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Article

ADAPTING TO CLIMATE CHANGE: NEED FOR A GEOGRAPHY LENS

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ABSTRACT

Climate change is univocal. A large section of humanity around world, particularly in developing countries, is vulnerable to the high-impact catastrophic events related to global warming. Human society has adapted to extreme climatic situations for centuries. However, the accelerated warming of the climate is a major concern. The COP27 reemphasized adaptation and identified five major sectors for the adaptation plans. India is experiencing the impact of climate change in ecological, economic and social sectors and several mission mode programmes are conceived under national and state-level action plans. This paper argues that while the global scenario provides a broad systemic idea, the local level change, impacts and manifestations are important for taking adaptive measures as there will be wide spatial variations in the velocity and direction of climate alteration and the underlying drivers of climate variation due to heterogeneity of earth surface. The relationships between scales of macro and micro and the interactions between macro structures and micro manifestations deserve more attention. Following a brief discussion on the vulnerability of India and state action plans, this paper highlights a couple of micro-level initiatives undertaken in Kerala, which have the potential to address emerging challenges due to climate change. It is suggested that local geography should be factored in while planning for adaptation, and all stakeholders across the society may be involved to face the challenge.

1. Introduction

The climate alteration and its effect on ecology, economy and civilization is a matter of global concern. Incidences of high-impact catastrophic events like cyclones, floods, extreme heat waves, and withering droughts are increasing and, in the course, they tend to threaten food security, economic well-being and livelihoods of billions of people across the world. The successive assessment reports produced by the IPCC have indicated that the temperature is increasing and irrefutably substantiated the effect of anthropogenic forces in the process of global warming. There is about 50% possibility that the world's average temperature will exceed or reach 1.5ºC in the near term, even for a decreased level greenhouse gas release situation (IPCC, 2022). The NASA-led investigator has specified that Earth's energy imbalance around doubled within 14 years from 2005 to the end of 2019 (https://www.nasa.gov/feature/langley/joint-nasa-noaa-study). The risks are increasing and the 'Safe Operating Space' is diminishing as climate change has already crossed the planetary boundary, a concept proposed by Rockstrom et al (2009) to indicate the limit of the resilience of earth system processes. It cautioned about the amplified risks due to climate change and possibility of creating new risks for natural and human systems. The socio-economically disadvantaged groups living in environmentally marginal areas and drawing sustenance directly from the ecosystems, or depending on the economic sectors that are sensitive to climate change are at greater problem and the level of hazard will be subject to on concurrent near-term (2021-2040) trends in susceptibility, exposure, level of socio-economic growth and adaptation (IPCC, 2022). Adaptation as a process of enhancing society's coping ability entails taking procedures to decrease the adverse properties of climate transformation by making suitable modifications and changes. There are various options and opportunities to adapt. Technological options, innovations, risk management, nature conservation, strengthening local buffer systems, insurance and behavioural changes at the individual and community levels are some of the channels for adaptation. Due to the increasing speed of climate change, the thrust is on the reduction of vulnerability and increased capacity to adapt.

Human civilization has a long history of adaptation in the face of climate variabilities and extreme events like drought or flood. Apart from developing various in-situ coping mechanisms, migration, temporary or permanent, is a critical adaptation strategy noted in both developed and developing countries during natural disasters. This type of migration is increasing in recent decades in climate-vulnerable countries; however, spatially, disaster-related migrations are predominantly domestic and from rural to urban areas (Chumky et al. 2022). India has witnessed several such bouts of migrations around large cities over the years. Due to the warming up of climate the local climatic variability that people have so far witnessed and have adapted to is changing and the change is with greater speed (UNFCCC, 2007). Therefore, adaptation is a major concern and needs to report the effects of climate alteration, particularly in developing countries as these countries face various constraints in deploying adequate technical, human and financial resources to adapt.

The COP (Conference Of Parties) 27 Presidency launched the 'Sharm-El-Sheihk Adaptation Agenda' to rally global action around 30 adaptation outcomes covering food and agriculture, water and nature, oceans and coastal areas, human settlements and infrastructure systems to enhance the resilience of four billion people breathing in the most climate vulnerable communities across the world by 2030 (Summary of Global Climate Action at COP 27: UN Climate Change, Marrakech Partnership). The adaptation outcomes spell out global explanations that can be adopted at the local level to respond to regional climate contexts, requires, and risks and will help the transformation of the system required to defend vulnerable public groups from the growing climate hazards in the increasingly warming world (Climate Champions, 8th November 2022). While it provides a guideline for action points, global cooperation, and financial requirements, like the bulk of the research relating local places to global climate change, the proposed adaptation strategy is also top-down, from the global to the local concentrating on the solutions derived from global models even though, these models have little regional and local specificity. However, the global change is tractable and actually experienced on local scale. The complex relationship among ecologic, economic and social processes that drive the change can only be unraveled by careful location-specific analysis. While there are systemic changes at the global level affecting local conditions, the local changes, in aggregation, can impact the global scenario. The question often arises in the local to global link is about the local manifestation of global change, the ways local places contribute to global change and how it changes over time, the drivers of these changes, behavioral pattern of the affected community and how the efforts at mitigation and adaptation can be locally initiated and adopted (Wilbanks and Kates, 1999). In recent years, there has been increasing interest in following a bottom-up approach for understanding issues related to climate change, its impact and adaptation measures. Attempts are underway to construct assessment models that are dynamic and can incorporate the effects of increasing local temperature on fundamental productivity, amenities and local characteristics (Cruz and Rossi-Hansberg, 2021).

India is the countries vulnerable to climate alteration and has a sizable section of people directly depending on climate-sensitive economic sectors. There are national and state level action plans prepared to address climate change-related issues and work out adaptation strategies, however, the top-down approach continues, and action plans are mostly sectoral and Government department oriented. Various micro-level initiatives and people's participation are hardly factored in. The thesis of this paper is that the local conditions and participatory approach deserve more attention to address spatial heterogeneity of the landscape, and varying manifestations of climate change and devise site-specific adaptive measures as appropriate and workable at ground level. The paper will draw examples from the insights of various micro- level action research programmes introduced in Kerala by the Government of Kerala, NGOs operating at the grass root level and lessons from individual farm-level initiatives in support of the argument.

2. Vulnerability of India

Since the middle of 20th century, India has been witnessing a rise in average and extreme temperatures, a decrease in rain during rainy season, a increase in sea levels and increased instances of droughts and cyclones. The average Indian temperature rose by around 0.7° C during 1901–2018 mainly on account of greenhouse gas (GHG) induced warming, partially offset due to anthropogenic aerosol loading and change in Land Use/ Land Cover (Krishnan et al. 2020). The annual mean temperature in India has enhanced by about 1.2^{o} C since the start of the 20th Century, and since 1995, the annual mean temperature has increased rapidly (Vineet Kumar, 2018). The average Sea surface temperature (SST) in the Indian Ocean mainly topical zone rose by 1^{o} C from 1951 to 2015, well above the global average of SST of 0.7^{o} C (Sangomla, 2020). According to a forecast, India's GDP may shrink by 3 % in the eventuality of 1^{o}C global warming (Picciariello et al. 2021). Heat island impact of urban areas is further aggravated and effective temperatures in major urban centres are more than the measured temperature. Major economic sectors like agriculture, animal husbandry, and fisheries, and a large section of people, existing in countryside areas are exposed to the effects of climate change. Extreme conditions will also witness the possibility of increasing rural-to-urban migration as a traditional coping mechanism followed by rural people over the centuries. India could experience a 40 % deterioration in farming productivity by the 2080s. The problem will be further compounded due to a decline in per capita freshwater availability from 5177m^3/year in 1951 to 1140m^3/year in 2050 (Mishra et al. 2020). Both biophysical and socio-economic systems are adversely affected. The UNICEF India report (2022) placed India as the 7th most affected country due to climate change-led extreme weather events in 2019, considering the number of fatalities as well as the financial losses (about 66182 million US$ PPP). A special report by UNICEF (2021) highlights that children are at risk due to climate change and the children in India are greatest at danger to the influences of climate alteration threatening their health, education and protection. India as a whole is warming up and is vulnerable to extreme hydrological and meteorological (or "hydromet") disasters like floods, droughts and cyclones, the frequency of which is increasing over the years, so is the loss of economy and even human lives. The entire country from the coastal tract to the mighty Himalayas experiences the impact of climate change in various measures.

The influence of climate alteration varies over space and time due to differences in exposure and vulnerability of various ecosystems, economic sectors and social groups (O'Brien et al 2008). One of the model studies highlights that under the projected climate change in India, there are indications of a shift in the direction of wetter forest types in the north-eastern area and drier forest types in the north-western area in the absence of human influence (Ravindranath et al. 2006). Temporal variations of temperature and precipitation are partly associated with forest losses, but the relationship recorded large spatial and seasonal variations (Haughan et al. 2022). Following the IPCC (2014) framework there is an attempt to work out the vulnerability status of states and districts in India (Anon. 2020). This study considered 14 indicators under three groups, namely, i) Socio-economic features and livelihood (5 indicators), ii) Biophysical aspects (5) and iii) Institutions and infrastructure (4). According to this study, all states are vulnerable to varying degrees and the vulnerability of eight states, namely, Jharkhand, Mizoram, Orissa, Chhattisgarh, Assam, Bihar, Arunachal Pradesh and West Bengal are relatively high (Table 1). Lack of forest coverage emerged as one of the main drivers of vulnerability for 17 states followed by lack of crop insurance (11 states) and rainfed agriculture (10 states). While vulnerability and population density are hardly related, there is a strong negative correlation between vulnerability and the Sustainable Development Goal index (Figure 1). Increasing vulnerability will hinder India's journey to accomplish sustainable development goals in a reasonable time frame.

Table 1: State level Vulnerability, population density and SDG
(Sustainable Development Composite) index

State	Vulnerability Index *	Population density # (persons/km^2	SDG Composite index @
Jharkhand	0.674	414	56
Mizoram	0.645	52	68
Orissa	0.633	269	61
Chhattisgarh	0.623	189	61
Assam	0.620	398	57
Bihar	0.614	1102	52

Arunachal Pradesh	0.594	17	60
West Bengal	0.592	1029	62
Uttar Pradesh	0.582	828	60
Tripura	0.571	350	65
Gujrat	0.562	308	69
Meghalaya	0.560	132	60
Jammu & Kashmir	0.550	297	66
Rajasthan	0.535	201	60
Madhya Pradesh	0.528	236	62
Manipur	0.520	122	64
Andhra Pradesh	0.510	303	72
Karnataka	0.503	319	72
Himachal Pradesh	0.486	123	74
Telangana	0.480	312	69
Sikkim	0.477	86	71
Punjab	0.472	551	68
Uttarakhand	0.468	189	72
Haryana	0.463	573	67
Tamil Nadu	0.462	555	74
Kerala	0.437	859	75
Nagaland	0.437	199	61
Goa	0.434	394	72
Maharashtra	0.419	365	70

Source: *DST, Government of India, 2020;# Census of India, 2011; @ NITI Aayog, 2021; $ Ministry of Statistics and Programme Implementation, Government of India. Note: States are listed according to vulnerability rank.

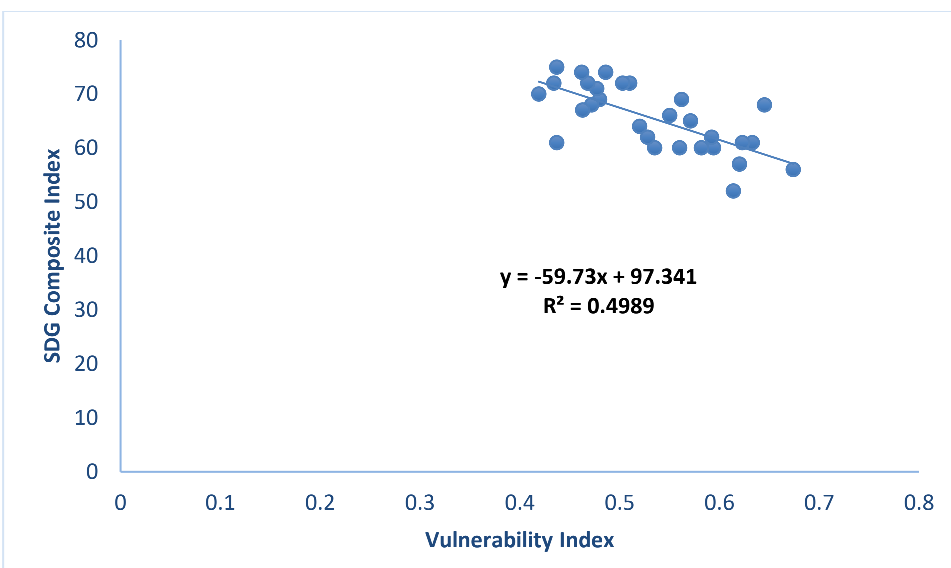

Figure 1: Correlation between vulnerability index and SDG composite index

3. Action Plan on Climate Alteration: National and State level initiatives

To address the critical challenges due to climate alteration, the Government of India initiated several steps both at the national and state levels. The Prime Minister's Council on Climate Change (PMCCC) envisaged a directional shift of development trajectories and to further improve the environmental sustainability of India's development path through national and state-level actions in 2008. The 'National Action Plan on Climate Change' (NAPCC) outlined eight mission mode programmes in various sectors including ecosystem-based management of the Himalayas (Table 2). To decentralize the process and go beyond the eight mission mode programmes of NAPCC, all States and Union Territories were asked to form a State Action Plan on Climate Change (SAPCC) in 2009. All 29 State and Union Territories have prepared their SAPCC based on the guidelines issued by the Department of Environment, Forests and Climate Change, Government of India. Some states like Kerala have come out with the second version of SAPCC in 2022. The State Action Plan for Climate Change (SAPCC) follows a common framework. It consists of five sections: i) Climate profile of the state, ii) Assessment of vulnerability to climate change, iii) Green House Gas emission (GHG) and energy needs, iv) Climate change strategy and v) Climate change action plans. Since, SAPCCs are adoption centric, and try to focus on good development, most interventions have been proposed to be implemented through ongoing sectoral programmes and schemes (Kumar, 2018). Stakeholder consultation for Kerala's SAPCC suggested to include women and children's vulnerability issues, decentralization, people's participation, women empowerment, new knowledge generation and water security, forest protection measures, transport solution and green building practices as part of Kerala's SAPCC (Thanal, 2017). As some of the reviews indicated, the SAPCC is a good initiative and provides an institutional platform to mainstream concern of environmental sustainability into development planning (Dubash and Jogesh, 2014; Gogai, 2017; Kumar, 2018). It created an opportunity for partnership and scope of productively engaging development practitioners, administrators, academicians, business and civil society. However, primarily, the approach is top-down, sectoral, mostly repackaging of departmental projects, with little scope for internalizing spatial variations, integration and innovation and filling up the data gap.

Table 2: National Mission on Climate Change (Government of India, 2021)

Missions	**Objectives, goals, initiatives and present status**
Solar Mission	Launched in 2010 to install 20 GW solar power by 2022, upscaled in 2015 to install 100 GW. Installed capacity is 36.32 GW by October, 2020. An additional 58.31GW under installation/ tendering process.
Mission for Enhanced energy efficiency	Four initiatives under this mission are: Perform Reach and Trade; Market change for energy efficiency; Energy efficiency financing platform; Framework for energy efficient economic development
Mission on sustainable habitat	Key deliverables include: Development of maintainable habitat standards commensurate to climate change concerns; Preparation of city growth plan addressing adaptation and mitigation concerns; Preparation on comprehensive mobility plans enabling cities to start long term, energy efficient, low-cost transport planning; Capacity construction to undertake mission happenings
Water Mission	Five goals include: Comprehensive data base in public area, and assessment of impact of climate change on water resources; Elevation of citizen and state actions for water conservation, augmentation and preservation; Focused attention to vulnerable areas including over-exploited areas; Increase water efficiency by 20 per cent; Promotion of basin level combined water resources organization
National Mission for Sustaining the Himalayan Ecosystem	The goal includes addressing issues related to the Himalayan glaciers, and related hydrological conditions and shield of biodiversity, wild lives, traditional knowledge and the Himalayan ecosystem. Four type of capacity generation to this end cover: Social and information capacity; Institutional capacity; Capacities for evidenced based policy building and governance; balancing among forces of nature and activities of

	man kind
Mission for Green India	The objectives are: Rise Forestry/ tree cover in 5 million hector and expand quality of forest in another 5 million ha; Improve ecosystem service-biodiversity, hydrological services and carbon appropriation; Rise forest dependent livelihoods of 3 million households existing in and around forest areas; greater yearly carbon sequestration by 50-60 million tons in 2020.
Mission for sustainable agriculture	Mission covers: Farm water management-per drop more crop-Pradhan Mantri Krishi Sinchayee Yojana; Soil health management; Soil health card
Mission for Strategic Knowledge for climate Change	Mission deliverables include: At least 10 thematic knowledge network, technical reports, regional and disaggregated climate models, 50 chair professorship, 200 research professionals, at least three viable public-private partnership on adaptation and mitigation, technology development and international collaborations

4. Geography lens: Addressing heterogeneity

Although climate change is often framed as a global problem affecting entire humanity, the heterogeneity of its manifestation, impacts and responses needs careful consideration (Sultana, 2014), which can be accomplished by following a geographical approach (Bailey, 2008; Winkler, 2016). Geographic knowledge coupled with enabling tools like GIS helps better understand the world and provides an important framework for studying complex problems like climate change impacts, making better decisions, conserving resources and improving the way of work (Dangermond and Artz, 2010). The heterogeneous effects of weather change across the spatial scale and geographic mobility in human adaptation to climate alteration warrant due attention in the course of the adaptation plan (Robert-Nicoud and Peri, 2021).

The process of an adaptation plan should begin with the proper understanding of the trend of climate change and therefore it is necessary to calibrate global and national climate change models according to geographic regions and sub-regions. This requires installing a system of long-term observation according to geographical regions, monitoring and analysis of interactions of global forces at the local scale and setting up Human Environment Research Stations to produce new knowledge and examine existing information. As global models have limitations in capturing regional issues, it is important to understand the actual changes that are taking place on the ground for devising adaptive measures. The study of IIT Delhi with support from the Department of Science and Technology (DST), Government of India, brought out that the trend of temperature rise and change in rainfall computed through IMD observations and Multi Model-mean differ significantly. It is observed that there is an underestimation in temperature (up to 16° C) over the Himalayas and North East and an overestimation over most of Central India (up to 4° C). Similar bias was observed in the case of rainfall also (Mishra et al. 2020). Even the scenarios computed using different models show variations. By the last part of the 21st Century, the normal temperature all over India is expected to increase by 4.4°C, relative to the recent past (1976-2005 average) under the RCP (Representative Concentration Pathways) 8.5 (high concentration pathways-radiative forcing of 8.5 Watt/ sq. meter) (Krishnan et al. 2020). The temperature rise may be limited to 2.4°C under the RCP 4.5 scenario (intermediate stabilisation pathway). Under these circumstances, it is important to work out the real situation for effective adaptation.

According to the Indian Council of Agricultural Research (ICAR) there are 15 agro-climatic regions (Fig. 2) and 72 agro-climatic sub-zones in India. Each of these agroclimatic zones/ sub- zones are characteristically different with variable resilience limit. Rainfall varies widely across India (Fig. 3). National Atlas and Thematic Mapping Organisation (NATMO), Government of India identified 57 physiographic units in the country. These physiographic units are also not uniform. There are internal relief variations and land use practices sensitive to variations in climate change. Even, the coastal zone, spreading over nine states and islands is not homogeneous. Coupling forest cover with these physiographic units, drainage basins and agroclimatic zones can help identify biophysical zones, units and sub-units. The present climate monitoring system is not sufficient to address these variations. As the climatic parameters cut across state boundaries, there is a need for data generation according to physiographic zones and greater coordination among the states to work out climate change scenarios and adaptation measures. The local level buffers to mitigate impacts of climate variation and related risks depend on micro-level variations in elevation, local topographic characteristics and location of settlements with respect to the vegetation, topographic features, and water bodies. Distribution of these spatially differentiated buffering features is under threat due to human interventions, thereby compromising the natural resilience of the area, which should be brought back as part of the strategic plan for adaptation.

Figure 2: Agro-climatic zones in India

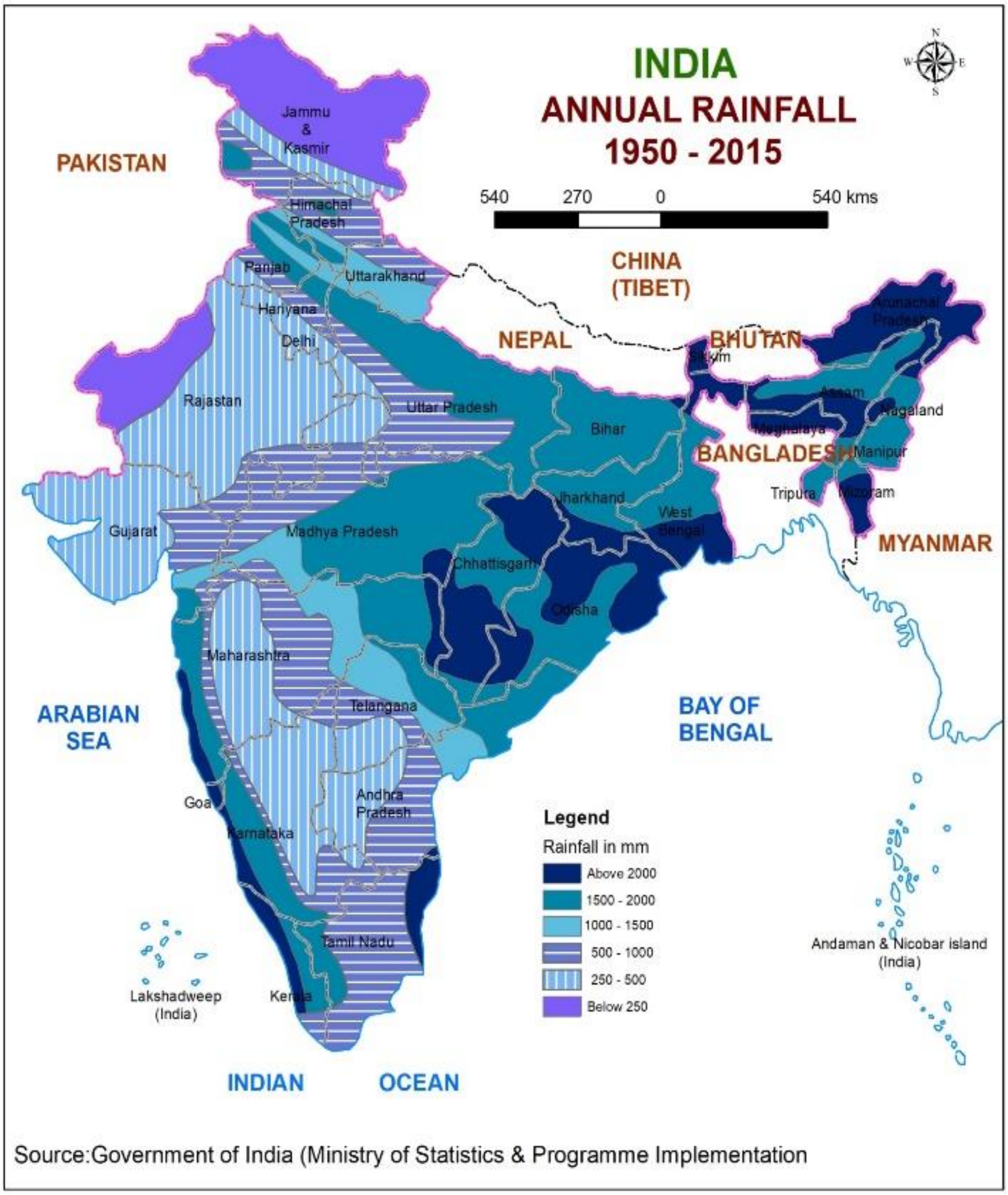

Figure 3: Average annual rainfall (1950-2015)

5. Developing micro-level geographic database for resilience

The ability of a region to maintain equilibrium among ecological, financial, and community cultural systems while managing their susceptibilities in the face of constantly shifting external conditions is known as resilience. These systems are dialectically linked, and the magnitude and intensity of their interactions are growing. As is now the case, vulnerability in one sector instantly impacts the other sectors and exposes areas to higher risks and uncertainties. In the face of these difficulties and increasing social-ecological vulnerabilities, which may emerge differently depending on the local climatic conditions, building resilience is a planning priority.

At the level of local territorial systems, a spatial and quantifiable information database outlining resource endowments, ecological conditions, infrastructures, and magnitudes of vulnerabilities must be built. Resilient area management plans must also be designed. There is a long history of creating mapping databases at the local level. The United Kingdom finished the Land Utilization Survey experiment in the 1930s by using high school instructors and students as volunteers and the Ordnance Survey map. The process was repeated in the 1960s, and additional attempts were undertaken in Britain in 1990 and 1996 to finish the map of land use and cover for the entire nation using satellite data. The USA Environmental Protection Agency (EPA) has created a national geographic data resource (Smart Location database) for characterizing the built atmosphere and destination availability on a neighborhood scale in the last ten years, realizing the value of micro-level data for decision-making. More than ninety characteristics are organized into ten areas in the database: administrative, area, demographics, employment, density, diversity (land use), design, transit service, accessibility of destinations by car and by transit, and regional summaries. (http://www.epa.gov>smartgrowth>smart).

Such a database is needed in India, particularly for rural areas. 69% of all people in our nation reside in 138 million families spread among 5.97 lakh inhabited villages, according to the 2011 Census (https://censusindia.gov.in/2011census/A3_vill/note_A-3_village). There are 115,080 villages with a population size class of 2000 to 10,000 where about half of the rural population lives. Although cadastral maps are available for practically every village in India, additional pertinent information, aside from demographic data, is not available for these communities. Additionally, there is practically slight spatial information on land use, water body, and environmental condition. The main goal of the Digital India Land Records Modernization Programme (DILRMP) is to computerize proper records.

It is crucial. A comprehensive map database should be created as well, though. Space travel has advanced significantly. India launched its own satellite to routinely gather data with a resolution of less than a meter. When cadastral maps and various remote sensing data products are used together, village-level mapping becomes feasible. The accurate position of the features, including homes, can be gathered and all data assimilated with the use of readily available IT tools like GPS and GIS.

As per the 73 Constitutional Amendment Act, databases and plans at the panchayat/village level can be combined at other hierarchical levels such as watersheds, blocks, districts, and so on. After receiving the necessary training, local NGOs, high school students, and NSS volunteers can map basic data on terrestrial, water, and local properties. However, professional assistance is needed to assimilate this data and prepare action plans for both individual villages and clusters of villages. Such initiatives were pioneered in Kerala.

6. Action at the local level: Some examples from Kerala

In 1991, Kerala was a trailblazer in the introduction of the Panchayat Resource Mapping (PRM) program, which involved volunteers and science and technology personnel on an experimental basis. It later became a significant action research project that involved every panchayet in the state. Mapping data on the land's characteristics, land use—both farming and non-agricultural—all water bodies—rivers, streams, springs, lakes, ponds, specific wells, roads, communication, the health and education schemes, and the environment—were produced by this exercise (Chattopadhyay et al., 2004). These maps are now being digitalized in part. Resource mapping has been carried out by some panchayats for a number of additional goals, including watershed management, river rejuvenation, water conservation, etc.

Kerala introduced river bank mapping as part of the river restoration programme (Chattopadhyay and Harilal, 2017; Chattopadhyay et al. 2011). All details of river banks stretching from foothills to lowlands are documented for all major rivers under three basic maps: Physical features, Land use and Man-made features (Fig. 4). There are also attempts for restoration of the river banks in Kerala (Viswanath et al. 2021). Another important initiative is building carbon neutral local bodies. The experiment was taken up in Meenangadi panchayet of Wayanad district, where local people were mobilized, and partnerships were developed among the panchayat, NGO, professional bodies, educational institutes and Government (Thanal, undated). The project began with the generation of a local geographic database through a baseline survey, resource mapping, benchmarking of carbon stock, emission, and sequestration followed by action plans. The carbon emission of this panchayat is estimated to be 30,334 tonnes/year. The present stock for sequestration is 15,114 tonnes/year. Panchayat proposed to manage the deficit of 15220 tonnes/year through reduction of carbon emission, enhancement of soil carbon, planting additional trees, and expanding forest and plantation cover. Excavation and rejuvenation of ponds is also another programme being undertaken at the individual level and also at the panchayat level. It has improved the water storing capacity of the ponds and helped the local water supply and irrigation (Fig. 5). Another significant initiative of high potential for local climate data generation is the setting up of school weather stations in 250 Higher Secondary schools across the state under 'Samagra Shiksha Kerala Abhiyan' (Fig. 6). It is an innovative programme to generate local climate data, train students for such activities, spread awareness and help understand the spatial and temporal change in the climate. Kerala experiments demonstrate the use of local coping strategies and traditional knowledge in synergy with government and local interventions.

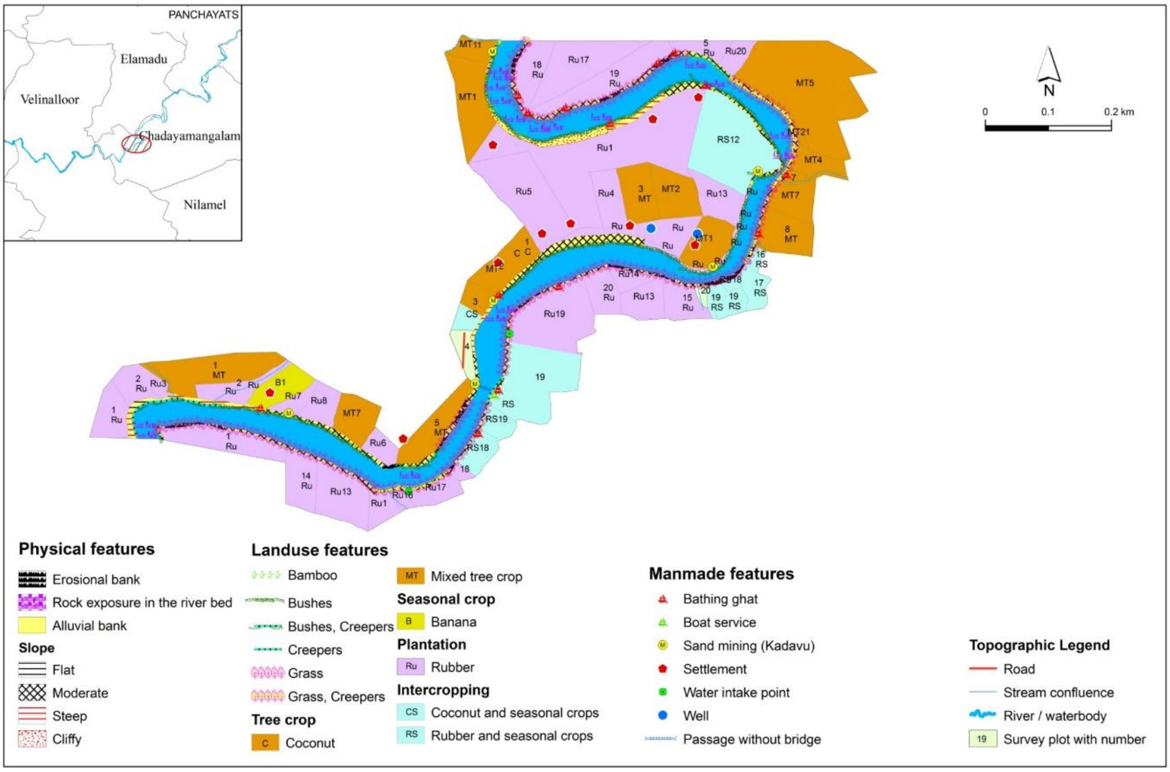

Figure 4: A sample river bank map, parts of Ithikkara river, Velinalloor-Chadayamangalam panchayat, Kerala

Figure 5: Water conservation structures in a panchayet in Palakkad

250 school weather stations for microdata

K.A. Martin
KOCHI

Weather is no more for making small talk. If the epic flood of August 2018 in Kerala taught a lesson, it is that weather is central to our lives. So much so that when a group of students at Government Higher Secondary School, Tirur, released data last week on daily rain in the area linked to extremely localised, heavy spells it made news.

It is a breakthrough that paves way for a future in which area-specific or micro-weather data will be collected through school-based weather stations to understand conditions to predict a pattern and possibly avoid crisis-like situations.

These efforts are under way in around 250 schools in the State through a programme under the Samagra Shiksha Kerala, in collaboration with Advanced Centre for Atmospheric Radar Research, Cochin University of Science and technology (Cusat).

These weather stations are expected to be fully functional with the reopening of schools for the new academic season that coincides with the arrival of monsoon, sources said.

The groundwork for running these stations is under way, including printing of data entry books. Teachers selected from the schools have been familiarised with the running of the stations.

Extreme weather variations experienced by the State in the last decade necessitated the setting up of the weather stations. Torrential rain, cloudbursts, landslips, floods and extreme climate events are now familiar to the State.

A teacher associated with the programme said that the school-based weather stations will not only help generate reliable data but also create the background for drawing students with aptitude to research in the future.

The success of the programme has been recognised by the Union Ministry of Earth Sciences, and a certificate of appreciation was issued to K. Dhanyasree, Kadeeja Farha and Muhammed Jusil, all students at the Tirur school, for their research paper on variations of atmospheric conditions in Kollam's Vayala region.

Going local: A weather station set up at Government Higher Secondary School, Tirur.

Figure 6: School Weather Station in Kerala and News paper report

7. Conclusion and way forward

It is well established that global warming and climate change will critically affect the natural resource base, ecosystem, livelihood opportunities, human health, and social and economic development and in the process will impede growth if appropriate timely actions are not taken. The impact of climate change will not be uniform across the world and even within the country. Heterogeneity of the earth surface across the scale and consequent spatial variations of both drivers of climate change and the impact of climate change deserve required attention as the local level impacts and manifestations will vary widely which should be factored in for taking effective adaptive measures. Some possibilities are looking at issues following a top-down approach may yield a different set of conclusions than looking at the same issue from the bottom-up. Besides, potential of local buffer, which enhances resilience to withstand climate emergencies are hardly considered in policy decisions. Integration of spatio-temporal dimensions of climate change is also necessary to understand the velocity and direction of climate change. India is vulnerable to the growing threats of climate change from the coastal tract to the high Himalayas. While continuing with global negotiations, the country-level tasks warrant strengthening of NAPCC and SAPCC for internal capacity building, and to design location-specific adaptive measures for navigating the emerging challenges arising out of climate change. The SAPCCs should be transformational, integrated cutting across the sectoral silos and linking climate resilience, sustainable development and science-based planning and participation. There is a need for reorientation and improvement of the SAPCC to make this document a true guide for a paradigm shift in the development process and striving for sustainability. An approach of analysing co-benefits, trade-offs and synergies to design adaptation strategies will reduce ecosystem cascades by building ecosystem management, resource management plans, mobilization, social stress, and appreciation of ecosystem services. Coordination and partnership among central, state and local bodies to formulate climate adaptation strategies internalizing spatial heterogeneity is required while avoiding conflicting targets. The planning should involve active and equitable engagement of all stakeholders across sectors and affected groups. Finally, adaptation should be mainstreamed as part of the sustainable development agenda. The core argument of this paper may be summerised as follows:

i) The present top-down approach of climate change analysis, adaptation and strategic planning should be changed to bottom-up approach, undertake appropriate policy, build necessary institutions and train human resources at different levels from local village schools to the higher education centres. Policy decisions and appropriate governance structures are necessary to equip the communities to build their resilience, with adopting appropriate technologies while making the most of traditional knowledge, in-situ intervention and diversifying their livings to cope with present and upcoming climate pressure. The adaptation plan should address the issue of most vulnerable groups like children, women, and senior citizens and economically marginal communities and be mainstreamed.

ii) In order to deal with ongoing changes in the social, political, economic, and also environmental environments in which companies function, localism, spatial arrangement, and resilience are being emphasized globally. The focus is on peaceful development where individuals may take full advantage of the natural resources found in their areas, turning variety into a strength. Place-based/territorial specificities, emerging from formal procedures, and the informal spatial evolution of a given location are all being prioritized.

iii) Geographic region-specific calibration of global and national climate change models is necessary. This requires installing a system of long-term observation points according to geographical regions, monitoring and analysis of interactions of global forces at the local scale and setting up Human Environment Research Stations to produce new knowledge and examine existing information. As global models have limitations in capturing regional issues, it is important to understand the actual changes that are taking place on the ground for devising adaptive measures. The school weather stations are important in this context both for data collection and for spreading awareness.

iv) Build micro-level geographic database at the panchayat/ city level, assessment of climate change buffering landscape elements and documenting local people's experiences of climate change and their attempts to withstand the change can help in a long way. It is essential for building resilient village/ panchayat, spatial planning, precision organization, and evidence based local-level decision-making in the face of forthcoming eventualities.

v) The district can be considered as this midway between the State and the panchayat/ local bodies. Most of the government departments have district-level units. There is also a district planning office and the Zilla Panchayat is a constitutional body. A district-level platform is necessary to coordinate departmental activities and to assimilate Panchayat/ city-level data. A Technical Support Group may be developed at the district level involving departments, R & D institutes, Universities, Colleges, NGOs and retired professionals. The SPACC may consider setting up such an institutional mechanism for carrying forward the action plans.

vi) Going beyond mere routine stakeholder consultation in preparing SAPCC, the participatory approach should engage local people, panchayats and works within the existing decentralized institutional bodies that can help local ownership, implementation of action plans to strengthen and enhance local resilience, bring cost-efficiencies, and ultimately contribute to achieving sustainability.

vii) Partnership and greater coordination of state Governments are necessary as local control of climate change is bio-physically determined and is not limited to the state boundaries. There is a need for sharing best practices and preparing a blue-print for effective application of climate variation adaptation and mitigation actions in a variety of contexts both at the national and sub-national levels.

REFERENCE

1. Anonymous (2020). Climate Vulnerability Assessment for Adaptation Planning in India using a Common Framework. Prepared by Indian Institute of Technology, Mundi, and Indian Institute of Technology, Guwahati in collaboration with Indian Institute of Science, Bangaluru with support from Department of Science and Technology, Government of India, New Delhi and Swiss Agency for Development and Cooperation, SDC, India. New Delhi. p169.
2. Bailey, I. (2008). Geographical Work at the Boundaries of Climate Policy: A Commentary and Complement to Mike Hulme. Transactions of the Institute of British Geographers, New Series, 33(3), 420–423.
3. Chattopadhyay, S., Sasidharan, C. K., & Mathai, J. (2004). Panchayat resource mapping: An experiment from Kerala. In G. R. Ravindra Kumar & N. Subhas (Eds), Silver Jubilee Compendium: Earth System Science and Natural Resources Management, Centre for Earth Science Studies, Thiruvananthapuram, (pp 401-416).
4. Chattopadhyay, S., & Harilal, K. N. (2017). River Restoration in Kerala: Developing a Co-evolutionary framework for river restoration action plan for Thiruvananthapuram city. Research Unit Local Self Government (RULSG), Centre for Development Studies, Thiruvananthapuram.
5. Chattopadhyay, S., Mathai, J., Thomas, P G., Sajith Babu, D., Madhusoodanan, K., Shaji, J., & Saniya, N. (2019). Handbook on river bank mapping and sand auditing. River management Centre, Institute of Land and Dosaster Management (ILDM), Government of Kerala, Thiruvananthapuram p115.
6. Chumky, T., Basu, M., Onitsuka, K., Parvin, G A., & Hoshino, S. (2022). Disaster-induced migration types and patterns, drivers, and impact: A union-level study in Bangladesh. World Development Sustainability. Vol. 1: 100013, ISSN 2772-655X. https://doi.org/10.1016/j.wds.2022.100013.
7. Cruz, J., & Rossi-Hansberg, E. A. (2021). The Economic Geography of Global Warming. NBER Working Paper No. w28466, Available at SSRN: https://ssrn.com/abstract=3785800
8. Dangermond, J., & Artz, M. (2010). Climate change is a geographic problem-The geographic approach to climate change, Redlands: ESRI.
9. Dubash N. K., & Jogesh, A. (2014). From margin to mainstream? State Climate Change Planning in India. Economic and Political Weekly 49(48): 86-95.
10. Government of India (2021). National Action Plan on Climate Change-Frequently Asked Questions. Ministry of Environment, Forest and Climate Change, Government of India, New Delhi. Press Information Bureau, Ministry of Information and Broadcasting, Government of India
11. Haughan, A. E., Pettorelli, N., Potts, S. G., & Senapathi, D. (2022). The role of climate in past forest loss in an ecologically important region of South Asia. Global Change Biology, 28: 3883-3901. doi:10.1111/gcb16161.
12. Intergovernmental Panel on Climate Change (IPCC) (2014). Climate Change 2014: Synthesis Report. Contributions to Working Group I, II, and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva
13. Intergovernmental Panel on Climate Change (IPCC) (2022). Climate Change 2022: Impacts, Adaptation and Vulnerability. Summary for Policy makers. Working Group II Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. WMO, UNEP. p35.
14. Krishnan, R., Sanjoy, J., Gnanaseelan, C., Mujumder, M., Kulkarni, A., & Chakraborty, S. (2020). Assessment of the Climate Change over the Indian Region. A report of the Ministry of Earth Sciences (MoES), Government of India. Springer open, Singapore: Springer Nature
15. Misra, S. K., Sahany, S., Joshi, S., Dash, S. K., Sharma, A., & Bhalla, A. (2020). Impact of Climate Change on India Economy, Yes Bank Ltd., Mumbai and IIT Delhi, Delhi
16. O'Brien, G., O'Keefe, P., Meena, H., Rose, J., & Wilson, L. (2008). Climate adaptation from a policy perspectives. Climate Policy, 8: 194-201
17. Gogai, E. (2017). India's State Action Plan on Climate Change: Towards Meaningful action. In Depth. Oxford Project Management New Delhi, 11P.
18. Picciariello, A., Colenbrander, S., Bazaz, A., & Roy, R. (2021). The costs of climate change in India: A review of climate related risk facing India, and their economic and social costs. ODI Literature review. London: ODI (www.odi.org/en/publications/ the-costs-of-climate-change-in-India-a-review-of-climate-related-risk-facing-India-and-their-economic-and-social-costs.
19. Ravindranath, N. H., Joshi, V. N., Sukumar, R., & Saxena, A. (2006). Impact of climate change on forests of India. Current Science, 90 (3): 354-361.
20. Robert-Nicoud, F., & Peri, G. (2021). On the economic geography of climate change. Voxeu Column 11th October, 2021.
21. Rockstrom, J. Steffen, W., Noone, K., et. al (2009). A safe operating space for humanity. Nature 461:472-475. https://doi.org/10.1038/461472a.
22. Sangomla, A. (2020). Spike in sea temperatures, cyclones increase in Indian Ocean region: Report. Down to Earth, 19 June, 2020.
23. Sultana, F. (2014). Gendering Climate Change: Geographical Insights. The Professional Geographer, 66(3), 372–381.
24. Thanal (undated). Carbon Neutral Meenangadi. Carbon Neutral Meenangadi Technical cell.

Meenangadi Gram Panchayath, Wayanad. Powered by Thanal. www.thanal.co.in

25. Thanal (2017). Climate Resilient Kerala. Stakeholder Recommendations for Kerala State Action Plan on Climate Change. Thanal, Climate Action Network South Asia (CANSA) and UNICEF, Thiruvananthapuram.
26. United Nations Framework Convention on Climate Change (UNFCCC) (2007). Climate Change: Impacts, Vulnerabilities and Adaptation in Developing Countries. Bonn: Climate Change Secretariate (UNFCCC), p60.
27. UNICEF (2021). The Climate Crisis is a Child Rights Crisis: Introducing the Children's Climate Risk Index. UNICEF, India.
28. UNICEF (2022). Climate Change and Environmental Sustainability. Unicef.org/india/what-we-do/climate-change
29. United Nations Climate Change (2022). Summary of Global Action at COP27. Global Climate Action, Marrakech Partnership. p16.
30. Kumar, V. (2018): Coping with Climate Change-An analysis of India's State Action Plans on Climate Change. Centre for Science and Environment, New Delhi.
31. Viswanath, S., Sandeep, S., Sreekumar, V. B., Vishnu, R., & Sanil, M. S. (2021).

Manual for biorestoration of river banks in Kerala. Kerala Forest Research Institute, Peechi. p 98.

32. Wilbanks, T. J., & Kates, R. W. (1999). Global change in local places: How scale matters. Climate Change 43(3): 601-628.
33. Winkler, J. A. (2016). Embracing Complexity and Uncertainty. Annals of the American Association of Geographers, 106(6): 1418–1433.