward trend in temperature and average rainfall but a downward trend in the number of wet days in a year. Increased sub-regional variations and more extreme rain events clearly show the impact of climate change. The average temperature change predicted is 2.33°C - 4.78°C along with CO_2 concentrations becoming almost twice from the current levels (2015) and the heat waves will lead to increased variability in summer monsoon precipitation.

To feed a population of about 1.38 billion (as of 2020), India faces major challenges in the form of increasing its food production to the tune of 300 MT. In order to meet the growing demand for food, the farmers are expected to produce 50% more grain by 2020 as compared to 2014[43], adding a lot of pressure on the resources. Along with that, major crops such as wheat are predicted to have a fall in the yield by 5-10% with every increase of 1°C (Figure 10). Overall, looking at the current trend, India could experience a 40% decline in agricultural productivity by the 2080s. Adding to the problem is the projected decline in mean per capita annual freshwater availability from 1951 to 2050 (Figure 11).

Figure 10: Commodity wise impact
(From modeling)



Source: DownToEarth

Figure 11: Population and per capita water availability

Year	Population (Million)	Per capita water availability (m^3/year)
1951	361	5177
1955	395	4732
1991	846	2209
2001	1027	1820
2025	1394	1341
2050	1640	1140

Source: Government of India, Ministry of Water Resources, 2009

[43] *Kumar, R. and Gautam, H.R. (2014). Climate Change and its impact on agriculture productivity in India. Journal of Climatology and Weather Forecasting, 2(1): 1000109.*

A study conducted by the DST CoE (IIT Delhi) covered the Indian Himalayan region that is facing climate change challenges due to warmer winters, uneven precipitation, increased aridity, and increased frost and storm events, leading to severe impact on horticulture and agriculture practices. Deciduous fruits such as apple, cherry, apricot, peach, and pear are substantial harvests of the Himalayan region. Apple-growing areas in Himachal Pradesh (Figure 12) provide sufficient winter chill as required by apple and other deciduous fruits. Singh et al. (2020)[8] assessed the change in the suitability of various deciduous fruit trees from the present climate to the RCP4.5 scenario. **The areas that are suitable in the current climate are projected to become less suitable or unsuitable under global warming.** The high-chill (requiring continuous low winter temperatures) demanding temperate fruits may no longer be suitable for the given locations and may have to be replaced by low-chill requiring fruits or vegetables as shown in Figure 13.

Figure 12: Location of Himachal Pradesh, India. The dotted lines (violet, black and red) divide the four physiographic regions (Greater Himalayas, Lesser Himalayas, Outer Himalayas and Piedmont plains)

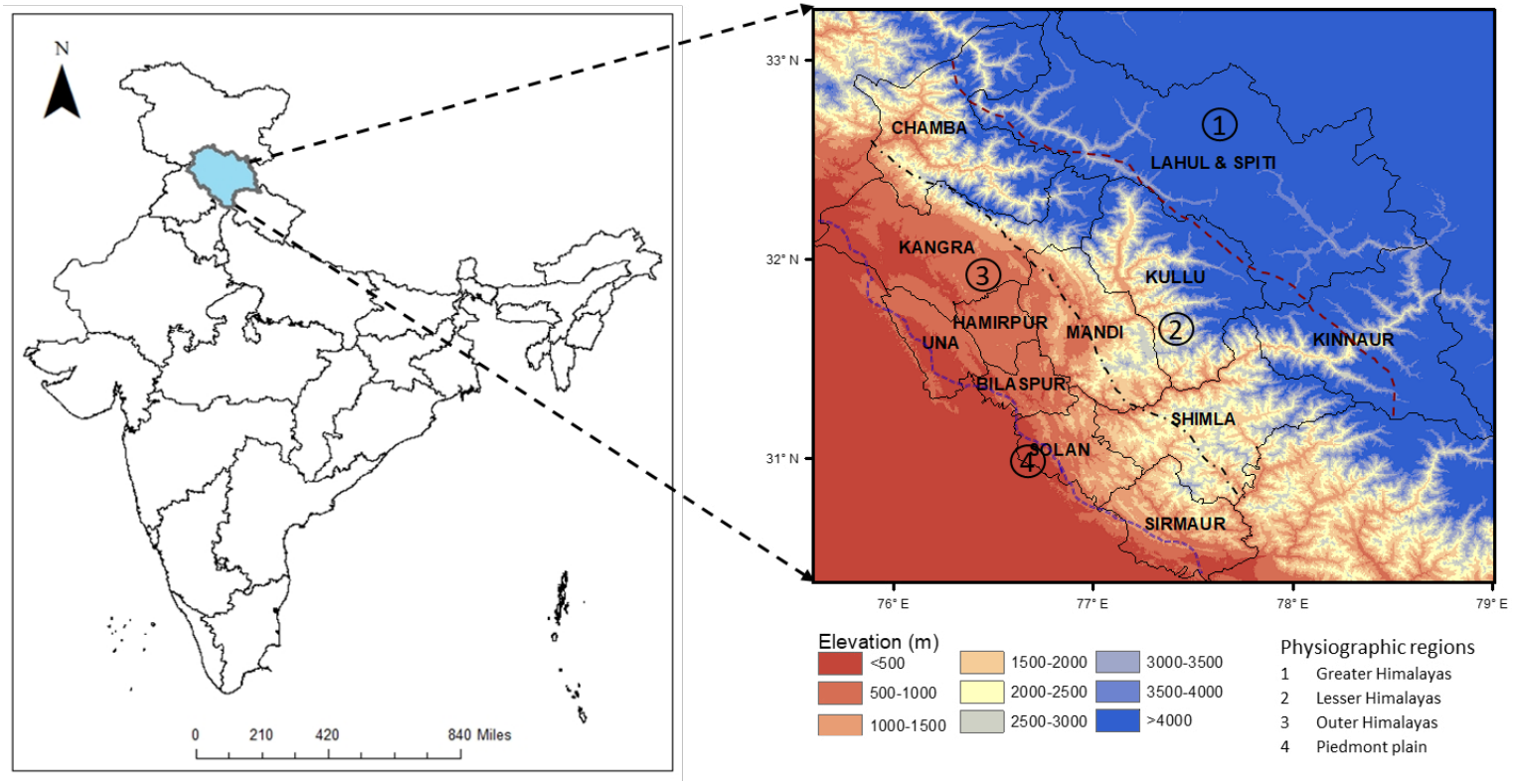


Figure 13: Change in land suitability for deciduous fruit cultivation from historical climate (1910 – 2005) and RCP4.5 (2075 – 2089). The shaded area is the suitable region and the white area is unsuitable region

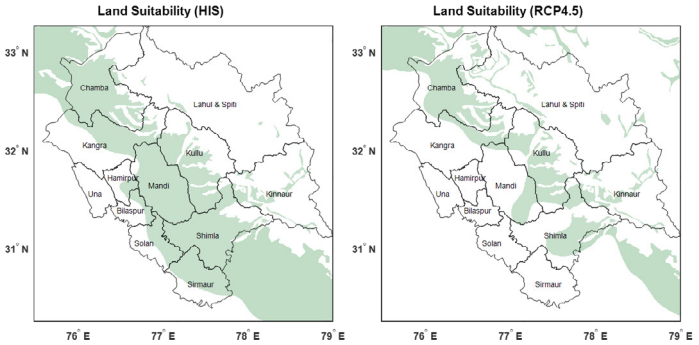
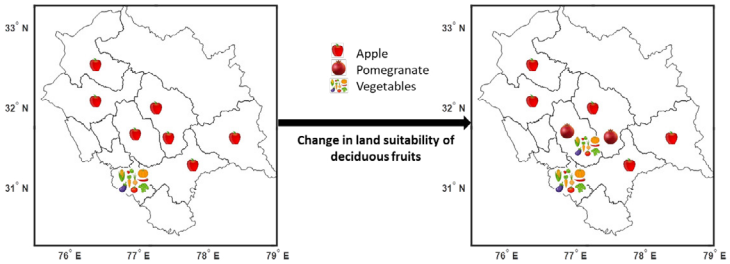


Figure 14: Shift in cultivation of deciduous fruits from high chill requiring fruits (apple) to low chill requiring fruits (pomegranate) and vegetables in lower-lying areas of Himachal Pradesh due to increase in temperature



In lower-lying areas of Himachal Pradesh, most of the high-chill demanding fruits species are already getting replaced by low-chill requiring fruits and vegetables because of degradation in the quality of high-chill demanding temperate fruits such as apple as a result of global warming (Figure 14). Pre-established orchards may witness a decline in productivity in the future. It would thus be necessary to introduce new fruit and vegetable species suitable for the changing climate to avoid a total failure. The life span of an orchard is around 40 years, and it takes 3-5 years to start producing fruits in new orchards. Unlike seasonal crops such as rice, wheat and maize, orchards are costly and therefore suffer much higher losses in both time and cost as a result of climate change. In the global warming scenario, the productivity of deciduous fruit orchards decreases because of low winter chill and at some point in time the orchards may stop giving any produce.

Looking at such problems faced in various regions in India, the government aims to reduce the greenhouse gas emissions to almost half by 2050[44]. Hence, coordinated efforts to strengthen the research to assess the impact of climate change on agriculture, forests, animal husbandry, aquatic life, and other living beings could be very helpful in lifting the economy of the country.

Many adaptation strategies are devised to cope with adverse impacts of climate variability and change on agricultural production; including altering what is produced, how it is produced (modifying the inputs used for production), adopting new technologies, and adjusting management strategies. Yet, these strategies have their limitations under severe climate change conditions and would require sufficient long-term as well as a short-term investment in changing the practices.

Some of the changes required in the current practices can be efficient water and nutrient management to enhance efficiency, evaluation of carbon sequestration potential, understanding better opportunities offered by conservation agriculture and agro-forestry, and identifying cost-effective methane/carbon emission reduction practices.

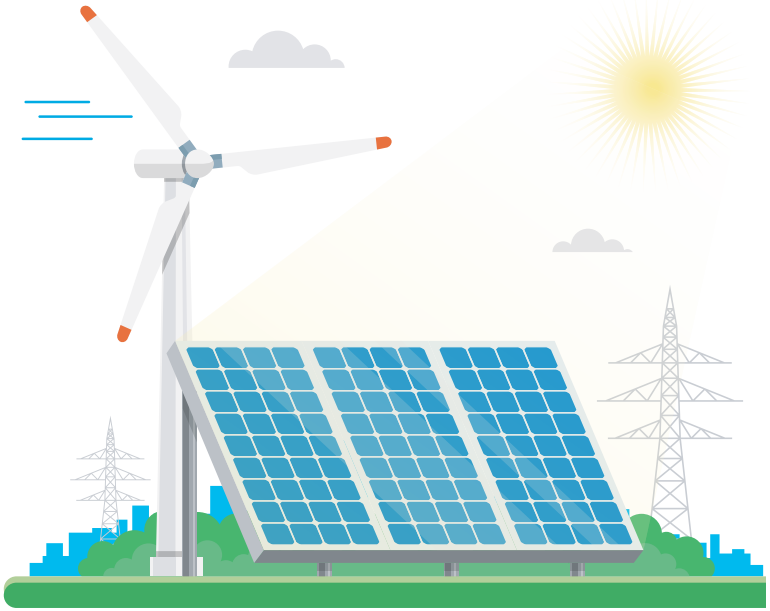
[44] *Gautam, H.R. and Sharma, H.L. (2012) Environmental degradation, climate change and effect on agriculture. J Kurukshetra 60: 3-5.*

2) Energy

India is the 4th largest emitter of GHG in the world after China, European Union and the United States. The energy sector is by far the largest contributor of GHG emissions, accounting for about two-thirds of the total emissions[45]. There exists a delicate balance between mitigating the harmful emissions produced and providing access to energy. If coal continues to be the dominant source of power, the emissions are bound to increase. To maintain this delicate balance, India relies on 2 core pillars – Increasing energy efficiency on both demand and supply side, and promotion of low carbon energy sources such as solar and wind power. Currently, there are two major drivers of mitigation, one being the market forces which are increasingly incentivizing move towards energy efficiency like the Perform, Achieve and Trade (PAT) which aims to improve energy efficiency by 1-2% per year for very large energy intensive industries. The second factor is the push to meet India's NDCs, and the energy targets adopted. The Government of India has set a target of installing 175 GW of renewable energy capacity by the year 2022, with 100 GW from solar, 60 GW from wind, 10 GW from bio-power and 5 GW from small hydro-power, and overall 450 GW by 2030.

One of the efforts made by Indian Government to reduce coal consumption and encourage renewables is to introduce a modest coal tax, known as GST compensation cess of INR 400 per tonne[46]. The amount collected from this tax is deposited in the National Clean Energy Fund. This fund is to be used to finance and promote clean energy initiatives[47]. Further, all new Ultra Mega Power Plants – Plants with more than 4 GW capacity – have to adopt High Efficiency Low Emission (HELE) technologies. The aim is to have 50% all Indian coal based fire plants adopt HELE technologies by 2030. There is also a trend of thermal power companies also getting involved in the renewable energy field, such as the TATAs, NTPC and Adani Power[48].

The ambitious targets for renewable power generation provide an impetus for companies to enter the renewable energy sector. Grid upgrades are a major need for the sector, for which the Indian government has announced plans for investment. Another tool to aid renewable energy generation is Renewable Purchase Obligations, which define a set quota of electricity for obligated entities which includes Discoms, Open Access Consumers and Captive power producers to purchase from renewable energy sources[49]. Renewable Energy Certificates (RECs) can be purchased by states and UTs which fall short of the targets[50]. Even though the country is pushing the renewable energy agenda forward, there are studies that indicate changing weather patterns, arising out of climate change, may negatively impact country's renewable energy generation capacity[51].



[45] *Chakrabarty, S. (2018). By the Numbers: New Emissions Data Quantify India's Climate Challenge. https://www.wri.org/blog/2018/08/numbers-new-emissions-data-quantify-indias-climate-challenge*

[46] *The Evolution of the Clean Energy Cess on Coal Production in India, IISD https://www.iisd.org/system/files/publications/stories-g20-india-en.pdf*

[47] *National Clean Energy & Environment Fund (NCEEF). https://www.doe.gov.in/sites/default/files/NCEF%20Brief_post_BE_2017-18.pdf*

[48] *Shidore, S. (2015). India's Power Sector and the Climate Challenge. Working Paper. https://stanleycenter.org/climatechange/SarangShidore-IndiaPowerSector.pdf*

[49] *https://rpo.gov.in/Home/Objective*

[50] *Renewable energy certificate sales down 10 per cent to 5.04 lakh in December, The Economic Times (2019) https://economictimes.indiatimes.com/small-biz/productline/power-generation/renewable-energy-certificate-sales-down-10-per-cent-to-5-04-lakh-in-december/articleshow/73027104.cms*

[51] *Choudhary, S. and Bhaskar, U. (2018). Climate Change to affect India's renewable energy plan: Study. Mint e-paper. https://www.livemint.com/Industry/jufptlWcH73mwj5ibSw2OI/Climate-change-to-affect-Indias-renewable-energy-plan-Stud.html*

3) Tourism

According to World Travel and Tourism Council (WTTC), travel and tourism contributed 9.6% to India's GDP in 2018 and ranked 7th in the world in terms of contribution to the GDP[52]. In 2019, the travel and tourism industry in India contributed around USD 268 billion to the GDP and roughly 4.2 crore jobs were created in this sector, which accounts for 8.1% of the total employment in the country[53]. Looking at the growth in this sector, the total contribution by travel and tourism sector to India's GDP is expected to increase from INR 15.24 lakh crore (USD 234.03 billion) in 2017 to INR 32.05 lakh crore (USD 492.21 billion) in 2028. In 2019, India recorded over 10.89 million foreign tourist arrivals, indicating a 3.2% growth rate from 2018[54]. To boost the growth in the Hotel and Tourism sector, cumulative FDI inflow of USD 15.28 billion were received between April 2000 and March 2020[52] and 100% Foreign Direct Investment (FDI) is allowed through the automatic route[55]. In addition to this, a five-year tax holiday has been offered for 2, 3 and 4-star category hotels located around UNESCO World Heritage sites[53].

India, being a geographically diverse country, has multiple offering for tourists. However, the sector is highly susceptible to extreme weather events that are caused due to increasing climate change, with massive impact on infrastructure, requiring emergency preparedness measures, increasing maintenance costs, and disrupted commercial activity. The factors that have direct impact on tourism are temperature increase, extreme events, and rise in sea-level. Moreover, in 2005, tourism was responsible for about 5% of global CO_2 emissions, contributed mainly through three tourism sub-sectors: transportation, accommodation, and tourist activities[56] and the numbers are increasing ever since. Combined, these account for high energy consumption and use of fossil fuels. The transportation of tourists exposes the industry to the challenge of finding mechanisms to reduce environmental impacts and carbon dioxide (CO_2) emissions. Reductions in seasons *(spring and summer)* causes losses for certain types of tourism, especially coastal *(sea rise, bleaching and mortality of coral reefs)* destinations. On the other hand, loss to mountains *(snow melting)* is detrimental to the winter tourism sector[57]. Various tourist activities depend on meteorology and climatology and therefore unfavourable conditions can affect the tourist's activities, operations, comforts, and flow of tourist to a large extent. The impact worsens due to flight delays, cancellations and re-routing, affecting tourist movement. In terms of radiative forcing, tourism contributes to 4.6% of global warming. The transport sector, including air, car and rail, generates the largest proportion, with 75% of all emissions. Air travel is responsible for 40% of the total carbon emissions caused by this sector, and 54-75% of radiative forcing. The accommodation sector accounts for 20% of emissions through heating, air-conditioning and the maintenance of accommodation infrastructure. Museums, theme parks, events or shopping also contribute to roughly 3% of emissions[58].

The sector can benefit from sustainable tourism and ecotourism initiatives that imply minimizing the negative and maximizing the positive effects of all the activities of tourism. This would benefit the environment, local communities, prosperity, heritage, *(cultural, natural, built, oral, intangible)*, help in economic growth and viability, supporting employment quality through social equity. It will result not only in fulfilment of tourist's needs but also in development of community wellbeing, restoration of biological diversity and emphasize resource efficiency. While the ordeal of travel may seem like a forthcoming affair, it is imperative to go green.

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4) Insurance

Extreme weather events have become more frequent in recent years on account of climate change, which results in losses of billions of dollars. For instance, the Kerala floods of 2018 led to about USD 5.6 billion worth of damage[59]. Unpredictable weather patterns, with short, intense monsoons have led to disruption in agriculture.

According to global climate risk index 2020, India suffered an economic loss of USD 37 billion in 2018 due to climate change[60]. Such huge quantum of losses puts substantial pressure on the insurance sector. While climate change poses a risk for the sector, it also provides opportunity to reorient the flow of capital towards climate-resilient investments, thereby making insurance a potential tool to address climate change issues. Innovative insurance products are being developed by World Bank and IFC in emerging markets. They also provide seed funding to organizations, such as Global Innovation Lab for climate change, to help them grow their climate related insurance programs. Farmers are being targeted by programs such as one developed by The World Food Programme, Oxfam America, and the R4 Rural Resilience Initiative to allow low-income farmers to pay for crop insurance with their own labour. The goal is to encourage them to pay for insurance with cash over time once they have perceived the benefits[61]. However, if climate related losses mount, it would spell the doom for insurance companies.

A case in point is the Pradhan Mantri Fasal Bima Yojana (PMFBY), launched in 2016, intended to insure farmers' crops[62]. However, it has experienced delays in payouts, and this may be partly attributed to climate change and its effects. The recent rise in extreme weather events such as untimely rains and sudden droughts have led to increasing losses of crops, leading to more applications to the scheme. As per government sources, in Maharashtra alone, there had been 5.2 million intimations of 100% losses in crops such as soyabean. This, along with similar other claims, have insurers bracing for tremendous losses[63].

In order to tackle the risks of climate change, it is important to use data analytics to better assess possible impacts of climate change on the firm, which, in turn, will help insurers to be better prepared[64]. There is a huge risk looming Indian insurance industry in terms of increase in environmentally harmful re-insurance, as other markets such as Europe have become extremely sensitive towards sustainability, resulting in re-insurance sector searching for new markets. In order to ensure robust growth of the insurance industry, there should be a shift towards long term goals and sustainability rather than short term returns for high risk areas. Embedding Environmental, Social and Governance (ESG) criteria as part of risk assessment frameworks, innovating resilient investment products such as climate change bonds, resilience bonds, would go a long way in proliferating a climate resilient insurance industry in India[65].

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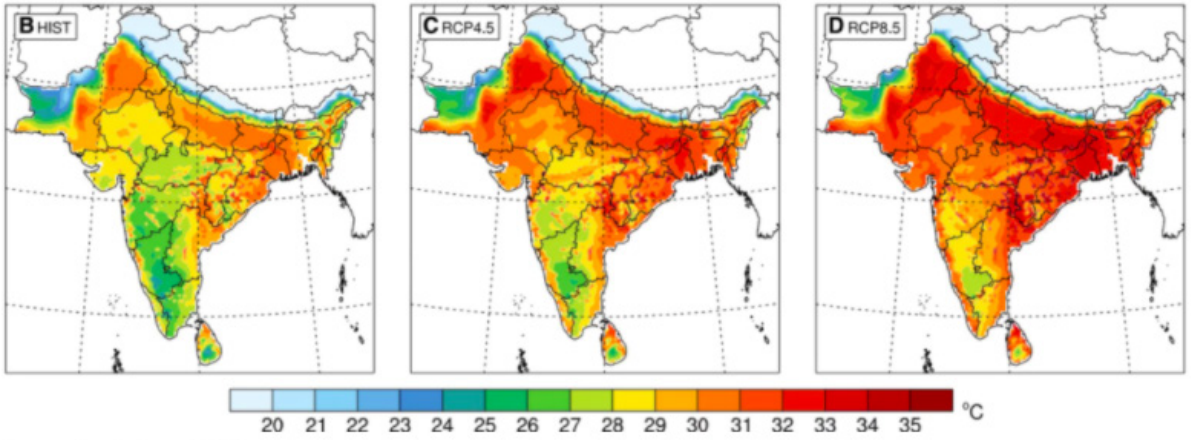
5) Human Health

Climate change poses significant threat to the health of the general public. In its Third Assessment Report, the IPCC concluded that *'Climate change is projected to increase threats to human health'*. It is expected that climate change will affect the health sector through increase in the frequency, intensity, and extent of extreme weather events as well as deteriorating air quality, increased spread of climate-sensitive diseases and intensified food insecurity. Transmission of disease through insects and pests, food, and water have a negative impact on health and well-being of people[21], which will be further exacerbated owing to the current pandemic.

Rising air and water temperatures add to the exposure to waterborne and foodborne diseases. Multiple cases in the past have shown to have an impact on human health across different regions in India. In 1998, the heatwave in Odisha took more than 2,000 lives. 1,421 people died in Andhra Pradesh due to a heatwave in 2003, similar effects of heatwave were also observed in Uttar Pradesh, Haryana, Punjab, Rajasthan, Gujarat, Bihar, and Orissa in 2003. In 2004, a cold wave in Uttarakhand and Uttar Pradesh, a tsunami affecting Tamil Nadu, Andhra, Kerala, and the Andaman-Nicobar Islands, floods in Madhya Pradesh, Maharashtra and Gujarat in 2005 and a cyclone in Andhra Pradesh took many lives and caused immense damage to health infrastructure. In June 2005, Odisha recorded the highest record-breaking temperature in the last 33 years of 46.3°C, which is 10° above the normal[21]. More susceptible in such cases are the ones having cardiovascular and respiratory disease. Im et al. (2017)[66] assesses the impact of climate change on the deadly combination of heat and humidity, measured as the "wet bulb" temperature (WBT). Once this reaches 35°C, the human body cannot cool itself by sweating and even fit people sitting in the shade will die within six hours (Figure 15)[67].

Figure 15: Distribution of maximum wet bulb temperature (WBT) from 1976-2005 (B), from 2071-2100 with 2.25°C of warming (C), from 2071-2100 with 4.5°C of warming (D). WBT of more than 31°C is considered extremely dangerous and over 35°C is fatal within hours



(Source: Carrington, 2017)

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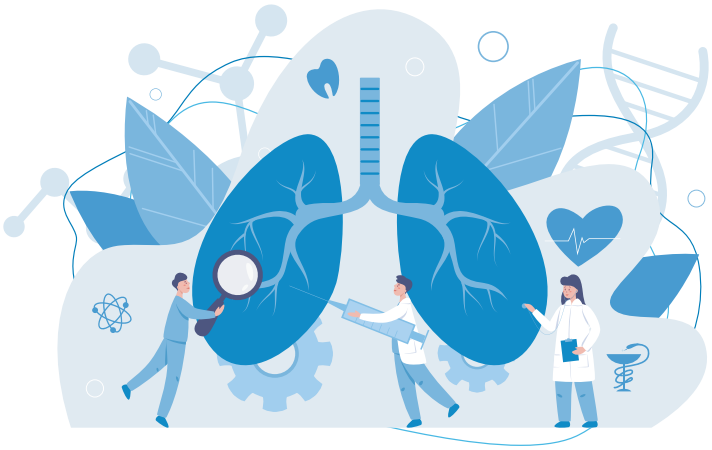
Adding to this problem is the increased frequency and severity of allergic illnesses, including asthma. Climate change can also alter the geographic range and distribution of many disease-carrying insects, such as ticks that carry Lyme disease and mosquitoes that transmit viruses such as Zika, West Nile, and dengue, with varying impacts across regions, exposing everyone to greater risk[68]. All of these effects are predicted to have a significant impact on global mortality and morbidity, and the available evidence indicates that children are most at risk[69]. Some other impacts due to increasing sea levels are death and injury caused by flooding, reduced availability of freshwater due to saline water intrusion, contamination of water supply due to water pollution, increase in disease-spreading insects, and the food insecurity.

Such an impact would translate into two major illnesses: diarrhea and malaria that are highly sensitive to drastically changing temperatures and precipitations which cause two million diarrheal deaths annually on an average[70], and more than a million deaths annually by malaria, mostly in young children[71]. Lack of water and poor water quality affect hygiene and health, including the risk of diarrhea, which kills approximately 1.8 million people every year. It is predicted that in 2030, the estimated risk of diarrhea will be up to 10% higher in some regions than if no climate change happens[21].

According to the WHO report[72], about 36% of the world population is exposed to the risk of contracting malaria. Malaria has a wide distribution of endemicity and this extends from South Asia and South-east Asian countries. India accounts for three-quarters of all malaria cases in South-East Asia, with around 85.7% of the population exposed to it[73]. Some of the high malaria prone states in India are Odisha, Jharkhand, Chhattisgarh, Madhya Pradesh, Maharashtra, Gujarat and West Bengal and the largest number of deaths reported in Odisha. Climate change studies on malaria show that in Odisha there may be a reduction in malaria transmission, but it may still remain malaria endemic in the near future. Odisha is also one of the most vulnerable states of the country affected by the effect of climate change.

Simulation studies using different models project that population are at risk due to malaria transmission in many parts of the world including India[74,75,76,77] specifically high transmission of malaria projects over tropics.

The DST CoE has investigated the spatio-temporal variability in malaria transmission over Odisha using a dynamical malaria model (VECTRI) driven by various climatic and non-climatic factors[9]. To examine the influence of temperature and rainfall on vector density and entomological inoculation rate (EIR), the correlation coefficients between temperature and rainfall with vector density and EIR are computed. Results from the annual trends for different parameters show that temperature and rainfall have a linear increasing trend during the study period (2002-2013) (Figure 16). In their study, Singh et al. (2019)[9] found that temperature and rainfall are the two key climate drivers that influence malaria vector development, and play a significant role in characterizing the intensities of malaria transmission in Odisha. Mosquito species *(plasmodium falciparum)* parasite development is linked with temperature and rainfall variations. The abundance of the mosquito populations in terms of malaria vector density have a significant strong positive correlation with temperature and rainfall. Rainfall of 7 to 11 mm/day and temperature of 28°C to 29°C are found to be favourable condition for mosquito growth, parasite development and malaria incidences during



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May to October over Odisha. The highest peak of malaria incidence is observed during August to September (Figure 17). Malaria incidences increase once the rainfall exceeds a certain threshold during the monsoon season.

Figure 16: Trend in VECTRI simulated annual mean (a) Rainfall accumulation, (b) surface mean temperature, (c) mosquito density, and (d) EIR, from 2000–2013 over Odisha

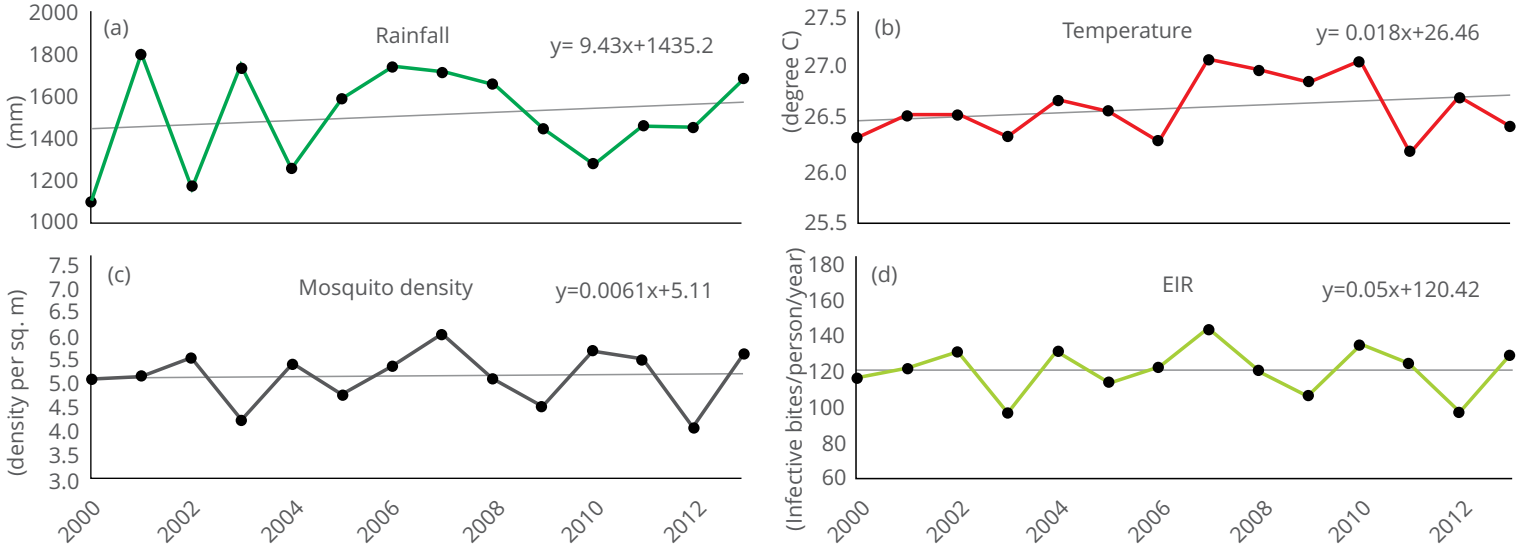
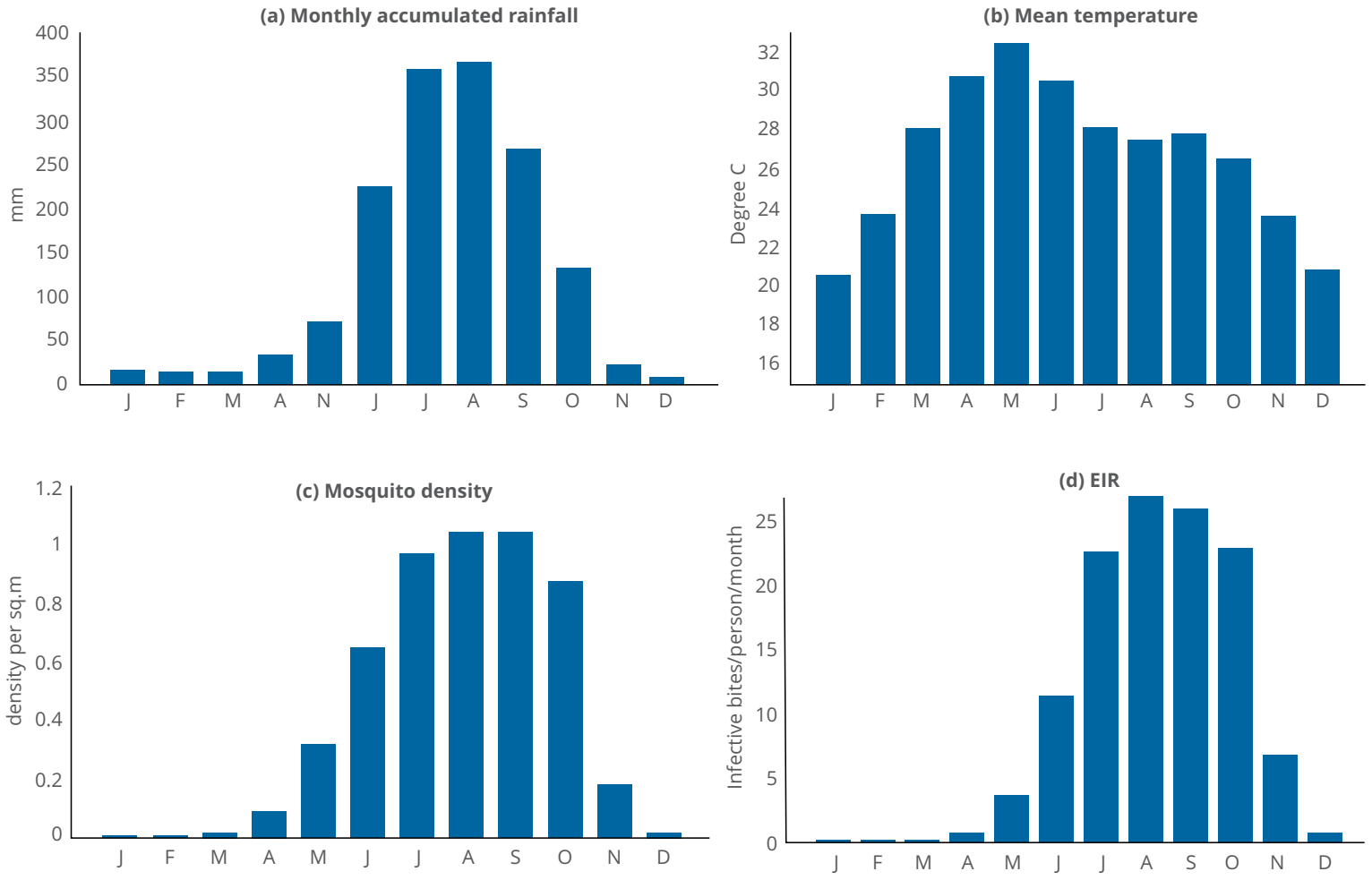
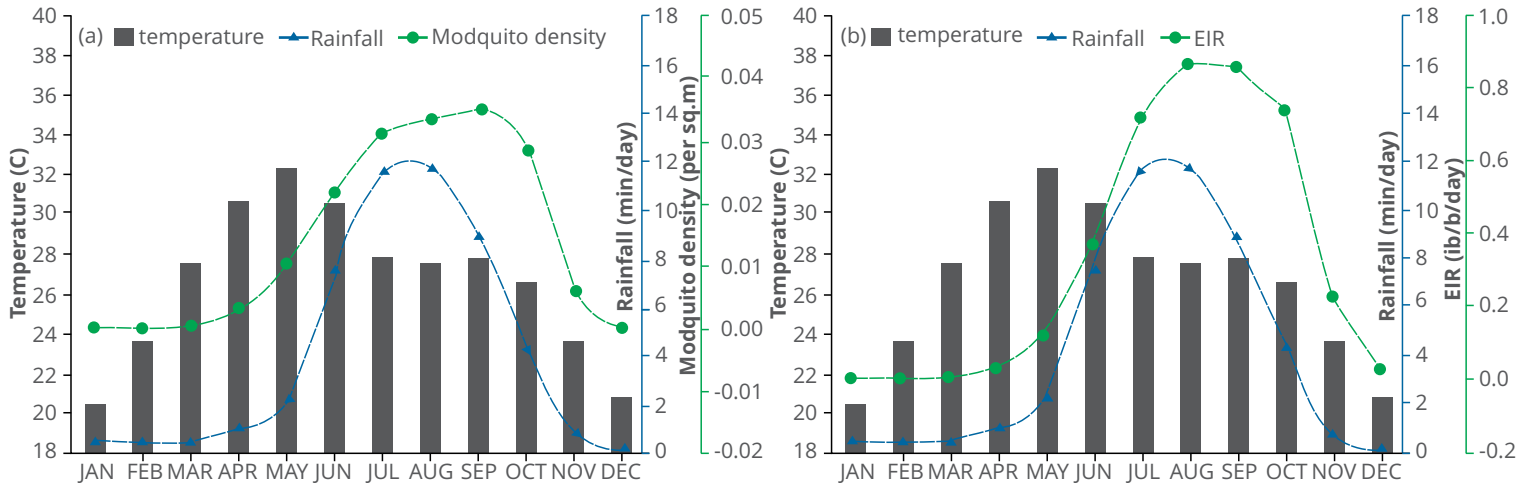


Figure 17: Monthly variations in VECTRI simulated. (a) Accumulated rainfall, (b) surface mean temperature, (c) mosquito density, and (d) EIR, over Odisha. The graphs correspond to the averaging period of 2000–2013



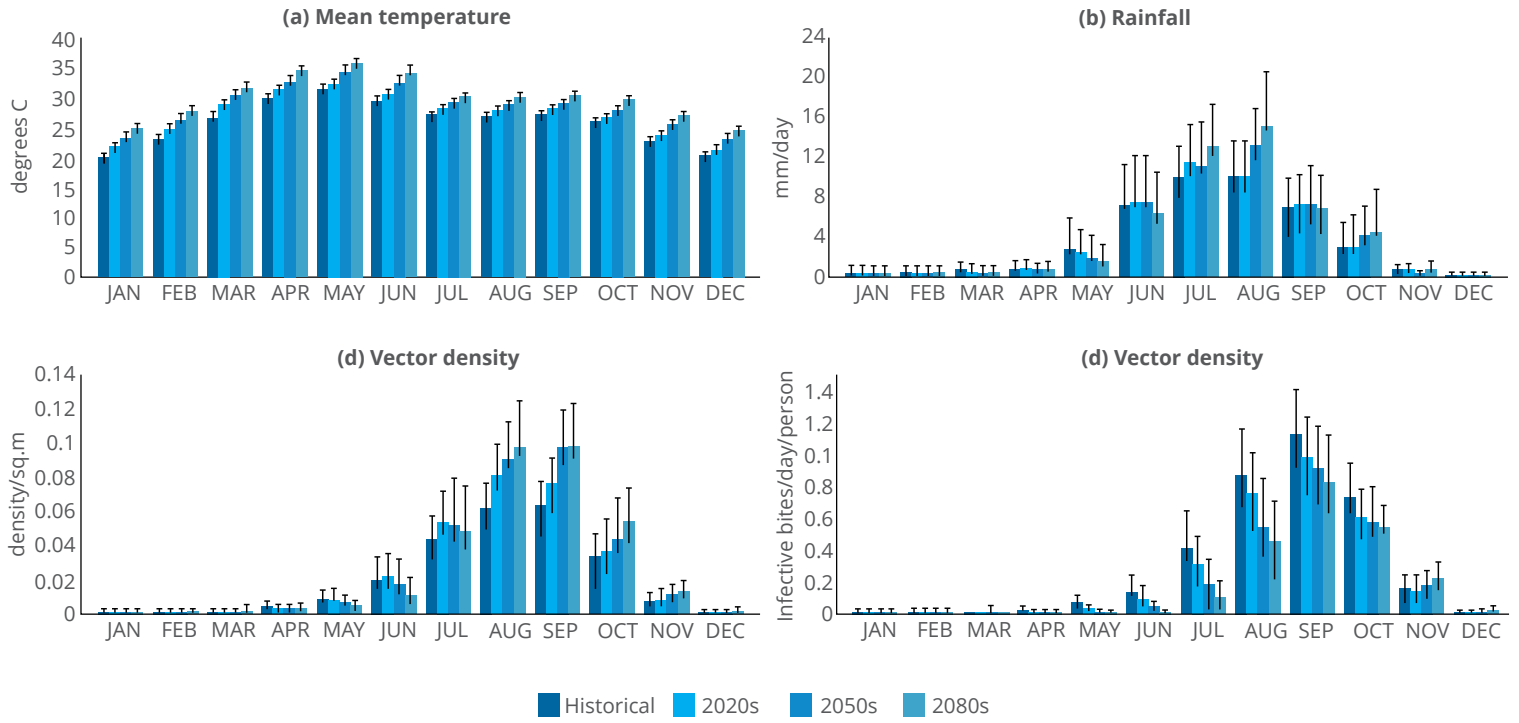
THEY FOUND THAT DURING MONSOON SEASON **MOSQUITO DENSITY VALUES INCREASE WHEN TEMPERATURE** AND RAINFALL VALUES REMAIN WITHIN THE RANGE OF **28–29°C AND 13 MM DAY-1,** RESPECTIVELY, BUT ABOVE A CERTAIN THRESHOLD **(TEMPERATURE ABOVE 30°C AND RAINFALL ABOVE 13 MM DAY-1)** THE MOSQUITO DENSITY VALUES DECREASE.

Figure 18: Graph showing the relationship between VECTRI simulated surface mean temperature and rainfall with: (a) mosquito density, and (b) EIR, over Odisha. The graphs correspond to the averaging period of 2000–2013



Further, the relationship between temperature and rainfall with vector density and EIR in terms of monthly variations for the study period is shown in Figure 18. It is found that the relationship among temperature and rainfall with vector density and EIR are strongly nonlinear. During monsoon season (June to September), the values of vector density increases with temperature and rainfall. A strong correlation is seen between EIR and temperature and rainfall during the monsoon season. They found that during monsoon season mosquito density values increase when temperature and rainfall values remain within the range of 28–29°C and 13 mm/day, respectively, but above a certain threshold (temperature above 30°C and rainfall above 13 mm/day) the mosquito density values decrease.

Figure 19: Monthly variation in bias corrected simulated by CCSM model Matrices of VECTRI Malaria model for the historical and three projections i.e. 2020s, 2050s and 2080s based on RCP8.5



Further bias corrected rainfall and temperature simulated from the CCSM4 model are used to compare the metrics of VECTRI malaria model for three future projections i.e. 2020s, 2050s and 2080s. These projections are based on RCP8.5 emission scenarios. Future projections show an overall reduction in EIR with an increase in temperature and rainfall particularly in monsoon season (Figure 19).

Air pollution also contributes to respiratory diseases, where in India about 6% of children and 2% of adults suffer from asthma[78]. The depletion of the ozone layer leads to exposure to ultraviolet radiation has been identified as a cause of skin cancer. Amongst other issues, mental health especially that of the farmers has led to an ever-increasing rate of suicide and constant pressure on their families[79].

Since climate change increase the demands for health care services and facilities, including public health programs, disease prevention activities, health care personnel, infrastructure, and supplies related to treatment of infectious diseases and temperature related diseases, it is clear that national ambitions for health, economic growth, and environmental sustainability need to go hand in hand and not as individual goals. Climate change negatively impacts human health, leading to higher levels of illness and disease and causing millions of working days to be lost annually. If long-lasting economic growth is truly the country's goal, India should focus on achieving emissions reductions alongside improvements to health services and infrastructure to avoid such unnecessary productivity losses.

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6) Infrastructure

The projected rise in Indian urban population is 745 million by 2041, which already puts pressure on the services and infrastructure in major cities. On top of this, the cities are now exposed to Climate-related hazards. Climate change will not only increase the risks of death, injury, and ill-health and disrupt livelihoods, but also damage property, infrastructure and settlements due to cyclones and coastal and inland flooding, storm surges and sea-level rise. By 2070, there will be an increased risk of storm surges in coastal areas including Chennai, Dhaka, Kolkata, and Mumbai as well as other low lying, densely populated coastal areas of India[80]. While efficient disaster preparedness in many cases have saved lives, there remains a significant challenge in rebuilding damaged infrastructure and returning to normalcy after the disruptions and the associated huge amount of costs. The Kerala floods in August 2018, destroyed around 280,000 houses, 140,000 hectares of standing crops, and about 70,000 Km of road network and the total recovery costs were estimated at INR 310 billion. On similar lines, the 2019 cyclone 'Fani' caused damage to roughly 500,000 houses, 6,700 hospital buildings, and 100,880 lakh ha of agricultural land. There was heavy loss to electricity infrastructure, resulting in overall losses of INR 500 billion and the coastal areas are estimated to take about 5 to 10 years to rebuild and recover[81].

India's densest coastal urban agglomerations such as Mumbai, Kolkata, Chennai, and Vishakhapatnam are hubs of critical infrastructure and assets. They contribute to the nation's economy and growth by providing efficient transport and freight networks, road and rail corridors, industrial zones and parks, maritime and port facilities, petroleum industries, and refineries. More than 60% of India's FDI inflows are received by the coastal states for development purposes, which are at risk due to the impacts of climate change[81].

Building resilient infrastructure has co-benefits that are not just limited to extreme weather events. These also create direct employment opportunities for the coastal communities, provide reliable water supplies, dedicated irrigation systems to overcome the impact of droughts and generate hydroelectricity through flood protection infrastructure. Additional benefits include reduction in soil erosion and deforestation, and resilient transport networks for commercial activity, improving mobility and employment. Community participation in maintaining such resilient infrastructure generates significant social benefits such as knowledge dissemination, enhanced communication, improved storage facilities, and labour, which will strengthen community cohesion even during non-emergency situations. Looking at the benefits, Amaravati, the capital city of Andhra Pradesh, is being planned as a sustainable city, incorporating climate resilient infrastructure development[82].

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7) Productivity

Workplace heat conditions, economic performance and sustainable development are highly correlated to each other. The relationship is such that the hourly work capacity beyond a certain heat exposure level *(temperature beyond 30-40°C, depending on humidity level)* goes down. In a study to investigate the effect of air temperature on labour productivity at call centres in India, it was found that there is a decrease in productivity by 1.8% per degree C above 22°C hot days[83]. Similarly, garment manufacturing and diamond picking in India where there is a decrease in productivity by roughly 3% per degree C above 25°C hot days[84]. It further affects the exports, industrial value added and services output as well as the GDP per capita (3% decrease per degree C hotter than average years)[85]. Increase in heat is already common during hot seasons and will result in reduced work capacity, lower labour productivity and an overall loss of economic output in India in the next three decades[84].

A McKinsey report estimates that the number of working hours lost due to extreme heat would increase roughly to 20% by 2050, which will have a severe impact on economic growth. 160-200 million Indians are exposed to rising heat and humidity levels with higher risk of lethal heat waves by 2030. 380 million people, which is roughly 75% of the labour force is exposed to heat-related stress[85]. Also, with rise in temperature, the frequency of interpersonal conflict increases by 2.4% at workplace[86]. The labour productivity losses occurring each year would eventually accumulate in a few decades to have a significant effect on poverty reduction and economic development. Noteworthy impacts are caused due to high geographic exposure, high occupational vulnerability, low adaptive capacity or limitation to adaptation.

The solution for acting on the impact can be structured according to response type such as technical, regulatory/ infrastructural, behavioural or R&D, and the responsible agent including individuals, business and government, with a focus on feasibility and scale of impact. Actions to build resilience against current and future effects of hot climate conditions include right adaptation techniques to protect working people from current high heat levels such as reactive or project-level adaptations, for example climate-smart municipal design. The correct assessment of such adaptations is equally important as it is context specific, for instance, shifting working hours to reduce the effect of peak temperatures, but only if there is sufficient flexibility in working patterns, application and feasibility of "green technology" for energy systems, cooling of buildings, transport and economic activities, in order to limit greenhouse gas emissions. A case in point is green roofs that improve the quality of the built environment, reducing health problems associated with particulate matter, as well as reducing noise pollution[87].

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8) Ecosystems

Ecosystems are important for not just human well-being but also economic growth as they provide numerous essential services including fresh water, food, medicinal products, energy, biodiversity and associated traditional knowledge. Due to extensive impact of climate change on the ecosystems, the plant and animal species that inhabit the mountains of the Himalayan regions have already started to migrate to higher altitudes as they fear extinction, causing changes in the characteristics of biomass.

The DST CoE (IIT Delhi) conducted a set of numerical experiments over Beas basin in North-Western Himalaya to understand the response of glaciers to the climatic changes and showed that glaciers are melting rapidly in the Beas basin under present climactic conditions, and will continue to do so in the future (Figure 20). The rate of volumetric loss is almost similar throughout the present climate, however, glacier area loss increased dramatically in the start of 21st century as shown in Figure 21. Even going forward, the temperature will continue to rise under RCP8.5 but may stabilize under RCP4.5.

The model also suggests that 50% loss as compared to 2006 is expected to occur during 2026-2035 under RCP4.5 and 2029-2035 under RCP8.5, increasing to 75% loss under RCP4.5 during 2051-2062 and 2052-2062 under RCP8.5, and to 90% loss in 2089-~2098 under RCP4.5 and 2076-2098 under RCP8.5. Further, there will be a considerable rise in total precipitation and temperature in later years of the century.

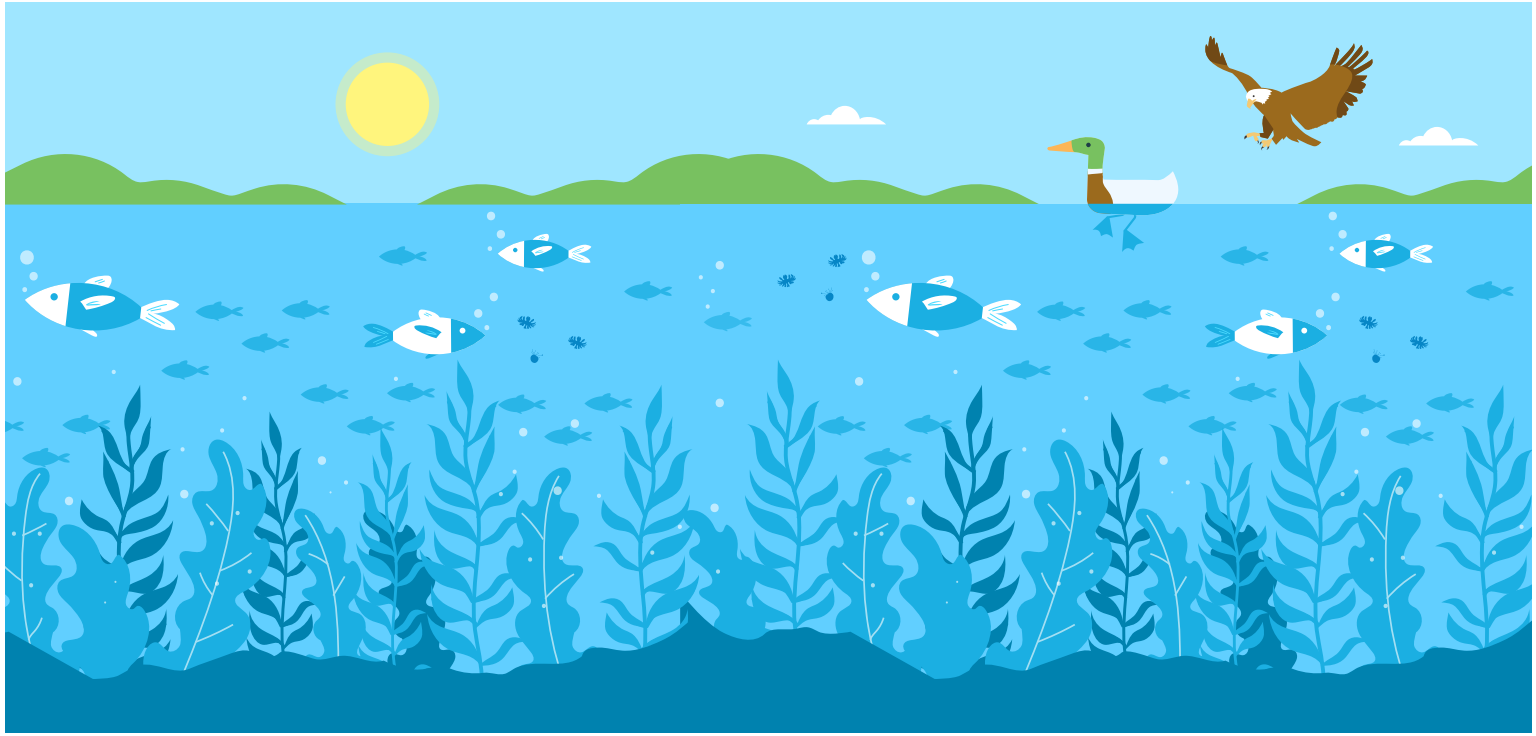
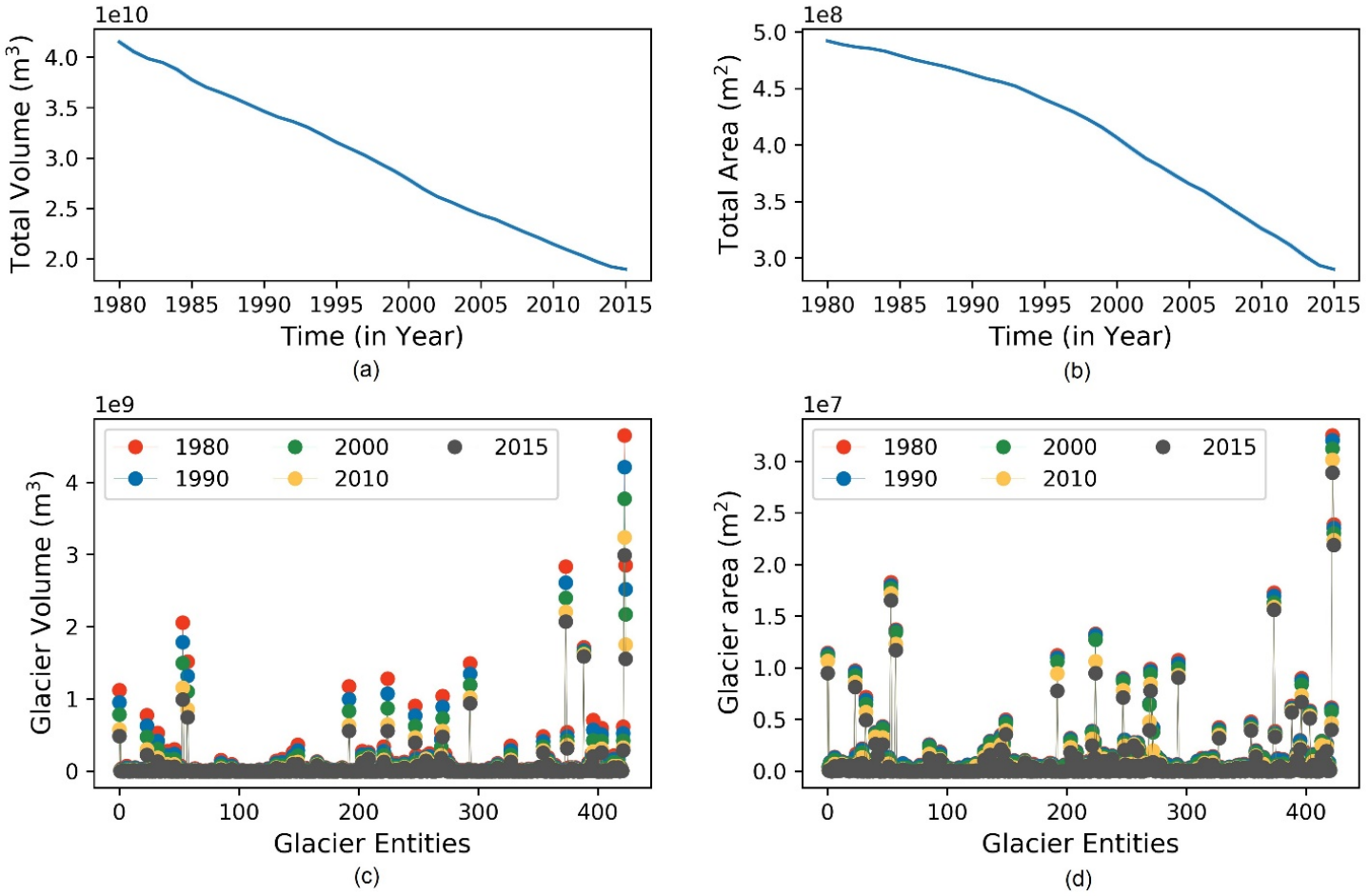
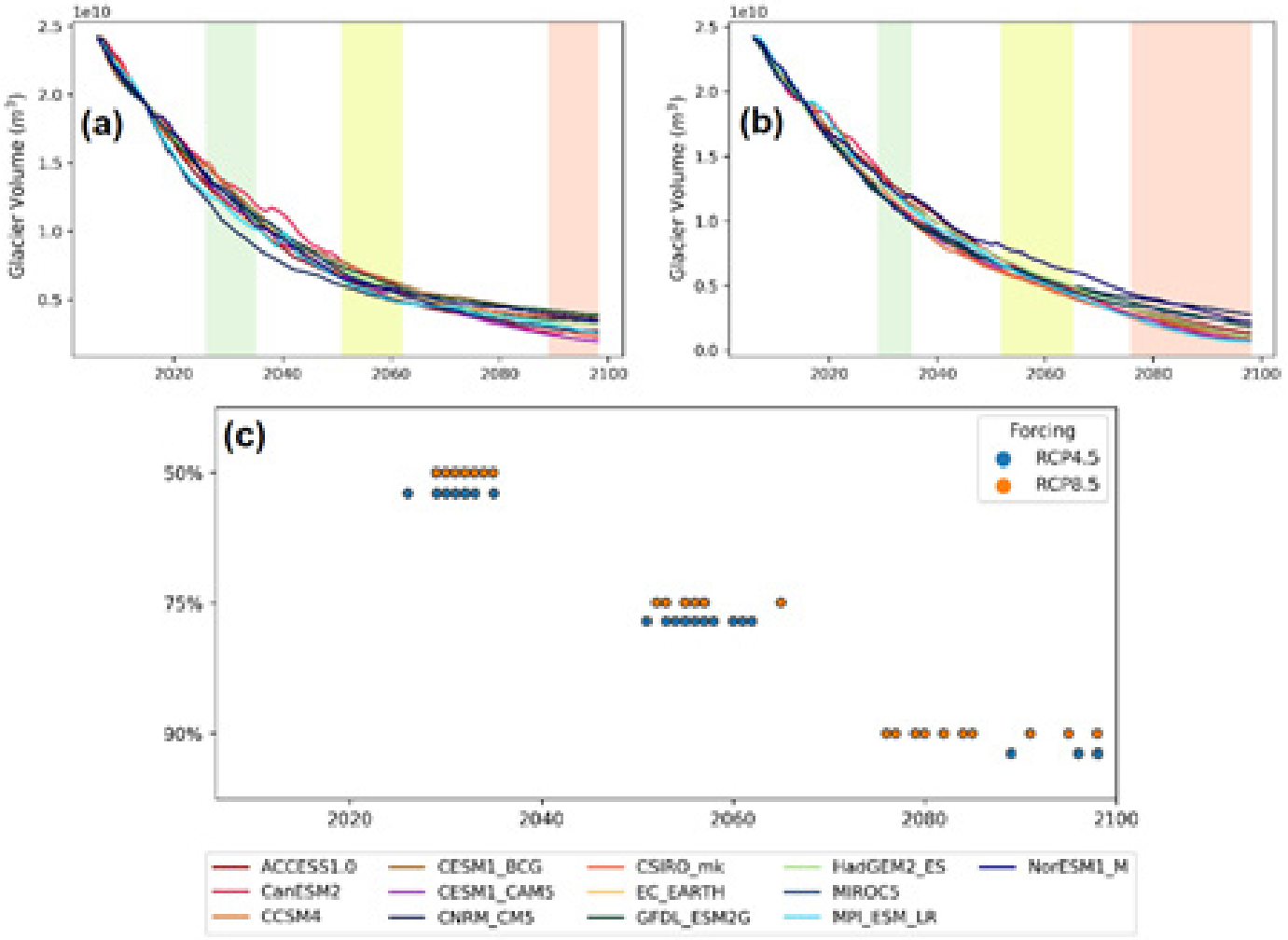


Figure 20: Glacier dynamics in Beas basin, in terms of their volume and extent area during 1980-2015: (a) total glacier volume, (b) total glacier area, (c) change in volume of each glacier entity (447 glacier entities) for few representative years, and (d) change in area of each glacier entity



GLACIER VOLUME USING OGGM WITH METEOROLOGICAL FORCING FROM SELECTED CMIP5 MODELS: (a) RCP4.5, AND (b) RCP8.5. THE GREEN, YELLOW AND RED SPANS REPRESENT THE PROJECTED TIMELINE FOR 50%, 75%, AND 90% LOSS, RESPECTIVELY

Figure 21: Glacier volume using OGGM with meteorological forcing from selected CMIP5 models: (a) RCP4.5, and (b) RCP8.5. The green, yellow and red spans represent the projected timeline for 50%, 75%, and 90% loss, respectively (as compared to 2006). The projected timeline for 50%, 75%, and 90% loss for individual models under RCP4.5 and RCP8.5 are shown in (c)



Even while sticking to the conservative temperature increase of 1–2°C, most ecosystems will be impacted resulting from changes in species composition, productivity and loss in biodiversity. Nearly 200,000 forest villages are naturally dependant on these forest resources. Along with them, for the period 2070 to 2100, the country as a whole is projected to bear economic losses as large-scale shifts in forest types will have adverse implications for biodiversity. This will result in 70% increase in net productivity of forest types, other implications includes loss in biomass production and timber markets, intensifying socioeconomic pressure. In certain cases even when there is no change in forest type, the local species are going to suffer[88].

A study by Ravindranath et al. (2006)[89], highlighted the impacts of climate change on Indian forests into the year 2085 under two emission scenarios (based on IPCC's Report on Emission Scenario): A2 (740 ppm CO_2) and B2 (575 ppm CO_2). As per A2, a more extreme scenario, growing human population and slower and inequitable economic development will lead to doubling of atmospheric CO_2 concentration by 2050 and reaching a higher value of 740 ppm by 2085. And as per B2 scenario, under moderate population growth, intermediate levels of economic development, adoption of environmentally sound technologies, and greater social equity, the colder forests will see an increase of about 3°C. Moreover in A2 scenario, most of the forests will show an increase of about 4°C, with the northern temperate forests experiencing an increase of around 4.6°C. Changes in the ecosystem functionality due to climate change have strong potential to alter the climate in the future, through either positive or negative feedbacks in the environment.

Greater focus should be on conserving the natural resources under the influence of climate change, reducing costly future damage, and taking advantage of possible beneficial opportunities. An approach of analysing the co-benefits, trade-offs and synergies to design adaptation strategies will also reduce ecosystem cascade by building ecosystem management, resource management plans, mobilization, social access and appreciation of ecosystems services[90]. Assessing the extent and drivers of various processes will lead to ecosystem conservation as well as catching hold of various opportunities for the restoration and sustainable use of ecosystems, and acting on the identified opportunities for integrated land use will thereby provide benefits to the climate, biodiversity and ecosystem services. This will enable species and genes to reach locations where they might thrive sustainably despite the challenges of a rapidly changing world. Further, local actions to protect and restore ecosystem can support the complexity and the structure that will ultimately build resilience to extreme events as it strengthens the capability of ecosystems to retain carbon, and in certain cases even continue to sequester additional carbon[91]. Along with that it enhances the efficiency, viability and local ownership of measures that will be incorporated. Thus, coordination and partnership among central, state, and local governments to formulate a Climate Adaptation Strategy is required while avoiding conflicting targets. This would also include incorporating climate change predictions and vulnerability assessments into the policies. It will ensure that the impacts are associated to ecosystem services losses and thus will help in mitigation. The planning should involve active and equitable engagement of all stakeholders across sectors. Lastly, a review of the incentives and disincentives for different land uses will help to identify opportunities to transition to sustainable management approaches that are also economically viable and enable positive contributions to local as well as national economies[92].

[88] *India: The Impact of Climate Change to 2030: A commissioned Research Report. Special Report, NIC 2009-03D. https://www.dni.gov/files/documents/climate2030_india.pdf*

[89] *Ravindranath, N. H. et al. (2006). Impact of climate change on forests in India. Current Science, 90(3): 354-361. arXiv:q-bio/0511001*

[90] *Lavorel, S. et al. (2020). Co-producing ecosystem services for adapting to climate change. Phil. Trans. R. Soc. B., 375:20190119. https://doi.org/10.1098/rstb.2019.0119*

[91] *Malhi, Y. et al. (2020). Climate change and ecosystems: threats, opportunities and solutions. Phil. Trans. R. Soc. B., 375:20190104. https://royalsocietypublishing.org/doi/10.1098/rstb.2019.0104*

[92] *Managing ecosystems in the context of climate change mitigation: A review of current knowledge and recommendations to support ecosystem-based mitigation actions that look beyond terrestrial forests, Secretariat of the Convention on Biological Diversity (2016). https://www.cbd.int/doc/publications/cbd-ts-86-en.pdf*

Section III

Dual threat of the pandemic and Climate Emergency

Section III

DUAL THREAT OF THE PANDEMIC AND CLIMATE EMERGENCY

As mentioned earlier, the sectoral analysis did not take into the account the additional complexities and sluggishness that has crept in the economy due to the COVID-19 mayhem. As the world is grappling to tackle the dual threat posed by climate change and COVID-19, the composite risk is set to further aggravate the stress on some of the key sectors contributing to India's economic growth. India, which observed one of the strictest lockdowns in the world, is experiencing the implications on its present and future economic growth. Various international agencies have quantified this impact in terms of contraction in the Indian economy in the fiscal FY 2020-21. World Bank has estimated 3.2%, international rating agencies like Moody's Investors Service, Fitch Rating and S&P Global Ratings have predicted a 4-5% contraction and Crisil predicts this to be the fourth recession since independence, and perhaps the worst to date[93]. In terms of sectoral impact[94], several agencies have predicted the extent of loses, including World Travel and Tourism Council (WTTC) estimating the cost to tourism sector at least USD 22 billion and the sector shrinking by 25% in 2020, International Air Transport Association (IATA) assessing passenger revenue losses of upto USD 252 billion in FY 21 and All India Manufacturer's Organization (AIMO) estimating about a quarter of over 75 million MSMEs in India facing closure, to name a few.

As the country gears up to tackle the unprecedented challenge posed by the pandemic, it is extremely important to adopt a dual lens and ensure a 'green' recovery. This will require the concerted efforts of government, businesses and civil society organizations, to ensure that the actions taken today shape a sustainable future for the societies of tomorrow. The Indian Government's economic recovery package of INR 20,000 crore (approx. USD 3 billion) should ensure that the long-term recovery and investments happen in-line with the overall climate targets and provide a boost to the climate-aligned sectors like renewable energy, electric vehicles, climate-smart agriculture and resilient infrastructure. Wherever possible, carbon-intensive investments may be avoided and the capital is channelized towards green, rather than brown activities. Given the humongous population and the agrarian nature of the economy, support to the vulnerable sections should further accelerate the resilience and adaptation goals.

Businesses and financial sector also needs to leverage this opportunity amidst adversity to bolster and reorient our economy towards a greener, inclusive and resilient pathway. Organizations need to assess their vulnerabilities, risk management frameworks, business continuity plans, and supply chain & stakeholder engagement strategies to ensure they create shared value in this recovery. Financial institutions

[93] *Bloomberg Quint (2020), World Bank Says Indian Economy To Contract 3.2% In FY 21 https://www.bloombergquint.com/business/india-s-economy-to-contract-by-3-2-per-cent-in-fiscal-year-2020-21-world-bank*

[94] *KPMG (2020). Potential Impact of COVID-19 on the Indian economy. https://home.kpmg/content/dam/kpmg/in/pdf/2020/04/potential-impact-of-covid-19-on-the-indian-economy.pdf*

hold immense potential to direct capital towards sectors that ensure long-term environmental and social benefits. Recently, several Indian CEOs came together to respond to this 'call to action' by signing a business statement[95] and support growth in sectors including social infrastructure, power, food, green manufacturing, green buildings, clean power and land degradation.

Challenges in assessment of climate change impacts

Despite the increasing level of significance of incorporating climate change considerations into decision making, both at a policy and business level, there are certain barriers to wide spread adoption:

- ✓ **Limitations of Economic models:** Currently the models used to assess and project future economic growth and contribution of key sectors of the economy do not take into account the rising climate emergency and its associated impact on critical aspects like natural capital and ecosystem services. There are research evidence[96] that indicates these shortcomings in the existing economic models used, in terms of underestimating the potential impacts of climate change and highlighting the benefits of adopting a low carbon growth trajectory
- ✓ **Lack of research and availability of quality data:** In India, one of the major challenge is the absence of granular data specific to sectors and geography, to calculate distributional impacts. According to the research by DST CoE (IIT Delhi), the global climate models used in the IPCC assessment reports show biases in the rainfall and temperature simulation[23,24,97&98] and these biases are approximately 100% and 25% of their mean values respectively. That's why there is a need for India centric climate model for reliable future projections to assess the impacts of climate change on economy and its key sectors
- ✓ **Limitations of predictions of the current models:** Methodology used for assessments may under- or over-estimate the future level of adaptive capacity in human and natural systems capacity, which could lead to under or overestimation of positive or negative impacts. Predictions also affect future impacts and using different estimates could eventually lead to a reversal of positive and negative impacts. With evolving times, the factors affecting climate change keeps changing and prediction for different nations becomes even more difficult
- ✓ **Globalization and dependency amongst nations:** Climate change is a global phenomenon which is impacting all the countries, even though the degree of effects may vary. Given mutual dependency, interconnectedness between countries and the complex nexus established by cross-country economic activities, it is difficult to compute and attribute the impact caused by a single country and also assess the impact of climate change on a particular nation
- ✓ **Calculation of sectoral impacts:** While it may be relatively easier to calculate economic implications of climate change on sectors directly impacting the GDP, assessment and quantification of impact on sectors such as human health and productivity are harder to assess
- ✓ **Limited capacity to assess climate risks:** The development of models and assessment of the impact requires investment in resources both intellectual and financial. The assessment, management and adaptation to risks, including resilience efforts gets delayed due to inadequate capacity to assess climate risks. Climate literacy, which includes training and diversifying human resource

[95] *https://www.teriin.org/ceos-future-business-action-green-recovery*

[96] *Fankhauser, S. and Stern, N. (2016). Climate Change, Development, Poverty and Economics. Grantham research Institute on Climate Change and Environment. http://pubdocs.worldbank.org/en/728181464700790149/Nick-Stern-PAPER.pdf*

[97] *Salunke, P. et al. (2018). Performance of the CMIP5 models in the simulation of Himalaya-Tibetan Plateau monsoon. Theoretical and Applied Climatology, 137(1-2): 909-928. https://doi.org/10.1007/s00704-018-2644-9.*

[98] *Pathak, R. et al. (2019). Precipitation Biases in CMIP5 Models over the South Asian Region. Scientific Reports. 9(1): 9589. https://doi.org/10.1038/s41598-019-45907-4.*

DEVELOPING NATIONS FACE MORE CHALLENGES IN COMBATING CLIMATE CHANGE DUE TO LIMITED UNDERSTANDING OF THE POTENTIAL IMPACTS OF CLIMATE CHANGE AND THE QUEST FOR RAPID ECONOMIC DEVELOPMENT.

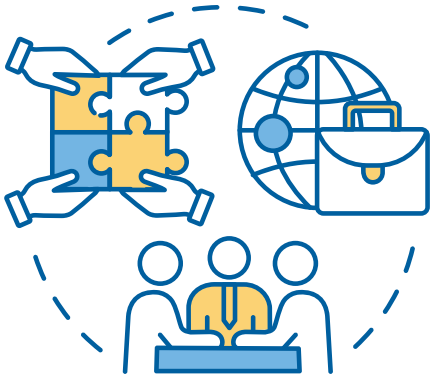
skills, to include social, environmental & developmental practitioners, researchers, for greater understanding of risk & opportunities is extremely important. Only when the capacity building of the entire ecosystem takes place, the country will be able to mitigate the risks and leverage the opportunities at the right time

- ✓ **Challenges for developing nations:** Developing nations face more challenges in combating climate change due to limited understanding of the potential impacts of climate change and the quest for rapid economic development.

The real challenge for emerging economies like India is to strike a balance between the required growth and ensuring minimal damage to the environment. The large quantum of long-term investments and attention required to tackle the global crisis of climate change competes with the current needs to ensure action on developmental priorities

Section IV

Tackling Climate Change: a multi-stakeholder approach

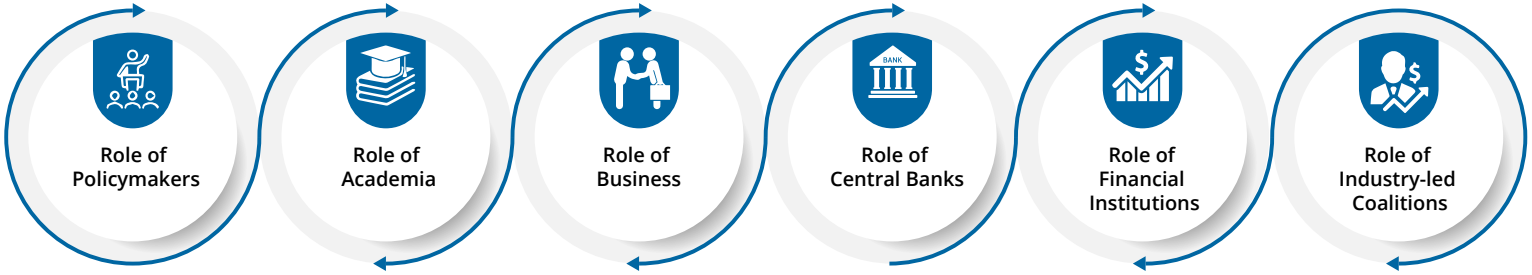


Section IV

TACKLING CLIMATE CHANGE: A MULTI-STAKEHOLDER APPROACH

With the rising level of awareness on climate change issues, risks stemming from it and the impact on a global, national, sub-national and individual level, it is important to mainstream climate change considerations into all aspects of decision-making. Achieving this for a country like India, with unique challenges (as listed above) and untapped opportunities, requires a systemic response involving transformative changes, notably in knowledge, policy and institutional systems from all sections of the society. Going forward, an orchestrated strategy requires the blended expertise and collaboration between Governments, civil society, academia, businesses and the financial sector players. The report in its concluding section brings out the importance of interconnected and aggregated response from the entire stakeholder spectrum.

THE REPORT IN ITS CONCLUDING SECTION BRINGS OUT THE IMPORTANCE OF INTERCONNECTED AND AGGREGATED RESPONSE FROM THE ENTIRE STAKEHOLDER SPECTRUM.



THERE IS A DICHOTOMY IN TERMS OF IMPACT OF CLIMATE CHANGE BEING OBSERVED IN THE FUTURE, WHICH GIVES VERY LITTLE INCENTIVES FOR ANY POLICY CHANGE IN THE PRESENT.

Role of Policymakers

Globally, countries are aware about the long term impact of climate change and have come together to tackle this challenge in the form of commitments under the landmark Paris Agreement and adoption of the Sustainable Development Goals (SDGs). National-level action in the form of enabling policies, ambitious targets and cross-country collaboration, to pool in technology and finance will lay the foundation of strong climate action. There are increasing number of regulations by governments to address climate change. For instance, when Kyoto Protocol was signed in 1997, there were only 72 laws or policies addressing climate change, in 2018, the number of laws and acts have reached well over 1,500[99]. Some of the countries have net-zero targets in place by law including Sweden, UK, France, Denmark, New Zealand, Hungary, Japan, South Korea, and China. Specifically, in terms of climate change, it is important to:

- ✓ **Support climate modelling research techniques**- As highlighted previously, there is a need for more reliable data on climate change specific to India[28]. DST CoE at IIT Delhi, is one of the few centers, with a focus on India-specific research on climate modelling. The research outcomes will feed into designing the policy fabric and building long-term strategies. Therefore, research and innovation should be promoted through specific institutions or providing grants to think-tanks and academic institutions
- ✓ **Institutionalize enabling policy framework**- Policymakers and regulators can aid the current situation of building climate action strategies by either formulating new policies or by incorporating climate considerations in the existing policies. Analyzing future climate policy scenarios and promoting investments in low-carbon infrastructure can bootstrap the economy as it focuses on long-term resilience. Any delay in introducing effective policies in the current situation post the pandemic will further expose all sectors to costly damages from climate impacts, pollution, and public health crises. Collaboration and partnerships would ensure that climate policies are fair, equitable and support businesses and communities, by ensuring the benefits for all
- ✓ **Promote capacity building for leveraging opportunities**- The post-pandemic scenario has clearly established the importance of skilled workforce to tackle the sudden situations and uncertainties that may threaten economies. Climate change impacts are no exceptions, and its impacts are clearly visible. The Paris Agreement has also assessed the importance of capacity building and education towards climate action. This will ensure there are no gaps in public awareness and could push international support to build, retain and upskill the organizational or institutional capacity. Efficient and effective plans, involving capacity building activities, will foster an environment that is necessary to meet the economic as well as climate action goals
- ✓ **Building Incentive Models**- There is a dichotomy in terms of impact of climate change being observed in the future, which gives very little incentives for any policy change in the present. However, numerous studies have established that incorporating climate change considerations in the national development plans create jobs, support domestic and global growth in climate-aligned sectors and result in overall sustainable development

[99] *LSE (2018). Policy brief Global trends in climate change legislation and litigation: 2018 snapshot. http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2018/04/Global-trends-in-climate-change-legislation-and-litigation-2018-snapshot-3pdf*

Role of Academia

As already highlighted, it is important to promote greater research in the field of climate change, to better understand its impacts and devise strategies to tackle it. Climate scientists, researchers and professors are playing an instrumental role in this direction by sharing critical inputs on arriving at the future projections of climate change, developing forward-looking scenarios, undertaking assessments and developing predictive models. The academic sector bridges the knowledge gap and provides insights to businesses, policymakers and civil society organizations, educate future leaders and innovate practical solutions to aid climate action. Some of the most reputed universities and educational institutions across the world house specific departments, centres of excellence and host educational programs, aimed towards further enhancing the capacity and technical know-how to deal with climate change.

A Case study by United Nations University (UNU): The Economics of Climate Adaptation (ECA) in San Salvador

Key Messages: The Economics of Climate Adaptation (ECA) framework is a valuable approach to (1) provide local decision-makers with the fact base to develop their adaptation strategy, (2) foster the development of investments portfolio to include more loan and program based finance, as well as climate risk insurance, approaches, not least in the context of (3) the future challenge of National Adaptation Plans (NAPs), and to (4) learn for its climate screening procedure.

Introduction

This case study in San Salvador offers a rare example of how risk modelling, via capacity building and stakeholder engagement, helps to unlock climate finance.

The Economics of Climate Adaptation[100] framework offers a systematic and transparent approach that fosters trust and initiates in-depth inter-sectoral stakeholder discussions. The methodology can be flexibly applied from the national down to the local level to different sectors and different hazards. It provides key information for programme-based approaches, insurance approaches and has the potential to support National Adaption Plans' development. Recently, KfW, the German development bank, decided to implement two pilot studies in Bangladesh and El Salvador using the ECA methodology. The main objectives were to support decision-makers in developing their adaptation strategy and to develop a climate change adaptation (CCA) measures investment portfolio. This case study presents the main finding, reflects on stakeholder capacity development and lessons learned.

Context

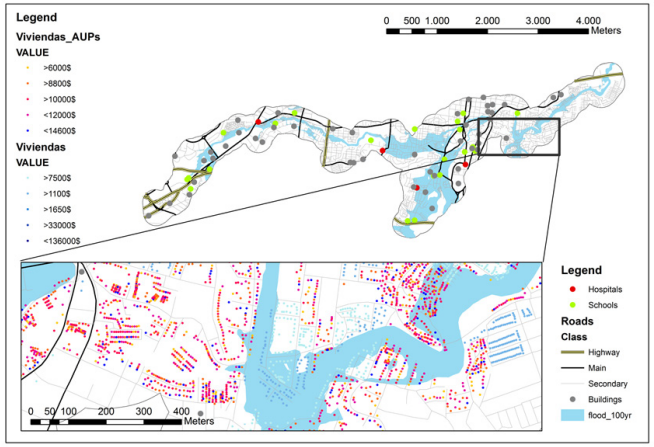
El Salvador and its capital city, San Salvador experience a high rate of urbanization putting increasing pressure on its ecological and environmental systems. It has also a limiting effect on potential areas to grow for the community. Climate change is increasing this pressure by rising the economic and environmental impacts of river floods, tropical storms and landslides in the country.

[100] *https://collections.unu.edu/eserv/UNU:6181/Guidebook_Economics-of-Climate-Adaptation_EN__002_.pdf*

THE ECONOMICS OF CLIMATE ADAPTATION APPROACH OFFERS A UNIQUE CONTRIBUTION, WHICH COMBINES RISK ASSESSMENT, ADAPTATION MEASURES AND RISK TRANSFER.

The main challenges facing the implementation of the study included that the ECA framework principles, developed by the reinsurance sector, were never applied to poor and vulnerable people. Could a monetarization of climate risk grasp the impact on those most vulnerable, but whose assets are worth the least? How to quantify assets with a very marginal value? Can the ECA framework possibly unlock climate finance by quantifying the impacts of various range of assets for different hazards? How to raise ownership for a method requiring advance skills in modelling and climatology?

Figure 22: Including poor and vulnerable people. Mapping at the household levels in a highly clustered urban area in San Salvador (UNU-EHS & KfW, 2016)



Developing a Climate Adaptation Investment Portfolio

In 2015 KfW started to implement two pilot studies in Bangladesh (Barisal) and El Salvador (San Salvador) testing the feasibility of ECA approach to prepare climate change adaptation measures in urban areas. KfW identified the ECA framework as a valuable approach to foster the development of KfW's CCA portfolio to include more loan and program based finance as well as climate risk insurance approaches.

The Economics of Climate Adaptation approach offers a unique contribution, which combines risk assessment, adaptation measures and risk transfer. Its results allow a flexible identification of cost-effective climate adaptation measures for a variety of projects and sectors. The ECA is powered by a unique open-source modelling platform CLIMADA[101] and it evaluates current and potential costs of climate change and how to prevent them by determining a location's total climate risk –calculated by combining existing climate risks, climate change and the value of future economic development.

The Economics of Climate Adaptation (ECA) addresses in particular the following questions:

- ✓ What is the potential climate-related damage over the coming decades?
- ✓ How much of that damage can be averted, using what type of CCA measures?
- ✓ What investments will be required to fund those measures -and will the benefits of these investments outweigh the costs?

In San Salvador, the study concentrated on three types of climate hazards: Flood risk, landslides and tropical winds. The choice of these hazards, as well as numerous decision regarding exposure, the definition of study areas, were the results of extensive stakeholder consultation with the main partners of the project.

101 *https://wcr.ethz.ch/research/climada.html*

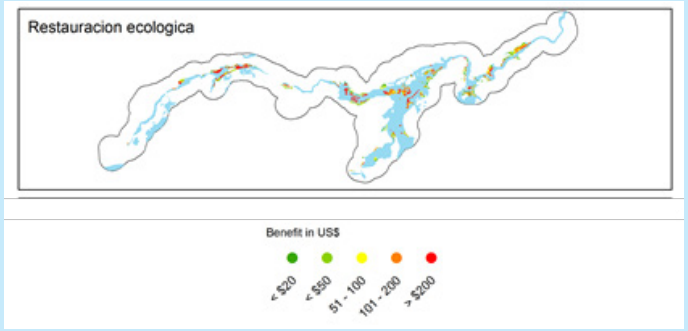
Results/solutions

The ECA Study in San Salvador offers a large range of results. First, a ranking of the best investments in term of adaptation measures was discussed between KfW and possible stakeholders. These measures included infrastructural projects but also Ecosystem-Based Adaptation (EbA) measures such as reforestation. The benefits of more than 28 measures were evaluated.

Second, the ECA Studies in San Salvador showed that the ECA framework and CLIMADA can be used to evaluate and quantify climate risk, as well as adaptation measures for the poor and vulnerable population.

Third, strong limitation due to the complexity of the approach, the set of skills necessary to its implementation, forced the stakeholders to put a particular emphasis on capacity building. Partners such as the UCA, a university, in San Salvador, but also UNU-EHS in Bonn developed several lectures, manual and guidebooks to disseminate the method.

Figure 23: Spatial distribution of benefits for ecosystem-based adaptation. A good entry point for stakeholder engagement.



Lessons learned

The studies showed both strengths and limitations of the ECA methodology as well as the need for capacity development and stakeholder engagement for quantitative risk analytics, especially for bridging between analysis and investment.

It showed the crucial role that a multi-stakeholder engagement approach can play in developing countries. The existing set of skills often available in academia and the private sector, allow countries to embed the ECA approach in their structures and therefore foster a more sustainable approach.

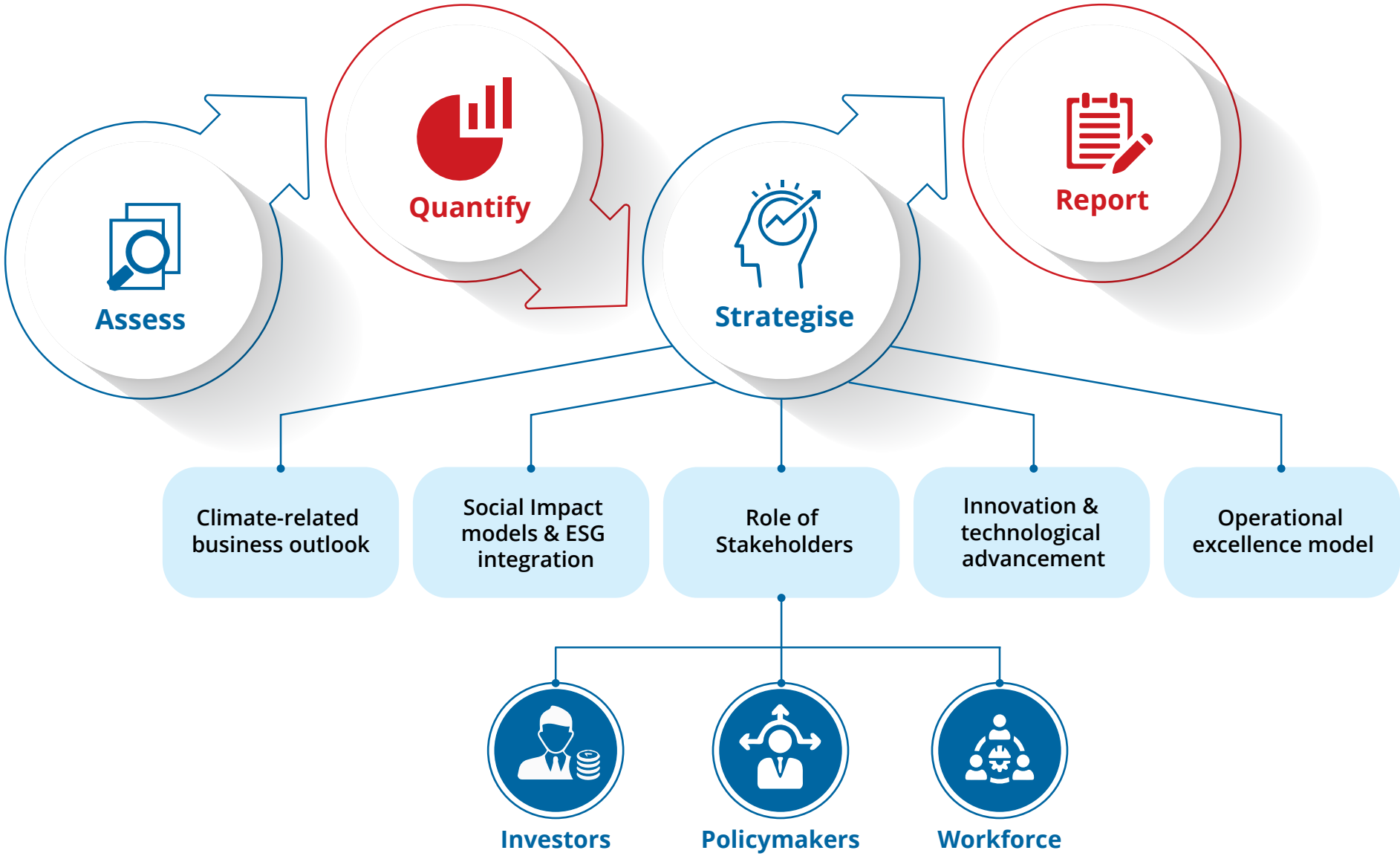
To achieve success, climate analytics, needs to be embedded in local structures. Its systematic and transparent approach builds trust and initiates in-depth stakeholder discussion across sectors helping to avoid a premature restriction on particular measures.

Role of Business

As seen in the previous sections, the impact of climate change on certain sectors can disrupt the business-as-usual, supply chains and pose threat on the profitability or even sustainability of organizations. Many business risks are directly or indirectly influenced due to changes in the climate. Thus, certain steps (shared in figure below) taken by businesses can help save costs, enhance productivity, boost employee motivation, make the supply chain robust, benefit the environment and influence the economy in a positive way.

- ✓ **Assess**: For any business, it is necessary to assess the impact of climate change on the functioning of the business including the supply chain, as a starting step. At a time where governments, investors and consumers are becoming increasingly conscious, it is imperative for any business to know where they stand in terms of identifying the risks so that they can set clearly defined targets and benchmark its performance against the identified key performance indicators (KPI). Some of the KPIs significant to businesses that can be considered are emissions to air, water, land, resource consumption and waste generation
- ✓ **Quantify**: With right tools emanating from research and analytics, it is possible to quantify the risks due to climate change, create scenarios and set targets to decarbonize and reduce build-up of such risks
- ✓ **Strategise**: Post identification, assessment and quantification of risks, it is important to dovetail these considerations in the business model through adoption of social impact models, Environment, Social & Governance (ESG) integration strategies, innovative products and services which incorporates environmental and social aspects across their life cycle, adopting integrated operational excellence models and Climate-related business outlook. The role of top management, investors and policymakers is critical in outlining some of these priorities and ensuring they are part of the core business models. Workforce or the human capital will play the essential role in actualizing the laid out climate strategy
- ✓ **Report and disclose:** Transparent and robust reporting on sustainability and ESG-related parameters, including climate risks, helps in measuring progress against the targets, serves as an important tool for communicating company's sustainability strategy to critical stakeholders including government, regulators and investors, to name a few. There are plethora of frameworks and reporting platforms available including Global Reporting Initiative (GRI), Taskforce on Climate-related Financial Disclosures (TCFD) recommendations, Sustainability Accounting Standards Board (SASB), Carbon Disclosure Project (CDP), Climate Disclosure Standards Board (CDSB), Sustainable Development Goals (SDG) Compass, Principles for Responsible Banking, Integrated Reporting (IR)

Impact of Climate Change on Indian Economy | Recommendations



Role of Central Banks

THE BASEL COMMITTEE ON BANKING SUPERVISION HAS RECENTLY ESTABLISHED A HIGH-LEVEL TASK FORCE ON CLIMATE-RELATED FINANCIAL RISKS (TFCR).

Central Banks are increasingly focussing on the linkage between financial stability and climate change risks. There are initiatives being led by central banks globally that focus on understanding, managing and enhancing transparency on Climate-related risks. The TCFD recommendations, which provides a voluntary framework for financial institutions to disclose on climate risks and Central Banks and Supervisors Network for Greening the Financial System (NGFS), which brings together central banks and supervisors to better understand and manage the financial risks and opportunities of climate change, will play a key role going forward. NGFS in 2020 published recommendations to manage Climate-related and environmental risks[102]. The Basel Committee on Banking Supervision has recently established a high-level Task Force on Climate-related Financial Risks (TFCR). In its recent stocktake report of members' initiatives on Climate-related risks, released in April 2020, it has been concluded that majority of the Basel Committee members consider it appropriate to address Climate-related financial risks within their existing regulatory and supervisory frameworks[103].

UK's Prudential Regulation has issued supervisory statements on enhancing firms' approaches to managing Climate-related financial risks and implementing TCFD recommendations. In a recent development[104], firms have been advised to fully embed their approaches to manage Climate-related financial risks by the end of 2021. The European Central Bank (ECB) also recently published[105] a guide which explains the expectation from banks to manage Climate-related and environmental risks and disclose such risks transparently as part of the current prudential framework.

The Reserve Bank of India (RBI), in its recent Annual Report, mentioned about the adverse impacts of climate change on the most critical sector of the Indian economy i.e. agriculture. India's central bank, cognizant of the increasing extreme weather events including droughts, cyclones, shift in the rainfall patterns and depleting groundwater, has highlighted the rise in global warming as a likely cause for decline in crop yields and farmer incomes. Given the agrarian nature of India's economy, impact on agriculture will result in an additional stress on the overall economy, financial system of the country and the inflation rates. The RBI also emphasized on the need for a suitable framework to identify, assess and manage the financial risks arising out of climate change.

[102] *Moody's Analytics (2020). NGFS Publishes Recommendations to Better Manage Environmental Risks. https://www.moodysanalytics.com/regulatory-news/may-27-20-ngfs-publishes-recommendations-to-better-manage-environmental-risks*

[103] *Bank for International Settlements (2020). Climate-related financial risks: a survey of current initiatives.*

[104] *https://www.bankofengland.co.uk/-/media/boe/files/prudential-regulation/letter/2020/managing-the-financial-risks-from-climate-change.pdf*

[105] *https://www.bankingsupervision.europa.eu/press/pr/date/2020/html/ssm.pr200520~0795c47d73.en.html*

SEVERAL GLOBAL BANKS HAVE TAKEN AMBITIOUS COMMITMENTS TO ADVANCE CLIMATE ACTION.

Role of financial institutions

Financial institutions, being central to an economy, have a critical role to play in tackling the impacts of climate change and facilitate transition towards a low carbon economy. India, despite its unique developmental challenges, has emerged as an active player in the global climate action space by displaying exemplary political will, evident from its ambitious NDC targets and aggressive plans to scale critical sectors like renewable energy and e-mobility. As per International Finance Corporation (IFC), South Asia has a climate related investment opportunity of USD 3.4 trillion (from 2018 to 2030), of which India alone presents a potential of USD 3.1 trillion in key sectors such as renewable energy, green buildings, transport infrastructure, electric vehicles, and climate smart agriculture, to name a few. In order to channelize investments at scale and break barriers, developing a sustainable finance architecture[106] to include favorable policies, innovative financial structures and accountability frameworks is extremely important, including:

- ✓ Demystifying Climate-related financial risks, including physical and transition risks and articulating a clear climate action strategy and governance framework to provide a unified approach
- ✓ Adopting a targeted approach to finance climate-aligned sectors to mainstream sustainable finance. Innovation of products and services with positive environmental and social outcomes and implementation of forward-looking practices like climate stress testing of the portfolio are important aspects
- ✓ Strengthening governance and risk management frameworks through Board-level Committees, and embedding climate/ESG risks into lending decisions and tracking of impact
- ✓ Encouraging non-financial disclosures towards enhanced transparency & accountability, including fast-tracking implementation of TCFD recommendations
- ✓ Enhancing climate literacy, which includes training and diversifying human resource skills, to include social, environmental & developmental practitioners for greater understanding of risks and opportunities to provide financing solutions

Several global banks have taken ambitious commitments to advance climate action. For instance, HSBC committed to provide USD 100 billion of finance and investments by 2025, towards clean energy, low-carbon tech, and projects contributing to the Paris agreement and SDGs. BNP Paribas pledged to have zero exposure to coal by 2030 in the European Union and by 2040 worldwide. Citi has committed to a five-year USD 250 billion Environmental Finance Goal to finance and facilitate transition to a low carbon economy. The Indian financial sector, which is at a classic inflection point, must follow suite and be future ready, thus emerging as the backbone to fuel sustainable development and economic growth.

[106] *Adapted from YES BANK's report Innovating pathways to Sustainable Finance in India*

GIVEN THAT NETHERLANDS IS HIGHLY PRONE TO FLOODS, THE ASSESSMENT WAS UNDERTAKEN WHICH INDICATED A MATERIAL INCREASE OF THE SUM OF EXPECTED LOSSES OVER THE NEXT 100 YEARS DUE TO FLOODING.

Analysis of climate risks: A case study of Rabobank

Rabobank, whose strategic ambition is to be a leading bank in the energy transition and climate smart agriculture space, has examined the potential impact of physical and transition climate risks on the quality of the bank's credit portfolio in the Netherlands and around the world. This case study covers Rabobank's four preliminary analyses that estimate Rabobank's exposure to climate change risks. The regions and sectors selected are Food and Agriculture (F&A) in the Netherlands and global, and the Dutch Residential mortgage portfolio, which reflect Rabobank's largest exposures. The four analyses were carried out using different methodologies[107] :

- ✓ **Worldwide stress test on transition risk:** The approach adopted for transition risks, was introduction of a new policy with respect to carbon pricing tax of USD 100 per tonne globally. The cumulative impact on Impairment Charges (IC) of this macro-economic stress test for energy transition risk policy shock were not found to be very severe over five years
- ✓ **Portfolio analysis on transition risk for F&A sector in the Netherlands:** The transition risk approach was a portfolio analysis of the impact on Rabobank's Dutch Livestock and Crops sectors, a methodology developed by the UNEP FI-TCFD working group led by Oliver Wyman. The analyses showed that the impact of transition risk differs significantly between sectors: covered crops were deemed most sensitive to transition risk in terms of future revenues and costs, this was followed by annual crops. Perennial crops showed little to no sensitivity over the horizon up to 2040. Similarly, pork meat was deemed more sensitive to transition risk than dairy cattle based on the sample set and scenario used
- ✓ **Portfolio analyses on water stress as physical risk for Europe, US, Australia/New Zealand:** To quantify the impact on water stress in terms of Expected Loss (EL), two possible scenarios were assumed i.e. a mild and a severe impact. In the mild impact scenario the Loss Given Default (LGD) increases by 40%, while in the severe impact scenario the LGD rises by 80%. Each of these scenarios is combined with a change in the Probability of Default (PD). This PD change is estimated based on the riskiness of the area where clients' exposure resides. The combined changes in LGD and PD were then used to estimate the new EL for the two different scenarios
- ✓ **Portfolio analysis on physical risk for the mortgage portfolio on flooding risk in the Netherlands:** Given that Netherlands is highly prone to floods, the assessment was undertaken which indicated a material increase of the sum of expected losses over the next 100 years due to flooding. The results corroborated Rabobank's proposed plan to further investigate flooding risk in the Netherlands, for instance, by increasing the scope, challenging the underlying assumptions and considering governmental support to homeowners in case of flooding. The preliminary analysis shows that extreme weather events are possible within a 100-year return period and could cause flooding leading to material damage in Rabobank's Dutch mortgages portfolio

[107] *For full case study, please refer to the report 'Climate risk and the financial sector: sharing of good practices' The sustainable Finance Platform*

THE BUSINESSES AND THE FINANCIAL SECTOR ARE INCREASINGLY RECOGNIZING THE IMPORTANCE OF UNDERSTANDING AND ADDRESSING CLIMATE CHANGE RISKS IN THEIR EXISTING STRATEGIES, OPERATIONS, AS WELL AS AND FUTURE INVESTMENTS AND BUSINESS PLANS.

Blended Finance Model for financing Agro-forestry and sustainable agriculture models in India

Given the agrarian nature of Indian economy, vulnerability of the sector to adverse effects of climate change and the associated environmental costs, there is a dire need to promote a strategy that allows agriculture to flourish without compromising the forest ecosystem and biodiversity. This includes activities that will reduce land-based emissions, such as agroforestry, sustainable forest management and low-emission agriculture. These strategies will result in creation of a sustainable landscape, one that will increase the income of small farmers and optimize farm productivity while also lowering or controlling the corresponding GHG emissions.

Even though sustainable landscapes offer opportunities to reduce the carbon footprint, the agricultural and forestry sector remains largely disorganized, making it difficult for the private sector to make a meaningful contribution. Mainstream investors still consider the risk associated with this sector to be high for multiple reasons including lack of awareness of technical and economic data on different agroforestry and sustainable forestry models; long gestation period in agroforestry; limited motivation in the farming community to pursue commercial forestry or agroforestry (owing to long gestation period); highly fragmented value chains of forest products necessitating dependence on middlemen and creating opaque market structures for the sale of produce; limited knowledge around low-emission and sustainable agriculture and Indian forests largely being owned and operated by Government, allowing limited private sector intervention.

To encourage lending to this sector, in September 2018, Rabo Foundation and USAID/India partnered with two local financial institutions (Samunnati Financial Intermediation and Services Private Limited and Ananya Finance For inclusive Growth Pvt. Ltd.) to support loans totaling more than USD 15 million in local financing through a loan portfolio guarantee structure. The financing is geared towards small and medium sized private enterprises (SMEs), cooperatives, producer companies and microfinance institutions that are directly or indirectly engaged in sustainable landscapes through agriculture, forestry and other land uses. This effort includes facilitating financing to SMEs and farmer producer organizations involved in value addition of sustainable forestry and agroforestry products; promoting climate-smart agriculture; and encouraging on-lending by microfinance institutions that are willing to provide loans to individuals or MSMEs exclusively for forestry/agroforestry and low-emission agriculture.

Rabo Foundation participates as a first-loss guarantor, while USAID acts as a second guarantor, sharing risk equally (pari passu) with the partner financial institution at the portfolio level, after application of first loss. The program size is USD 15.3 million with a duration of 10 years. The local financial institutions selected for the program are mission-aligned and have created impact-oriented portfolios that show their commitment to sustainable agriculture. This is the first-of-its-kind program in India to channel commercial funds to this otherwise underserved sector. The program is a perfect example of development and commercial organizations coming together to blend soft money with commercial funds to attain larger objectives of financing climate-smart agriculture and sustainable forestry and agroforestry in India.

IT IS EVIDENT THAT THERE IS A CLEAR NEED TO MOVE AWAY FROM A 'SILO' APPROACH TO A MORE INTEGRATED ONE, WHICH CUTS ACROSS POLICY MAKING, EVOLUTION OF BUSINESS MODELS AND TECHNOLOGICAL ADVANCEMENT AND FINANCING FOR CLIMATE ACTION PROJECTS

Role of Industry-led Coalitions

The businesses and the financial sector are increasingly recognizing the importance of understanding and addressing climate change risks in their existing strategies, operations, as well as and future investments and business plans. The growing momentum has led to evolution of an increasing number of initiatives, coalitions and commitments to drive action. Nearly 44 initiatives, networks and coalitions are focusing on integration of climate change considerations by the financial sector[108]. It is interesting to witness that these collaborative platforms are bringing together governments, FIs, central banks, civil society organizations, think-tanks to pool in their blended expertise to tackle the task at hand. These joint initiatives result in knowledge sharing, understanding of best practices, development of frameworks, methodologies and robust disclosure mechanisms. This collective knowledge ultimately results in proper implementation of the adopted strategies and monitoring of progress.

UNEP FI Pilot projects for TCFD Implementation in Banking Sector

Established by the Financial Stability Board (FSB) in 2015, Taskforce on Climate-related Financial Disclosures (TCFD) is an industry-driven effort which aims to solve the barrier of information asymmetry for investors by providing a voluntary disclosure framework for financial institutions (FIs) to disclose on climate risks. The four elements of disclosure include information on Governance, Strategy, Risk Management and Metrics & Targets. Given the strategic importance of TCFD recommendations, United Nations Environment Programme Finance Initiative (UNEP FI) has been promoting greater understanding and uptake of the recommendations within the Banking sector through pilot programs. In the first phase, UNEP FI spearheaded a year-long project, involving 16 global banks[109], to pioneer and further develop transition and physical assessment models and metrics to enable scenario-based, forward-looking assessment and disclosure of Climate-related risks and opportunities. The first phase laid the foundation and equipped the participating banks and the banking industry at large to better implement TCFD recommendations.

Building on the phenomenal success of Phase I, UNEP FI engaged 39 global FIs[110] across six continents in TCFD Phase II banking pilot. The program enabled participants to identify, assess, and manage their climate risks and opportunities with a focus on exploring the spectrum of climate scenarios, determining availability of climate relevant asset-level data, creating a comprehensive risk taxonomy across sectors and geography, developing practices for creating an internal climate risk program. The output of this phase was development of a blueprint of physical risks, a transition risk web tool, collation of best practices and climate scenarios in the financial sector.

Going forward, UNEP FI plans to scale these programs with the support of climate modelers, regulators and the financial community, to improve climate scenario analysis practices and disclosures. While the climate modelers will aid in building a better understanding of the needs of the financial industry and adding granularity in scenarios, geographies and variables, the involvement of regulators would facilitate development of sustainability standards and targets like the EU taxonomy and push the industry towards adoption of climate goals. The FIs would benefit from development of governance for climate risk management, integration of physical and transition risks in analysis and sophisticated quantitative climate risk disclosures.

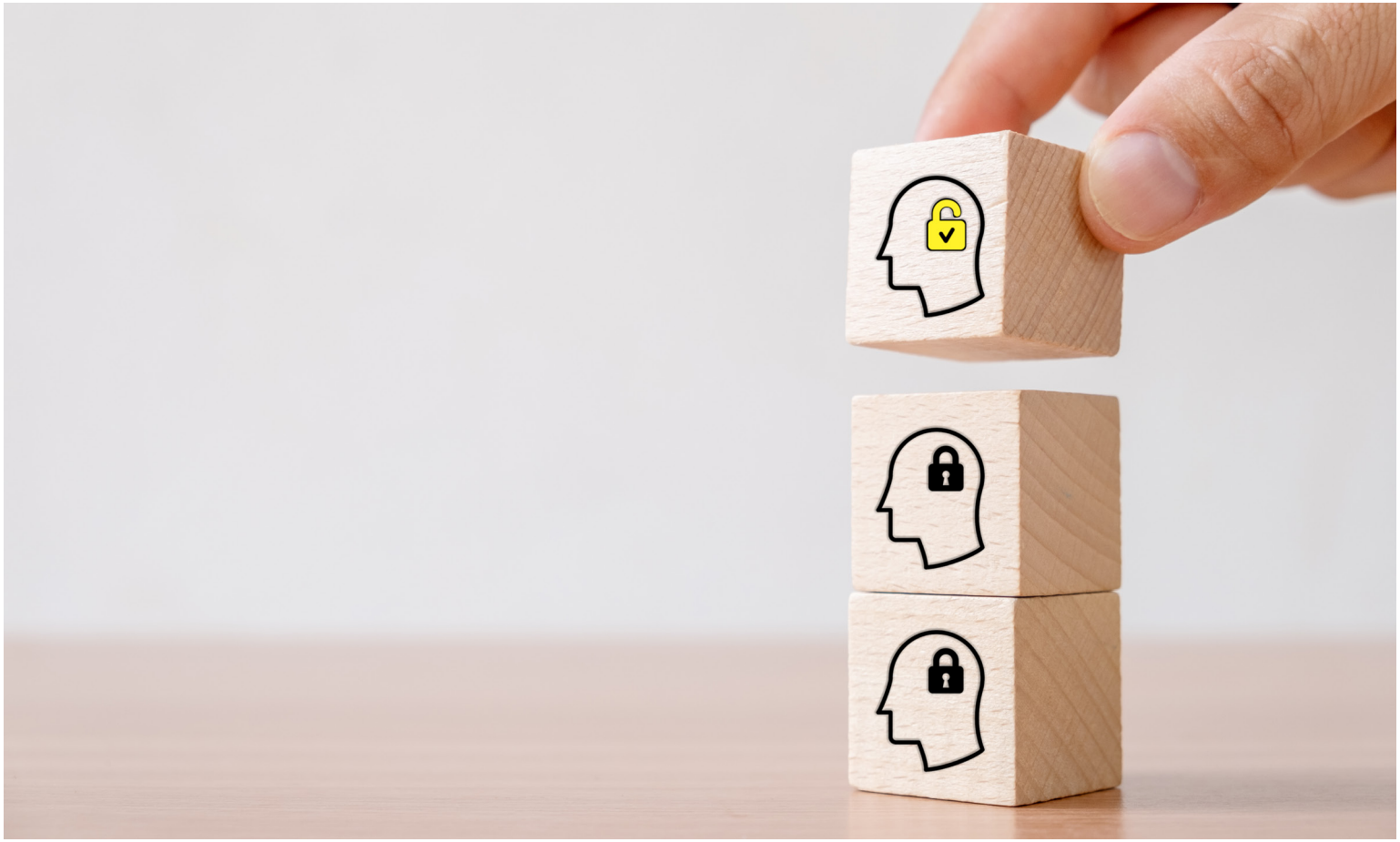
[108] *Crishna Morgado, N. et al. (2020). Climate Action in Financial Institutions: Future Strategy and Roadmap 2021 – 2025. A report prepared for EBRD on behalf of the Climate Action in Financial Institutions Initiative, Paris.*

[109] *ANZ, Barclays, BBVA, BNP Paribas, Bradesco, Citi, DNB, Itaú, National Australia Bank, Rabobank, Royal Bank of Canada, Santander, Société Générale, Standard Chartered, TD Bank Group and UBS https://www.unepfi.org/banking/tcfd/*

[110] *ABN-AMRO, ABSA, Access Bank, Bank of Ireland, Barclays, BMO, Bradesco, Caixa Bank, CIBC, CIMB, Citibanamex, Credit Suisse, Danske Bank, Deutsche Bank, DNB, EBRD, FirstRand, ING, Intesa Sanpaolo, Itau, KBC, Lloyds, Mizuho, MUFG, NAB, Nat West, Nedbank, NIB, Nomura, Nordea, Rabobank, Santander, Scotia Bank, Shinhan, Standard Bank, Standard Chartered, TD Bank, TSKB and UBS https://www.unepfi.org/banking/tcfd/*

Conclusion

It is evident that there is a clear need to move away from a 'silo' approach to a more integrated one, which cuts across policy making, evolution of business models and technological advancement and financing for climate action projects. While Governments continue to play a key role in integrating climate change considerations into national strategies and policy frameworks, the current emergency requires all the stakeholders to come on board, thereby leveraging the **'power of collective'.** This report attempts to establish the nexus approach required to deal with climate change and its impact on the economy, with the involvement of relevant stakeholders, to carve a sustainable future.



The image on the front cover signifies the expanding economic impact of climate change. Concerted efforts by all the stakeholders will help Indian economy navigate through the climate emergency and ensure a sustainable growth trajectory