

# Changing Tides

Climate Action and Justice in India

Edited by Anjal Prakash and Marcella D'Souza

Innovations, Practice and the Future of Public Policy in India



# CHANGING TIDES

This book explores climate action and justice in India, a country which has been facing extreme climate events and complex sociopolitical challenges arising from climate change. It offers diverse perspectives and insights into India's evolving climate landscape, policies, grassroots initiatives, and response to climate vulnerability and inequality.

The book scrutinises policy efficacy, addresses community vulnerabilities and perspectives, and showcases innovative sustainable development strategies. It draws upon climate adaptation literature to underscore the significance of global cooperation in tackling climate change challenges. With a focus on inclusivity and global collaboration, the book will serve as a great resource for policymakers, researchers, and stakeholders in navigating the complexities of climate action and justice in India.

Part of the Innovations, Practice and the Future of Public Policy in India series, this open access volume will be of interest to public and climate policy professionals, social science professionals, and students working on climate change, climate action and justice, public policy, social sciences, environmental science, geography, and South Asia studies.

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on enhancing livelihoods of tribal communities in Central India. He presently is the executive director of Collectives for Integrated Livelihood Initiatives (CInI), an associate organisation of the Trusts. The ‘Lakhpatti Kisan – Smart Village’ programme, focusing on meeting the aspirations of more than 100,000 small and marginal farmers in Central India, is being implemented by CInI under his leadership. He leads the Sustain Plus programme, which has been co-founded by Selco Foundation, Social Alpha, and CInI, focusing on integrating decentralised renewable energy towards addressing challenges in areas of livelihoods, healthcare, education at scale. One of his key facets is his involvement in analysing the areas of technology and innovations in the ecosystem to create sustainable solutions that meet the needs of rural communities. He is the director at the Foundation for Innovation and Social Entrepreneurship (FISE) and Sustain Plus Energy Foundation.

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# FOREWORD

The urgency of tackling climate change has never been more pressing, especially for a country as vast and diverse as India. With its rapidly growing economy, unique ecological zones, and deeply rooted social fabric, India faces complex challenges that require innovative, inclusive, and context-specific solutions. *Changing Tides: Climate Action and Justice in India's Landscape* offers a comprehensive and insightful exploration of how India is navigating this multifaceted crisis, emphasising technological advancements and the essential principles of equity and social justice.

This book is a timely contribution to the global conversation on climate change, illustrating how India's experience provides key lessons for the world. It underscores that climate action must be rooted in justice – an understanding that those most affected often have the least capacity to adapt or recover. Many chapters reveal the stories of rural farmers suffering from erratic monsoons, women managing water resources amidst scarcity, and marginalised communities facing displacement – all narratives that breathe life into the abstract science and policy debates that often dominate climate discourse. The book reminds us that climate resilience is inherently social; it is about empowering communities, respecting local knowledge, and ensuring that no one is left behind.

What sets this collection apart is its nuanced approach. It highlights how national policies, like India's ambitious renewable energy goals and adaptation programmes, are transformed when implemented locally – considering community vulnerabilities, Indigenous knowledge systems, and the socio-economic realities. The emphasis on decentralisation, community participation, and gender inclusiveness resonates with the understanding that sustainable change must emerge from the grassroots. This approach aligns with broader

global movements advocating climate justice – a call for fairness, equity, and recognition of the historical responsibilities many developed nations must bear.

The insights offered here also emphasise the importance of integrating diverse knowledge systems – scientific and traditional – to tackle the climate crisis effectively. Indigenous practices and community-led innovations are not just supplementary but essential components of resilient strategies tailored to local contexts. By amplifying these voices, India demonstrates that climate resilience is more about social equity than technology or resource management.

Furthermore, the book shines a spotlight on the importance of international cooperation. Climate change knows no borders, and India's engagement with global frameworks such as the Paris Agreement and the International Solar Alliance exemplifies the power of collaborative efforts. Yet the real challenge lies in translating international commitments into local, practical actions – an endeavour that demands coherence, mutual understanding, and respect for the diversity of national circumstances.

As an observer of India's ongoing journey toward sustainable development, I believe this book offers valuable insights for policymakers, researchers, activists, and communities. Its multidisciplinary perspective captures the interconnectedness of ecological, economic, social, and political factors that shape India's climate journey. It serves as a mirror to reflect current strategies and a roadmap to inspire future initiatives rooted in justice and inclusivity.

In sum, *Changing Tides* is more than just an academic collection; it is a call to action. It demonstrates that climate justice is not an abstract goal but a practical necessity – integral to India's development and the well-being of its people. As the nation faces rising challenges, this book reminds us that resilient, equitable, and sustainable solutions are within reach when we listen to communities, harness local knowledge, and commit ourselves to shared responsibility. It is my sincere hope that these pages will inspire meaningful dialogue and tangible change, both within India and beyond.

**Dr Debra Roberts**

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# PREFACE

In the following sections of this book, we delve into the intricate history of climate change and social justice in India and its changing dynamics. How India deals with one of the most pressing crises of our time is captured in this collection of essays and case studies, which showcase the country's many challenges and innovative solutions. A story in these parts depicts the social dimension of environmental sustainability, bringing India's attempts to balance development with climate justice to the fore.

India's large population, accompanied by its socio-economic structure, puts it at a critical crossroads. It must face the complex challenge of maintaining economic development while adapting to climate change's impacts. The consequences of climate change are observed throughout the country, from the melting glaciers of the Himalayas posing a danger to water security to an increase of floods and droughts and water insecurity in other parts. These difficulties are worsened by socio-economic divides that often neglect vulnerable groups, such as marginal farmers, Indigenous people, women, and the urban poor, who have little power to influence social changes. Understanding these aspects is crucial for formulating policies aiming for environmental preservation while promoting equity and justice.

The primary concept marking this compilation is climate justice – the realisation is that the people who are the least responsible for the climate crisis are most likely to suffer its pernicious effects. This is why India has to implement equity-based strategies that help alleviate suffering for marginalised groups as the country progresses toward its climate commitments. Indigenous knowledge systems and community-driven traditional practices are some of the Indian aspects that give life to this paradigm, and they stem from India's invaluable mosaic of ecological wisdom. Including these frameworks

and scientific knowledge enhances the capacity for resilience and sustainable development by providing a more comprehensive approach to fiscal and non-fiscal policies.

In the chapters, the readers will find a thorough description of India's national and sub-national policies in greater detail. India's climate policy framework, the impact of government initiatives such as the NAPCC (National Action Plan on Climate Change), and the policy's funding and operational constraints outline the challenges that emerge when attempting to operationalise these lofty ambitions. For example, the discourse around how regional and municipal bodies must be empowered to own climate initiatives speaks to the broader need for devolution and local-level governance. When grounded in local realities, decision-making becomes more practical, which increases the likelihood of enduring solutions.

The chapters focusing on the community perspectives document the experiences of farmers dealing with erratic monsoons, women managing hydraulic resources with changing rainfall, and even displaced, marginalised groups – all of which amplify the anthropogenic dimension of climate vulnerability. These stories go beyond the narratives of struggle and become accounts of local ingenuity and resilience. There is a focus on reclaiming and giving prominence to Indigenous and community knowledge systems, which proves to be a significant finding that explains why there is, indeed, innovation within communities when they are given a chance to be heard.

Indigenous innovation is a key feature of the Indian climate innovation ecosystem. The book presents how India's conservation approach to the environment is changing, ranging from developing renewable energy initiatives like the International Solar Alliance to adopting community-centred, environmentally conscious agricultural techniques. Modern science offers useful tools that can be adapted to local realities, as seen in smart agriculture, watershed restoration, and urban flood management, proving that sustainable development is a rich blend of inclusiveness and practicality. Far from being piecemeal programmes, these initiatives represent a growing paradigm shift towards comprehensive sustainable development.

India's climate policy is influenced by international cooperation. India's position within international frameworks such as the Paris Agreement and the International Solar Alliance enables it to further its climate objectives through global collaborations. The chapters on global diplomacy and India's participation in these forums underline that climate change is an interdependent challenge that binds all countries together. Also, balancing international obligations with national realities and community aspirations emerging as important lessons serves as a reminder that while global ambitions exist, they should not be aspirational to the extent of being out of reach.

The book also explores the one under-researched aspect of advocacy and activism – that is, social transformation activism, as we name it, which usually

emerges from the ground. Women's and youth movements and civil society groups highlight the effectiveness of social action toward climate injustice. From women managing natural resources to advocating for climate-resilient livelihoods and exercising decision-making roles, these emphasise the value of gender and social equity. They advocate that climate-resilient development is not only a technological undertaking but also anchored on robust social change.

At every step, one point stands out: Climate action and justice are the same. Dealing with one dimension without the other sacrifices social equity, which is detrimental to sustainable development. In one way or another, be it via policy changes, community engagement, creative initiatives, international relations, or even diplomacy, India's case illustrates a global reality: Sustainable development must be grounded on social equity and inclusiveness.

This collection has a broader appeal: It is meant for policymakers, people working in climate action, students, community leaders, and anyone interested in India's climate issues. We expect it will help trigger the right debate, stimulate innovation, and drive action. There is no question that climate change is one of the most difficult challenges we face in our century, albeit it does provide a reason to rethink how we relate to nature.

Anjal Prakash  
Marcella D'Souza

# **PREFACE: MICROSTUDIES IN HUMAN DEVELOPMENT**

It is indeed a fulfilment of a dream to publish six volumes of micro-studies on human development. These cover diverse sectors like education, health, nutrition, climate action, institutional challenges, and livelihood and skills. A part of the on-going Innovations, Practice, and the Future of Public Policy in India series, these six volumes capture experiential learning in these sectors and subject them to rigorous academic scrutiny. 192 authors who have contributed 102 Chapters to these volumes are academics, civil society professionals, activists, policy makers and practitioners. The thrust has been on capturing the processes of transformation. It has been a unique journey of partnership across sectors among the finest in their respective spheres, coming together to provide a micro insight on their work.

All the Volume Editors have worked tirelessly to capture the diversity of experiential learning and subjecting these to academic scrutiny. The six volumes represent an effort to capture human development as it is lived and practiced, and it was achieved through a series of workshops and dialogues, multiple online sessions, cross sectoral inputs for multi disciplinarity, and a commitment to combine experiential knowledge and academic rigour. The reflection and analysis presented across the chapters provide important lessons for the future. These Volumes have been visualized as a necessary reading for students of public policy. There has been a dearth of micro studies in public policy in India, and these six volumes have started to fill that major vacuum. These have also been designed in a manner to provide comprehensibility to policy makers, programme implementors, civil society initiatives, and a range of interested citizens wishing to contribute to the transformation of lives and livelihoods of the deprived.

The thrust on human development is a timely one as India's journey to a high-income status hinges on better performance in sectors like education, health, skills, livelihoods, nutrition, as well as in ensuring inclusive development. It is important to understand the institutional constraints to human development to be able to address them meaningfully. These volumes are a record of the journey of committed professionals from diverse backgrounds creating knowledge from practical experience. We hope this knowledge contributed to the creation of a framework for innovations and reform across these sectors, based on the rich evidence included in these volumes.

As you read the chapters in this volume in your hand, please remember that the chapters included here are part of a larger tapestry woven across five other volumes. By virtue of reading this preface, we believe you will agree with us that human development is multi-dimensional and our success in achieving it is critically dependent on our ability to connect the dots across these dimensions. The threads that link health to nutrition and education to livelihoods are not hidden. The value of the six volumes lies in making them visible at once, to enable better informed debates and hopefully more nuanced public policy.

We sincerely hope that you find the volume useful, and the chapters that follow inspire you to pick up one or more of the other five volumes produced in parallel.

Amarjeet Sinha  
Ashwini Chhatre  
August 2025

#### **Available titles in this cluster:**

*Changing Tides: Climate Action and Justice in India* (Edited by Anjal Prakash, Marcella D'Souza)

*Healthcare for All: Community Action and Public Systems for an Inclusive India* (Edited by K. Srinath Reddy, Girija Vaidyanathan, Amarjeet Sinha)

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*Reimagining Institutions: Collaborative Pathways to Social Development in India* (Edited by Pushpinder Puniha, Aarushi Jain)

# ACKNOWLEDGEMENTS

We are pleased to present this volume, a comprehensive exploration of India's climate change and social justice landscape, a project that has been both an academic endeavour and a collective journey. The creation of this book embarked with a shared vision to delve into the intricate ways climate change intersects with social equity in India, capturing stories of resilience, policy challenges, Indigenous innovations, and grassroots activism. This volume aims to serve as a reference point for policymakers, practitioners, students, and anyone interested in understanding the multidimensional facets of climate justice within India's unique socio-economic and ecological contexts.

The process of bringing this book to fruition has been both challenging and rewarding. It involved extensive research, multiple phases of collaboration, and rigorous review processes. The initial phases included drafting proposals and inviting contributions from diverse authors, each bringing their expertise and local perspectives. These submissions underwent a thorough peer-review process, ensuring the chapters' accuracy, relevance, and depth. To facilitate this, we organised a peer-review authors' workshop, which proved instrumental in refining the content, fostering dialogue among authors, and elevating the quality of the volume.

Throughout the process, the coordination efforts were substantial. We worked diligently to manage timelines, provide feedback, and ensure that each chapter maintains coherence with the overarching themes of climate justice, policy, community resilience, and Indigenous innovations. This collaborative effort was made possible through the incredible dedication of a support team and a network of experts committed to advancing knowledge on this critical issue.

In addition to the scholarly contributions, considerable effort was invested in editing, fact-checking, and overall publication management. We would like to thank Doris Canter Visscher, the copy editor for this volume, who was involved in multiple review cycles and used careful language and style editing to make the chapters more pronounced.

Behind this entire effort stands a dedicated team that worked diligently to support the publication's technical and logistical aspects. We extend our heartfelt thanks to all the individuals whose tireless work helped shape this volume into its final form. We would like to specifically acknowledge the invaluable contributions of Dr Pallavi and Ms Prerna Yadav. Dr Pallavi played an instrumental role in the initial stages, coordinating with authors, organising the authors' workshop, and overseeing the manuscript submissions and review processes. Her efforts ensured a smooth flow of work and kept us on schedule. Ms Prerna Yadav seamlessly took over, managing the review responses, coordinating revisions, and steering the book through production. Her meticulous management and dedication kept the project moving steadily towards completion. Their combined efforts exemplify effective teamwork and leadership at every stage of this complex process.

Ms Nimisha Jain coordinated with the publisher to meet deadlines and maintain quality standards. While much of this work was behind the scenes, it was vital to successfully deliver the final volume. Many thanks to her for coordinating this volume.

Further, we are grateful to the research assistants and coordinators from the Bharti Institute of Public Policy at ISB, whose support in research and logistics was crucial. The support staff who provided logistical and documentation assistance were indispensable, ensuring that operations ran smoothly from manuscript preparation to publication.

We also thank the anonymous peer reviewers appointed by Routledge who generously dedicated their time and expertise to evaluating the chapters. Their feedback was fundamental in refining the content, strengthening arguments, and enhancing clarity. The peer-review authors' workshop, which brought together all contributing authors, served as a platform for lively discussion and constructive critique, ultimately elevating the quality of the volume. This collaborative process reflects the spirit of participatory scholarship and shared inquiry that underpins this work.

We are deeply grateful to everyone who contributed – authors, reviewers, editors, support staff, and peers. Your collective effort, patience, and commitment have made this project possible. This volume embodies not just individual insights but also a collective mission to foster a deeper understanding of climate justice in India and to inspire actionable pathways forward.

A word of thanks to Shoma Choudhury, commissioning manager at Routledge India, for her continued support. Thanks to Shloka Chauhan, the editorial assistant at Routledge India, for all the painstaking work and follow-ups.

In closing, we hope that this book will act as a catalyst for meaningful dialogue, innovative solutions, and policy reforms. The challenges posed by climate change are formidable, yet the resilience, ingenuity, and inclusive approaches documented within these pages provide grounds for optimism and action.

# 1

## CHANGING TIDES

### Climate action and justice in India's landscape

*Anjal Prakash and Marcella D'Souza*

#### **Embracing climate justice: ensuring equity in India's climate action**

The *climate justice* framework believes that all countries should accept and address historical injustice (Porter et al., 2020; Sultana, 2022). This is especially so when such a form of injustice has subjected the poor and vulnerable of the world to being more susceptible to climate change (Winsemius et al., 2018; Kaspersen et al., 2022). It also furthers the understanding that those most impacted by global warming, in terms of being displaced, food insecurity, and vulnerability to suffering extreme climate, are the people who are the least responsible for causing climate change through greenhouse gas emissions (Robinson & Shine, 2018; Khan et al., 2020).

In India, climate justice becomes important due to the variation in the economic and social status of people in various parts of the country (Sharmila, 2023; Acharya, 2024). Many rural farmers are suffering the impacts of climate change even when their climate footprints have been limited in scale. This perspective calls for adequate participation, fair and just sharing of resources, and capacity-building measures of the affected communities in the relevant decision-making processes (Chakraborty & Sherpa, 2021). With this perspective, India aims to bring about climate justice in the context of development, which is to say that there will be no climate exclusion that will place disadvantaged groups in this country at the periphery of developmental goals (Alves & Mariano, 2018). Such an approach will reduce the reasons for marginalisation, shape the multiple dynamics of coping mechanisms and transformation with climate change, and more crucially, improve fairness about climate change activities and results (Shukla, 2019).

## 2 Changing Tides

In this context, *Changing Tides* comprehensively explores climate action and justice within India's dynamic sociopolitical context. Through a multidisciplinary lens, this book delves into four thematic dimensions. Firstly, it scrutinises India's climate change policy, analysing its efficacy, identifying gaps, and proposing mid-course adjustments for effective public policy. Secondly, it highlights the imperative for sub-national frameworks to ensure inclusive climate action. It focuses on community perspectives and vulnerabilities, particularly regarding crop residue burning, gender mainstreaming in water resource management, and gendered vulnerabilities in regions like the Sundarbans. Thirdly, it showcases innovative sustainable practices such as the 'Lakhpati Kisan' approach, NABARD's initiatives, which offer insights into improving economic security and building climate resilience. Lastly, it emphasises international collaboration and advocacy, elucidating the interplay between global negotiations, India's policy, and local community engagement. *Changing Tides* serves as a roadmap for stakeholders, policymakers, and researchers navigating the complexities of climate action and justice in India.

### Climate change policy in India

Climate change presents a formidable challenge to humanity, impacting communities worldwide with its multifaceted consequences (Toromade et al., 2024). Among the most vulnerable are rural communities, whose livelihoods and well-being are intricately linked to the environment (Roy et al., 2022). Despite efforts to address climate change, critical aspects remain that do not work effectively, necessitating a re-evaluation of approaches and interventions that can inform climate change policies in India (Khatibi et al., 2024; Jha & Gupta, 2021; Dhanapal et al., 2023).

One of these aspects is also financing climate resilience in the country. Given India's vulnerability to climate change, massive financial resources are needed for building climate-resilient infrastructure and communities (Kumari et al., 2024). Without access to adequate financial resources, developmental priorities would overshadow climate action, further marginalising communities and aggravating climate change impact (Prasad & Sud, 2019). However, there are numerous challenges to financing climate resilience in India, especially at the state and local levels. Some of these are inadequate fund allocations, issues with accessing and utilising these funds due to limited stakeholders' awareness and capacity, high transaction costs, inadequate data on climate risks and adaptation requirements, insufficient local capacity, and fragmented governance structures (Anjanappa & Samant, 2024; Kumari et al., 2024). It is pertinent to note that India's federal structure adds to these challenges due to the inadequate and mismatched policy frameworks amongst different levels of government and across its different departments,

resulting in policy incoherence, coordination challenges, and delays in fund processing, as evident in the implementation of NAFCC (Anjanappa & Samant, 2024; Gupta et al., 2022). NAFCC is a central government scheme that provides a discretionary federal grant to support state governments in implementing adaptation projects as per the NAPCC and SAPCCs (Anjanappa & Samant, 2024; Kumari et al., 2024).

Some of the possible avenues for addressing these challenges are through different financial instruments (such as target lending, green bonds, weather-indexed insurance, tax credits, national climate fund), mobilisation of additional financial resources through both public and private finance, building awareness and capacity, improving coordination between the national and state governments, and as well as policy coherence between different departments (Dhanapal et al., 2023; Gupta et al., 2022). Given the locally contextualised phenomenon of climate vulnerability and adaptation, the role of state and local governments is central to the success of any adaptation interventions. The chapters in this section of the book captures the country's multifaceted approach to address the pressing challenges of climate change at the national and state level.

In the chapter by Rajani Ranjan Rashmi, titled 'Climate Change Policy in India: Hits and Misses, Lessons for Mid-Course Changes in Public Policy', the author outlines India's proactive stance in combatting climate change through an ambitious climate strategy. With a focus on expanding clean energy soon, India aims to transition towards a net-zero economy in the long run. This policy initiative has not only generated potential for sustainable domestic growth but also garnered international recognition. However, India faces challenges stemming from the historical responsibility principle's oversight in international climate dialogue, the imposition of aggressive trade measures, and a lack of adequate climate financing, which can hinder progress for developing nations. Despite notable achievements in renewable energy, there are significant hurdles regarding systemic energy transition, particularly concerning finance and technology. For long-term sustainability, the transition towards low emissions must prioritise inclusivity and justice. The chapter emphasises the urgent need for increased climate finance to bolster India's adaptation efforts amidst widespread vulnerability and inadequate resilience.

The need for enhanced local governance in climate action is further explored in 'The Need for Sub-National Frameworks for Inclusive Climate Action in India', by Vani Prasad and co-authors. This chapter argues that while climate action at the state level is often relegated to the implementation of mandates from the central government, it is crucial to recognise and empower sub-national actors as key contributors in climate policy formulation. As the epicentre of climate change impacts, states possess legislative authority over vital natural resources, thus warranting a shift from merely executing central directives to assuming a more significant role in the climate

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agenda. The authors advocate for developing policy and governance structures that encourage sub-national autonomy, ensuring that state-level objectives such as the net-zero commitments made in response to national pledges are consistent with the principles of federalism. This would facilitate a cohesive approach to achieving climate goals across different levels of governance in India.

Additionally, the chapter by M. Manjula and R. Rengalakshmi, 'Climate Change Impacts, Vulnerability, and Adaptation for Food and Livelihood Security: A Case Study of Maharashtra', emphasises the critical intersection of climate change, vulnerability, and adaptation in the agricultural sector, situated in the state of Maharashtra. This chapter highlights the significance of agricultural performance in safeguarding food and livelihood security for India's growing population. The authors employ the Livelihood Vulnerability Index (LVI) from the IPCC framework to assess vulnerabilities at macro- (national) and meso- (state and district) levels, revealing that household vulnerabilities arise from broader socio-economic contexts. The study uncovers varying degrees of vulnerability across the state by classifying and ranking Maharashtra's districts according to their exposure, sensitivity, and adaptive capacity. For instance, it notes that Wardha exhibits the highest exposure index, while Gadchiroli shows the lowest adaptive capacity. The findings outline a spectrum of vulnerability, identifying highly vulnerable districts such as Washim and Nanded alongside less-vulnerable regions like Sangli and Kolhapur. This chapter provides evidence for tailored adaptation strategies to enhance resilience and minimise the risks associated with livelihood vulnerabilities unique to each region.

The contributions to the theme of climate change policy in India collectively underscore the complexities and challenges the nation faces in its quest for effective climate action. They accentuate the necessity for a multi-tiered approach involving local, state, and national governance frameworks while advocating for enhanced financial support and inclusive adaptation strategies. As India navigates its climate commitments, these chapters illuminate critical pathways and lessons learned, facilitating ongoing discourse and policymaking in the context of global climate action.

#### **Community perspectives and vulnerabilities**

Understanding community perspectives and vulnerabilities in India provides insight into the intersection of the impacts of climate change and climate justice (Sam et al., 2020). Climate vulnerabilities are experienced differently by various groups, including the Indigenous people, farmers, urban poor, and women, depending on their socio-economic status (Prakash, 2024). These differential experiences could be owed to their means of livelihood and geographical locations (Pandey et al., 2021). For instance, climate change

poses severe risks to rural farmers, particularly due to erratic monsoons and increasing temperatures (Yadav, 2022), which could sabotage agricultural activities and threaten food security (Dagdeviren et al., 2021). Farmers from the Himalayan states of India experience vulnerability very differently from those in the coastal states (Dimri et al., 2021; Prakash et al., 2022). Urban poor communities living in informal settlements are also vulnerable to problems such as heat waves and floods, among others, due to a lack of basic infrastructure (Kaur & Pandey, 2021).

The importance of Indigenous knowledge in adaptation and mitigation strategies to climate change is undisputed. The literature documents how the inclusion of Indigenous knowledge and community-led initiatives in the development and implementation of extensive mitigation and adaptation strategies could be helpful in reducing vulnerability to climate change (Aich et al., 2022; Dorji et al., 2024; Vijaykumar, 2019; Nyong et al., 2007). However, there are challenges to this inclusion due to reasons such as adaptation and mitigation strategies being mostly anchored in Western scientific knowledge (Makondo & Thomas, 2018), the social limits to participation contingent on ethics, knowledge, attitudes to risk, and culture (Adger et al., 2009). As evident from the chapters in this theme, there are possible ways to integrate the unique and scientific Indigenous knowledge systems into the knowledge systems that form the scientific repository for the formulation and implementation of different adaption and mitigation strategies (Makondo & Thomas, 2018; Sukula, 2006).

Adding the community aspect into climate policy is critical to developing effective strategies. There are adaptive solutions based on local vulnerability focused on local knowledge and local practice (Singh et al., 2022). Similarly, ensuring that communities participate in decision-making enables the creation of policies relevant to people experiencing the worst effects of climate change (Singh, 2020). With inclusion of community experiences, India can address climate issues more effectively and fairly.

The theme of *community perspectives and vulnerabilities* encapsulates several critical insights into the multifaceted challenges communities face in the context of climate change. The chapters demonstrate the interplay of socio-economic factors, gender dynamics, and traditional knowledge in shaping community responses to climate-related risks.

Shiladitya Dey and co-authors, in their chapter, 'Uncovering the Silent Factors Responsible for Crop Residue Burning: Evidence from Peninsular India', tackle the environmental issue of crop residue burning, particularly in the agrarian state of Andhra Pradesh. While extensive research has documented its adverse effects, less attention has been given to understanding the underlying factors driving this practice among farmers. The authors identify several determinants influencing the decision to burn crop residues through a comprehensive survey involving 200 farming households and a probit model

analysis. Their findings show that education levels, family size, livestock ownership, and environmental awareness negatively correlate with crop-burning decisions. Conversely, the prevalence of residue burning increases with higher off-farm incomes, larger landholdings, and greater residue management costs. To mitigate this issue, the authors advocate for adopting livestock farming, utilising advanced agricultural technologies, fostering awareness among farmers, and promoting alternative uses for crop residues.

In the chapter 'The Challenges in Mainstreaming Gender in Water Resource Management in Changing Climate in India', Eshwer Kale and co-authors examine the persistent barriers to women's participation in water management, exacerbated by climate change. The study reveals that gender biases rooted in patriarchal norms hinder women's involvement in decision-making processes despite their active roles in implementation. Through qualitative interviews with 100 individuals engaged in water management, the authors underscore the necessity of systemic changes to promote equitable participation. Affirmative interventions, although beneficial, fall short without addressing structural inequalities tied to class, caste, and gender dynamics. The chapter provides case studies of successful engagement by women in water management, calling for a comprehensive understanding of social relations and gender budgeting strategies that challenge existing norms.

The chapter 'Gendered Vulnerabilities in the Sundarbans, India: Unraveling the Complex Tapestry of Climate Impact on Communities', by Jayati Chourey, explores how climate change disproportionately affects vulnerable populations, particularly women in the Sundarbans. The ongoing research identifies the myriad vulnerabilities faced by communities least responsible for environmental degradation, highlighting narratives from frontline individuals, such as adolescent girls and women in fisheries. The chapter emphasises the concept of climate 'injustice', where those with minimal contributions to the cause bear the brunt of its (climate change) consequences. It calls for equitable solutions that address these intricacies and advocates for an integrated approach encompassing mitigation, adaptation, and community resilience.

Ranjan K. Panda discusses the issue of climate-induced displacement in his chapter, 'Ensuring Justice for Climate-Displaced People'. He highlights the normalisation of climate displacement in society and governance, arguing that welfare schemes should not replace the need for comprehensive policies protecting displaced communities' rights. With the number of internally displaced people rising due to climate events, the chapter estimates that up to 143 million individuals could face displacement by 2050. It examines the vulnerabilities of communities along the Bay of Bengal coast and critiques existing policies while emphasising the importance of climate finance and the effective integration of the Loss and Damage Fund to support local initiatives.

In their chapter, ‘Inclusion of Traditional Knowledge on Adaptation and Resilience in Higher Education as an Enabler of Research on Climate Justice’, Suparana Katyaini and co-authors assert the need to integrate traditional knowledge into higher education systems to address climate justice effectively. The authors bridge the gap in climate justice understanding in the Global South by documenting experiential learning and local knowledge systems. The study presents insights from participatory research that enrich academic discourse and support community resilience. Their findings encourage the recognition of traditional practices, particularly among tribal communities, emphasising the importance of experiential learning in shaping sustainable development initiatives.

Finally, the chapter ‘Women-Led Climate Action – Lessons from MGN-REGS and DAYNRLM’ by Amarjeet Sinha and Ashok Pankaj explores the impact of women-led initiatives under India’s flagship programmes for sustainable livelihoods. The authors analyse the intersections of the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) and the Deendayal Antyodaya Yojana National Rural Livelihood Mission (DAYNRLM), showcasing how these programmes promote climate-resilient actions through women’s collectives. Case studies of natural farming and organic agriculture initiatives illustrate women’s significant role in fostering community-centric climate action. The chapter also offers policy recommendations to strengthen women-led strategies that enhance livelihoods and resilience against climate change.

In sum, the contributions to the community perspectives and vulnerabilities theme reveal the complex dynamics influencing communities in the face of climate change. They highlight the urgent need for tailored approaches that address the specific vulnerabilities of diverse populations, promote gender equity, and recognise traditional ecological knowledge.

### **Innovations in sustainable practices**

The discussion on tackling the climate crisis and preserving the environment, in general, has to centre on advancing innovative solutions (Shahzad et al., 2021). However, different regions in India have started looking for new approaches to achieving sustainability. For instance, the implementation of windmills and solar technology is gaining popularity, thus increasing the supply of clean energy and reducing the reliance on fossil fuels (Kumar & Majid, 2024). The drought-prone regions focus on watershed development to preserve water and capture rainfall to store underground and use when needed (Srivastava & Chinnasamy, 2024).

Moreover, industrial bio-fertilisers and smart farming practices are revolutionising agriculture, producing more with less environmentally destructive processes (Angom et al., 2021). This means that farm-based systems or

community-based systems, and population-based approaches to food provision, conservation of biodiversity, and assured availability of appropriate food, rely on smarter management methods and techniques that require less input (Bisht, 2021; Dey et al., 2024).

From an upcycling to zero waste methodology of waste management, new strategies are emerging that encourage the community towards better material reduction, reuse, and recycling (Priyadarshini & Abhilash, 2020). Likewise, green building and green construction practices aid in constructing low-impact, energy-efficient buildings (Sharma, 2020). All these transformations are necessary for India to tackle climate challenges, along with fostering and facilitating social equity and growth while anticipating a sustainable era.

The theme of *innovations in sustainable practices* addresses vital strategies and approaches aimed at enhancing sustainability and resilience among communities in India, particularly within the rural and urban contexts. The contributions highlight diverse methodologies, stakeholder engagement, and the integration of local knowledge, with an overarching goal of fostering socio-economic and environmental sustainability.

Ganesh Neelam and Sujit Kumar Gopinathan introduce the ‘Lakhpati Kisan approach’ in their chapter, ‘Enabling Economic Security and Climate Resilience Principles through the Lakhpati Kisan Approach’. This initiative emerged from the need to address small and marginal farmers’ vulnerabilities in rural and tribal communities, particularly in light of climate change challenges. The Lakhpati Kisan programme focuses on empowering women and enhancing their aspirations, striving for a balance between economic security and climate resilience. The authors emphasise the use of systems thinking to illustrate the connections between livelihood practices and climate factors, guiding community members in recognising the interplay between their economic activities and environmental health. Through dynamic engagement, the programme promotes sustainable practices, such as improved water management and soil health, ensuring community members can manage their resources effectively while fostering long-term sustainability.

The chapter by C. S. R. Murthy and co-authors, ‘Programmes to Address Climate Justice: NABARD’s Experiences and Way Forward’, explores the significant challenges faced by rainfed areas in India, including erratic rainfall and land degradation. By implementing a participatory watershed development model, NABARD has facilitated community-led initiatives that enhance agricultural productivity and resource management. The watershed approach integrates community participation and focuses on the needs of local farmers, particularly women, to effectively address climate vulnerabilities. The authors highlight NABARD’s successes in improving livelihoods and promoting ecological restoration, affirming community engagement’s importance in climate adaptation and sustainable development.

The chapter by Bhavana Rao Kuchimanchi, ‘Creating Pathways for Focused Climate Action for a Resilient Future’, investigates agricultural transitions in Telangana’s dryland regions. By employing a comprehensive research methodology that combines qualitative and quantitative data, the study reveals that increased agricultural intensification often exacerbates environmental degradation and marginalisation of local households. The research highlights the need for resilient farming practices that conserve natural resources while supporting local economies. The findings advocate for collaborative efforts between scientists, policymakers, and communities to develop integrated resource management strategies that are both environmentally and economically sustainable in the face of climate change.

In the chapter ‘Combating Urban Floods in Changing Climate’, Padmini Ponukumati and co-authors emphasise the increasing risk of urban flooding in a warming climate, particularly in developing nations. The study critiques existing stormwater management systems (SWMS) and the use of intensity-duration-frequency (IDF) curves, revealing the inadequacies in current practices. By analysing rainfall patterns from 2014 to 2023 in Hyderabad, the authors provide insights into rainfall variability and its implications for urban flood management. The study concludes with recommendations for implementing low-impact development (LID) practices, underscoring the need for adaptive and sustainable solutions to mitigate the impacts of flooding in urban areas.

Together, these contributions reflect a critical understanding of the dynamic interplay between socio-economic practices and environmental challenges across various contexts in India. The chapters present a pathway toward a more resilient and sustainable future by focusing on community-driven initiatives, integrating traditional knowledge, and developing innovative solutions. The emphasis on stakeholder engagement and participatory approaches highlights the role of local communities in driving sustainable practices that improve livelihoods and enhance ecological resilience in the face of climate change.

### **International collaboration and advocacy**

International strategies and advocacy efforts must be activated to address climate change and sustainable development (Thomas et al., 2020). Numerous efforts have been made in recent times to collaborate on an international scale and bring consensus among countries (Bernardo et al., 2021; Bacchetta, 2023). Climate change can be addressed through the collaboration of states, governments, and civil society through knowledge, resource transfer, and technology transfer (Wei et al., 2021). In India’s context, international cooperation is pertinent in augmenting the response to climate change without sacrificing developmental aspects.

India also targets several such goals concerning its acceptance of other international treaties, such as the Paris Agreement, which targets the mitigation of greenhouse gas concentrations in the atmosphere while also targeting the enhancement of the state of the environment (Mor et al., 2024). Other initiatives of this kind, such as the International Solar Alliance, are aimed at providing solar energy, developing clean technology, and supporting poorer nations through such initiatives (Jha, 2021). Moreover, such participations as North–South coalitions and COP meetings engage countries in stating their problems and action strategies assessing climate change and actions (Ahmed, 2023). They increase interplay at the international level and help marginalised countries, which are crucial for fair and effective climate measures to be implemented worldwide.

The *international collaboration and advocacy* theme highlights the intricate relationships between global climate negotiations, national policies, and grassroots community actions. The contributions underscore the need for cohesive strategies that integrate international frameworks, local realities, and the overarching pursuit of social equity in addressing climate change.

The chapter by Jayanta Basu, ‘Climate Action: Linking International Negotiation, Indian Policy, and Local Community’, critically overviews the United Nations Framework Convention on Climate Change (UNFCCC) and its role in facilitating international cooperation to stabilise greenhouse gas concentrations. Basu cites the growing body of scientific evidence indicating an urgent need for increased climate action to avert catastrophic outcomes. While some agreements have been reached recently, concerns persist regarding inadequate financial support from developed nations and the overwhelming focus on market-driven mitigation efforts. With India’s being a significant player from the Global South, the country’s ongoing reliance on coal and its challenges in enacting comprehensive domestic climate policies, particularly in vulnerable regions like the Sundarbans, highlight the gaps in climate action where it is most needed. Basu calls for a more integrated approach that ties international commitments to concrete actions at the community level.

In the chapter ‘Equity, Climate Resilience, Sustainable Development: Bundling for Social Well-Being’, authors Purnamita Dasgupta, Girika Sharma, and Anjal Prakash argue for a unified approach to simultaneously advance development goals, climate resilience, and social equity in low- and middle-income countries (LMICs). They contend that siloed decision-making undermines equity, as policies targeting climate or development independently may yield disparate impacts across different populations. The authors advocate for integrative approaches that engage various stakeholders at all levels of decision-making to achieve holistic outcomes. Their empirical analysis employs six equity-oriented variables across three domains – policy, risk management, and resilience capacity – to explore the correlation between social equity, climate action, and sustainable development. The findings

underscore the interconnectedness of vulnerability and equity, suggesting that fostering equity considerations within climate action frameworks can yield more effective and just outcomes.

Together, these contributions illuminate the complexities of climate governance at multiple levels, emphasising the importance of effectively integrating international frameworks with local actions to address urgent climate challenges. The call for enhanced collaboration among diverse actors, stakeholders, and communities is essential for achieving climate goals and securing social equity and long-term sustainability. Ultimately, these insights advocate for a synchronised response that recognises the interdependence of climate resilience and social well-being, guiding future initiatives in advocacy and collaboration.

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## **PART 1**

# Climate change policy in India



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# 2

## CLIMATE CHANGE POLICY IN INDIA

### Hits and misses, lessons for mid-course changes in public policy

*Rajani Ranjan Rashmi*

#### 2.1 Global climate change

##### 2.1.1 *Global response to climate change*

Global climate change has emerged in this century as one of the most critical and urgent challenges facing mankind. There is consensus in the international scientific and political community that humanity will face disastrous consequences if actions are not taken in time to reverse the current trends of climate change. A few decades ago, there were doubts in some quarters, including scientists, on the origin and nature of climate change. These doubts often led to the notion of human-induced climate change being dismissed as a hoax (Pasquini et al., 2023). However, over the years, the evidence of global warming has mounted, and intensive scientific research and sustained political dialogue have led to an almost universal consensus on the anthropogenic character of climate change. There is recognition of the fact that global warming is unequivocal. Also, it is attributable in large measure to the rising concentration of globally warming greenhouse gases (GHG); these, in turn, can be traced to human activities involving fossil fuel burning and similar activities involving the consumption of natural resources.

Consensus on the anthropogenic nature of climate change took time to evolve because of disagreement among countries on the assessment of the threat of climate change and the best strategy to address it. Some countries viewed this threat as one emanating from current and rising emissions in the modern, globalised world and called for an immediate transition from fossil fuel-based energy to low-carbon or clean energy-based systems. Others pointed to the cumulative nature of emissions taking place over centuries and

emphasised the necessity of reduction of past concentrations in time as well as the importance of strengthening adaptative capacity and building climate-resilient systems.

An international climate policy emerging from this global consensus is reflected in the United Nations Framework Convention on Climate Change (UNFCCC), agreed at the Rio Conference in 1992. A more recent version of this international consensus is found in the Paris Agreement on climate change, enacted in 2015 within the overarching framework of the Convention. The Agreement has replaced the Kyoto Protocol and is the regime in force from 2021 onward. The Convention and the Agreement envisage that member states should cooperate with one another to take action on multiple fronts, such as mitigation, adaptation, technology, finance, and capacity building, as well as to stabilise the climate within an early time frame.

### 2.1.2 *Climate change and India*

Climate change affects India with greater intensity than it does many other countries of that size. This is mainly because of a high climatic variability over the country, the diversity of its geographical features and climatic regions, and insufficient adaptive capacity.

India is very vulnerable to climate change and is exposed to huge risks – social, economic, and environmental (India’s National Communication – NATCOM). In 2021, it was ranked 7th amongst the top 10 countries most affected by climate change globally (Eckstein et al., 2021). Almost all key social and economic sectors experience an increasing variation and intensity of climate change. This applies to agriculture, industry, transport, and forests and involves biodiversity, urban infrastructure, and natural ecosystems (Krishnan et al., 2020). The rising incidence of aggravating climate change has adverse effects on human health, habitats, and water supply, particularly for people in coastal, mountainous, and arid areas.

This may cause GDP losses over time and a slowdown of economic growth as resources have to be diverted to address climate-induced disasters and adverse impacts. India needs a well-designed climate policy to take appropriate measures and deploy resources for sustainable economic growth, including energy transition, enhancing adaptative capacity, reducing vulnerabilities, and building climate resilience.

### 2.1.3 *Early climate plan of India*

India’s initial vision to address climate change is expressed in the National Action Plan on Climate Change (NAPCC), which was launched in 2008. The NAPCC identified a few critical areas that needed focused intervention through eight specific *missions*. Three of these (solar, enhanced energy

efficiency, a green India) concentrated on mitigation, while the rest dealt with building capacity and strengthening adaptation responses (sustainable agriculture, sustainable habitat, water, sustaining the Himalayan ecosystem, strategic knowledge) (NAPCC, 2008). One more mission (Health) was added subsequently to enlarge the scope of the Action Plan (MoEFCC, 2023b).

The NAPCC had been framed in the context of ongoing international negotiations on the future of the Kyoto Protocol. It was intended to provide India's response to the mounting pressure on developing economies to enhance climate actions in a binding and obligatory framework. The Plan deflected the pressure and indicated the extent to which India was willing to contribute to the global efforts in a non-binding manner.

The NAPCC essentially reorganised ongoing development programmes, such as those for energy efficiency, renewable energy, rural development, afforestation, building norms, and water use efficiency, that had the potential to enhance mitigation and adaptation-related activities. The intent was to demonstrate that India had already been investing hugely out of its own resources to combat climate change; further actions could be taken if international support was available. The Plan was strictly domestic in character, avoided any target-bound activity,<sup>1</sup> and was dependent on the availability of additional resources. India took care to indicate that the Plan adhered to the principles of the Convention but was not to be construed as an international obligation.

#### **2.1.4 Outline of India's climate policy**

In recent years, India has come up with a more structured climate policy with specific climate goals. It was outlined in a set of so-called nationally determined contributions (NDCs) submitted to the UNFCCC Secretariat under the Paris Agreement in 2016 (UNFCCC, 2016). The 1st NDC was updated in 2022 (UNFCCC, 2022b). The NDCs comprise climate actions envisaged in a time frame up to 2030. They contain specific targets for the reduction of overall GHG emissions in the economy relative to economic growth, the expansion of a renewable and clean energy share in the energy system, and the augmentation of the natural carbon stock in forests. Besides, there are goals relating to adaptation, finance, lifestyle, and capacity building. These are qualitative in character, and quantifiable targets have not been laid down.

The policy has evolved to include a long-term goal of achieving a net-zero emissions economy by 2070. It is complemented by a long-term low-emission development strategy released in 2022. The policy in the medium term has made remarkable progress in the field of renewable energy and created space for green growth in the future. Yet several issues relating to energy transition

and climate resilience need to be addressed to make it sustainable in the long term.

This chapter attempts to describe India's evolving response to climate change at the national and international levels, as well as the hits and misses of the policy in addressing current and future challenges. First, it provides the international context in which India has committed to and undertaken climate action. Second, it presents the mitigation and adaptation components of the policy. The third and final part covers issues of climate finance relevant to mitigation, adaptation, and net-zero transition.

## 2.2 International climate regime

### 2.2.1 *Framework convention*

The United Nations Framework Convention on Climate Change (UNFCCC), adopted in 1992, obliges parties to take cooperative action to stabilise climate, with the caveat that such actions should not compromise sustainable development. Article 2 of the Convention states that the

level of stabilisation should prevent dangerous anthropogenic interference with the climate system; be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change; and be done in a way that would enable economic development to proceed in a sustainable manner.

The Convention mandated that countries take action strictly on the basis of the principles of equity and common but differentiated responsibility and respective capability. Developed countries were expected to demonstrate that they 'are taking the lead in modifying long-term trends in anthropogenic emissions' (UNFCCC, 1992). Developing countries were expected to act on a voluntary basis if additional support in terms of finance and technology was available from developed countries. This formulation of equity was the foundation for the Convention and the Kyoto Protocol, which laid down specific emission-reduction obligations for the 38 main industrialised countries.

### 2.2.2 *Equity principle and India's approach to equity*

*Equity* in climate actions generally refers to efforts that are proportional to the problem. Although the Convention did not specifically define 'equity', the ideas of per capita emission and historical emissions used in the preambular paras of the Convention (UNFCCC, 1992) are usually taken as an interpretative measure of equity. India, along with the G77 and China, argued strongly for the operationalisation of this principle in global plans to mitigate, adapt, and finance actions to address climate change.

India's concern while participating in international plans for stabilising climate change was that the principle of equity and common but differentiated responsibility should not be diluted. However, it was challenged when negotiations began at the end of the first commitment period (Rajamani, 2009) of the Kyoto Protocol and the question of its extension into the second commitment period came up. The G8 countries (G8 Secretariat, 2007) began to argue that collective actions could not succeed unless all major economies agreed to contribute in a binding manner. Equitable effort sharing, that is, the sharing of efforts in terms of climate actions by developed and developing countries on an equitable basis, was demanded on the grounds that climate change was a classic, common problem that could not be addressed effectively without a common effort (IPCC, 2013). Ethics, morality, and universal treaty commitments were cited as the other grounds for effort sharing. Under the Barrack Obama presidency, the United States started a process of regular meeting of major economies (MEM) to convince China and other countries to agree to a binding commitment.

Interestingly, India's prime minister said at the G8 meeting held in Heiligendamm in 2008 that 'even while India pursues its economic and social development goals, it will not permit its per capita GHG emissions to exceed, at any point of time, the average per capita emissions of developed countries' (Embassy of India, 2008). The NAPCC reiterated that 'India is determined that its per capita greenhouse gas emissions will at no point exceed that of developed countries even as we pursue our development objectives' (NAPCC 2008). This implied that India was willing to make efforts commensurate with capability if there was an agreement on the principle of convergence of per capita emissions and equal per capita entitlements of GHGs to all. India's call was consistent with the principle of equal per capita emissions emphasised by developing countries (Mattoo & Subramanian, 2010) and the expectation that developing countries consider quantitative restrictions on their emissions provided the per capita emissions of developed and developing countries converged as their incomes converged (Frankel, 2007). The offer was never seriously discussed; instead, international negotiations proceeded to craft a new climate regime based on universal commitments, which led to the Paris Agreement.

### ***2.2.3 The Paris Agreement and India's engagement***

The Paris Agreement lays down a regime of universal and binding climate actions to be taken by all countries from 2021 onward. It mandates all countries to commit themselves to specific goals and targets through declared nationally determined contributions (NDCs) and achieve them in a specific time frame. India declared its climate goals in pursuance of this mandate. These include national goals for emissions intensity reduction, renewable

energy expansion, carbon sequestration in forests, aspirational goals for adaptation, mobilisation of finance, lifestyle changes, etc.

The significance of the Agreement regime lies in establishing an arrangement for transparency, which obliges countries to report their actions and outcomes to the UNFCCC Secretariat for review and critical assessment. This arrangement leads to the process of global stocktake. This is to take place every five years to assess the progress made in achieving the global goal of stabilising climate change.

A critical addition made to the global climate regime by the Paris Agreement is commitment to the global goal of limiting temperature rise to 1.5°C above pre-industrial levels. This, in a way, quantifies the goal of climate stabilisation that had been left undefined in the original formulation under Article 2 of the Convention. Mid-century net-zero goals announced by various economies at the commencement of the Paris Agreement in 2021 took the goal further and converted it into an aspirational emissions reduction goal for the entire global community. The IPCC stressed in its 1.5°C special report that, to achieve 1.5°C stabilisation in an early time frame, the international community must achieve net zero by mid-century and reduce global emissions by at least 45% in 2030 compared with 2010 levels (IPCC, 2018a).

### 2.2.3.1 Hits and misses

The regime of climate commitments and actions established under the Paris Agreement has several positive features for India (UNFCCC, 2018). Yet there are many issues of critical importance on which progress is not satisfactory. The hits and misses from India's point of view in the new set of obligations established under the Paris Agreement and their future implications are analysed as follows:

*The principle of equity and differentiation has been preserved.* The principle of equity and differentiated responsibility, as recognised in the Convention, has been preserved in the Paris Agreement. However, the universal nature of commitments under the Agreement has often led to an assertion that it has diluted the principle of equity and obliterated the differentiation between developed and developing countries. The Paris Agreement has dissolved the distinction of countries into Annex I and non-Annex I and made it mandatory for all to contribute to the global goal. Significantly, it avoids the top-down model of target setting as under the Kyoto Protocol and gives freedom to countries to set their own targets. In this way, it recognises the diversity of actions implicit in the principle of common but differentiated responsibility recognised under the Agreement. It allows sufficient freedom for countries like India to set national goals and take actions to

reflect equity and the common but differentiated responsibilities in light of national circumstances.

*India's commitments and actions are substantial.* India's climate goal includes a target of economy-wide emissions reduction relative to the country's gross domestic product (GDP). A conscious policy of reducing fossil fuel-based energy production and consumption through efficiency and other measures is implicit in this goal. Notably, the country had already achieved a reduction in the emissions intensity of the GDP by 24% between 2005 and 2016, which was against the committed target of 45% by 2030. This indicates a sustainable path of growth and a decoupling of economic growth from emissions growth (Government of India, 2022). India is among the few G20 member countries whose NDCs were found 2°C compatible in 2019 (Climate Action Tracker, 2019). The evidence of India's movement toward sustainability at a pace faster than that of others has raised India's profile and brought international acclaim.

*The historical responsibility principle has been downplayed.* It remains an open question whether the Paris Agreement reflects the best deal for protecting and stabilising the global climate. Since the process of target setting in relation to the global goal has been made subject to national flexibility, the emphasis on historical emissions as the benchmark for targets has weakened; instead, current emissions have become the reference point.

*The targets declared under the Paris Agreement are highly inadequate.* According to a UNFCCC assessment, global emissions will increase by 10.6% by 2030 compared to 2010 levels (UNFCCC, 2022c) despite the pledges made by all countries in their NDCs. This contrasts sharply with the IPCC recommendation of a targeted reduction of 45% compared to 2010 levels by 2030 to meet the 1.5°C goal (IPCC, 2018). The deficit in efforts is largely attributable to inadequate measures taken by developed economies in relation to their responsibility.

*There is unfair pressure on India to raise its ambition further.* India's climate efforts are fairly ambitious in light of its national circumstances and the scarcity of resources to meet the Sustainable Development Goals, yet the expectation from India continues to be high in view of its status as the third largest-emitting country in the world in terms of current emissions. India's per capita GHG emission (including land use) in 2017 was 2 t compared with the average of 7.21 t of G20 countries in 2021 (Climate Transparency, 2021).

India's contribution to the total net global emissions in 1994 was 3% approximately, that is, 1.2 Gt (MoEFCC, 2023a), out of a global volume of 40 Gt (IPCC, 2022, p. 7). The latest data for 2019 show India's position

at 4.4%, that is, 2.6 GT (MoEFCC, 2023a) out of a global volume of 59 Gt (IPCC, 2022). In terms of cumulative emissions also, India contributes only 3.2%, that is, 55 Gt out of 1,600 Gt from 1850 to 2019 (MoEFCC, 2023a). These data show that India's efforts are already exceeding its share of global responsibility. Further efforts need an international framework for measuring efforts or performance. The performance or achievement needs to be linked to mechanisms for financing transition in developing countries that achieve more than their fair share.

*The global carbon space for development is declining.* The 1.5°C stabilisation goal adopted under the Paris Agreement places an absolute carbon limit on the future growth of developing countries. The balance available carbon budget for achieving net zero (from 2020 to net zero) is only approximately 400 Gt (at a 67% probability of staying below 1.5°C), as the rest is occupied by historical emissions. The space will run out in 7–12 years at the current annual rate of gross net global emissions at approximately 40 Gt (IPCC, 2021).

This will seriously affect the right to development enshrined in the Rio principles, as the right is dependent on an equitable or fair share of global carbon space (Sengupta, 2019; Jayaraman, 2015). Equitable share of India alone in the remaining space is 71–441 Gt (2020 to net zero) if historical responsibility is excluded (India's LTLEDS, 2022, p. 18; UNFCCC, 2022a). The BASIC group of countries,<sup>2</sup> of which India was the leading member had anticipated this and argued that equitable access to sustainable development is the core principle for climate actions (BASIC, 2010). The debate on carbon entitlements has remained inconclusive since the Paris Agreement has avoided the issue of historical responsibility and allocation of carbon space.

*Carbon border adjustment measures violate the NDCs.* The regime of nationally determined contributions (NDCs) under the Paris Agreement is disrupted by unilateral measures announced by the European Union (EU) to levy carbon border adjustment measures (CBAM) on its trading partners. The proposed levies are targeted against imports of products from countries that do not have mandatory carbon emissions reduction laws (carbon taxes or cap-and-trade in emissions rights) or have carbon intensity standards different from those in the EU. There is a likelihood of protectionist lobbies in other countries making demands for similar non-tariff trade barriers. Such unilateral trade measures are violative of the agreed international framework of Article 3.5 of the Convention, which prohibits unilateral and restrictive measures on trade taken in the name of climate change (UNFCCC, 1992).

The CBAM upsets the fine balance of reciprocal obligations under the Paris Agreement and adversely affects both the willingness of developing countries and the readiness of their industry to take voluntary and positive

measures toward sustainability. India faces the challenge of protecting its multilateral approach in international cooperation while preparing its industry to move gradually to low-carbon transition through regulatory, fiscal, and financial measures.

*New and stronger mechanisms for meeting financial obligations are needed.*

Global cooperation continues to be hampered by the failure of developed countries to provide additional resources to developing countries as envisaged under the Convention. This is among the principal causes of less effort by developing countries to meet the 1.5°C goal. The global capital needed for the world to achieve the net-zero emissions goal by 2050 is estimated to be around USD 5.8–5.9 trillion a year by 2020 (UNFCCC, 2022d). Current flows from all sources, including debt flows at market rates, amount to less than USD 100 billion a year. Developing countries have argued for a provision of at least USD 1.3 trillion a year in climate finance between 2025 and 2030 (UNFCCC, 2021) to help them raise their efforts for mitigation, adaptation, and loss and damage.

India's challenge is to remain engaged with this conversation and ensure that the identified sources of contributions and mechanisms do not restrict financial flows to India or cast an additional burden on the country. India could also suggest setting up a committed financing facility to incentivise energy transition in hard-to-abate industries, such as steel, aluminium, or cement. The facility could function on the lines of the Montreal Protocol Fund (for ozone-depleting substances) to support the additional cost per unit of carbon in each of these industries.

## 2.3 India's climate policy

### 2.3.1 Nationally determined contributions

India's present climate policy is articulated in the NDCs presented in pursuance of the Paris Agreement. NDCs propose actions in a 10-year time frame up to 2030 and lay down binding and monitorable climate goals in eight specific areas, three of which are quantifiable. The latter refers to an emissions reduction relative to the growth in GDP, expansion of renewable energy capacity, and creation of an additional carbon sequestration potential. Other goals, inter alia, relate to the promotion of adaptation by enhancing investments in development programmes in vulnerable sectors; adopting a cleaner path of economic development; promoting a sustainable lifestyle including conservation; and mobilising new and additional finance from all sources.

All climate goals are equally important and binding in nature, but measuring the progress of the quantified goals relating to energy management is easier than those where actions relate to adaptation and sustainable development involving communities and human systems.

### 2.3.2 *Net-zero goal*

At the Glasgow Climate Conference in 2021, India declared that it would have a net-zero economy by 2070. The declaration came along with the announcement of *Panchamrit* – a set of five key goals, including an update of three existing international commitments and an addition of two new domestic goals. India raised the international commitment (expressed in the NDCs) of the emissions intensity goal to 45% and the clean electricity generation capacity goal to 50%.

To these were added domestic goals of renewable electricity capacity addition in absolute terms of 500 GW, and GHG emissions reduction, by 1 billion Mt by 2030. The absolute numbers are however not part of the updated NDCs. The ‘Panchamrit’ also updated an existing NDC goal of sustainable living based on moderation and conservation to a so-called LIFE – lifestyle for environment, a movement for sustainable living. The implication of the net-zero goal is that India can no longer take fossil fuels for granted in the long term to meet its energy requirements. The net-zero goal also has implications for the NDCs because the level of effort will need to be raised consecutively in the next rounds to demonstrate a higher level of transition.

The long-term transition depends on the deployment of clean fuels and technologies at scale and, consequently, involves a specific trajectory of low-carbon growth for all economic sectors. To this end, the government has put out a long-term low-emission development strategy (LT-LEDS). This strategy focuses on low-carbon transition in seven key sectors, namely, electricity, transport, urbanisation, industry, forests and ecosystems, and CO<sub>2</sub> removal. The seventh sector of action is resource mobilisation to finance the transition. The strategy is still in its infancy because detailed roadmaps for sectoral transition are yet to be drawn up. Agriculture, which has a predominance of small and marginal farmers (MoEFCC, 2023b), is excluded from the strategy at the present stage.

### 2.3.3 *Mitigation goals*

India’s key policy goal relating to emissions control aims at an economy-wide emissions intensity reduction of the GDP at a 45% reduction compared to the 2005 level by 2030. The goal does not place a restriction on the growth of energy or production-related emissions; it implies that India’s energy emissions will grow in the medium term to meet the needs of development but will be used much more efficiently. It will result in reduction of emissions per unit of output till such time as alternative fuels and technologies are available.

The second goal aims at scaling up the clean electricity share in the total installed electricity generation capacity to 50% by 2030. The third goal is in terms of carbon sequestration and envisages an addition of 2.5 to 3 Gt of additional carbon stock in forests by 2030. The goals announced in the

NDCs are affirmation of India's intention to go beyond energy efficiency and invest in cleaner energy systems to facilitate energy transition and gradually bend the country's emissions profile. Energy emissions constitute almost 75% of the country's total emissions (MoEFCC, 2021). They are a natural target for a policy change in the emissions profile in the medium term.

### 2.3.3.1 Hits and misses

India's climate commitments have resulted in some obvious hits in the short term, such as improvements in energy efficiency measures and diversification of energy sources. However, there are also challenges or misses of the policy that are embedded in the country's larger energy system. To outline some of them:

*The emissions intensity of the GDP in India is declining at a fast rate.* The country's emissions relative to the GDP have been declining continuously at a rate faster than the global average. By 2016 (the latest year for which data were available), India's emissions intensity of the GDP had fallen by 24%, against the targeted 45% by 2030. In the advanced policy scenario arising from the updated NDCs and the net-zero goal, the actual progress in relation to emissions control may outstrip the targeted reduction.

*Energy efficiency improvements have led to energy savings at scale.* India started several regulatory standards and labelling programmes for energy efficiency early on. These have since become part of the Mission approach under the NAPCC. They have incredibly advanced energy efficiency in industry and energy consumption in buildings for residential and commercial use and are mainly behind the emissions intensity reduction trend in the country.

India runs a unique programme of Perform, Achieve, and Trade (PAT) under its energy efficiency regulations for over 1,100 major units across 13 sectors. These have created a system of energy management and auditing, which has now helped in the evolution of the carbon market in India.

*India has added renewable energy capacity at a remarkable pace.* Prior to the NDC announcements, renewable energy sources like solar energy were an incremental element in the energy basket. The NDCs have transformed this scenario, making renewable energy the mainstay and future goal of the energy policy. In 2021, the clean electricity generation capacity in India had already reached a level of 41.5% of the total electricity capacity (MoEFCC, 2021). The renewable energy capacity increased by 2.5 times in the last decade, showing a jump from 73 to 178 GW (MNRE, 2023). The annual addition in solar capacity alone is 5 times more than in 2015 (IEA, 2021). The change has helped in the diversification of energy sources and the growth of a renewable energy ecosystem consisting of wind, solar, biofuels, and

biogas and sustained a movement toward a cleaner and greener energy system.

*India is an early user of market instruments and regulations for climate benefits.* India is among the few countries in the world that have a wide array of market instruments targeting sustainable energy use without compromising on energy security or placing an absolute limit on energy consumption. The primary objective of many of the market instruments in the past, such as high taxes on fuels, cess on production and consumption of coal, and the PAT scheme under the Bureau of Energy Efficiency, has been to incentivise industry for an efficient use of energy with co-benefits for climate. In recent times, many new instruments have been designed with direct benefits for climate, such as renewable electricity purchase obligations of distribution companies (DISCOMs), biofuel blending norms, renewable energy consumption obligations, a voluntary programme for green credits, and now the initiation of a carbon credit trading scheme based on emissions intensity standards for major units. While there are issues with each of the instruments, mainly because of uncertainties in demand and supply and structural inflexibility in a grid-based energy system, the larger impact has been salutary.

*Renewable energy suffers from grid integration and systemic issues.* While the profile of renewable energy has grown in recent years and the debate has moved beyond the goal of energy efficiency, structural inadequacies of the energy system are coming to light. The growth of variable energy like solar and wind energy has been sustained primarily by the falling cost of solar panels and production at scale. With renewable energy generation suffering from lower efficiency and less variability, the baseload requirements of a grid must be met from other uninterrupted sources of supply, which are cheaper if sourced from coal or hydel and costlier if additional storage systems are used. The renewable energy industry brings to its wake the issues of the management of huge electronic waste and the pressure on land use. The climate policy will need to address these issues early for a faster and more effective energy transition.

*Investments in renewable energy capacity are not commensurate with the goal.* Capital investments in renewable energy capacity are currently taking place at a rate of about USD 20 billion per annum, which is way behind the curve of commitments. These need to be at least doubled to meet the targeted capacity of 500 GW by 2030. Investments needed for renewable energy to sustain the Green Hydrogen Mission are additional. This may not need regulatory or fiscal intervention, but systemic and infrastructure support in terms of transmission and integration costs are critical. For investments to pick up, the energy policy must also go beyond capacity creation and look at energy pricing at production and distribution levels, where both political and social purchases are needed.

*Long-term transition needs certainty about the trajectory and peaking of emissions.* In the context of the net-zero scenario, a question that needs to be settled is the dateline by which India can reasonably peak its emissions. In the absence of a clear technology path, a peaking date is likely to be indeterminate. China announced its emissions peak year of 2035 more than 5 years ago because it has nearly reached the peak of its coal emissions and energy demand.

*Energy efficiency in medium, small, and micro enterprises (MSMEs) has not received due attention.* MSMEs, which account for over 30% of India's industrial production, consume nearly 25% of India's energy, 85% of which is used in thermal form (TERI, 2022) involving low-efficiency fuels. Thus, MSMEs offer a significant potential for improvement in energy efficiency and emissions reduction even without decarbonisation. The PAT scheme implemented by the Bureau of Energy Efficiency (BEE) excludes them from the mandate of the scheme because of the informal and unorganised nature of their operations and the low level of technology. Simplified and ready access to low-cost finance is critical to motivate MSMEs to adopt better technology and improve energy intensity of production. An imaginatively designed programme for energy audits in MSMEs coupled with technical capacity and access to finance can lead to large emissions reductions at minimal cost.

*Low-emission development needs sectoral roadmaps for decarbonisation.* Sectoral roadmaps for decarbonisation are needed early to provide certainty to future investments and market demand. The power sector has the potential of reaching carbon neutrality without further fiscal or regulatory concessions. But, carbon neutrality in this sector will need solutions to meet rising energy demand in the medium term and baseload demand from clean energy sources in the long term. With the system cost of solar energy coupled with battery storage becoming competitive with that of coal-produced power by 2030 or 2035, it may be technically possible to look at a sectoral transition here if higher investments in clean energy sources like nuclear storage systems are made.

*Decarbonising the hard-to-abate sector needs CO<sub>2</sub> removal and technological innovations.* About 30% of India's emissions come from use of fuels like coal and processes in heat-dependent industry sectors such as steel, cement, aluminium, metallurgy, petrochemicals, etc. An additional 15% comes from the combustion of liquid fuel in surface transport, shipping and aviation, and biomass for cooking. Currently, no low-carbon or clean energy sources except natural gas or nuclear energy can replace coal or oil in such industries on a commercial scale.

Modelling studies of emissions in India suggest there will be residual emissions to the extent of 30% of total emissions even in 2050 if only renewable energy is deployed for energy transition (TERI, 2021). The

LT-LEDS of the government of India admits that for achieving net-zero carbon goal, removal technologies will need to be deployed (UNFCCC, 2022a). Alternatively, technological innovations in the use of hydrogen, nuclear energy, and energy storage need to be made in time for the transition to proceed. Announcements have been made in the form of the hydrogen mission and the small modular nuclear reactors (SMNR). These must be advanced in a time-bound manner and made available in a technically feasible and economically viable manner. Similarly, the promotion of clean cooking with the help of natural gas as a transitional fuel may be a fair social investment, with co-benefits for climate and health, even if it has to be subsidised.

*The role of coal in the transition needs to be spelt out.* Currently, coal meets almost 65% of India's energy requirement. Its share in the overall electricity capacity has generally remained stable since 2016. However, its share needs to rise to meet the rising energy demand since the penetration of renewable energy in demand is only 19%, although the capacity is about 41.5%. With the energy demand by 2050 likely to be four times the current level, clean energy capacity (after taking energy efficiency measures into account) will need to be scaled up to no less than 1200 GW, or even more, to replace coal. The peaking of coal in the energy system and its phase-down will depend both on the rising demand and the level of cost-effective investments in the alternatives. It was for this reason that India insisted on replacing the word 'coal phase-out' with 'coal phase-down' and fought against restrictions on energy options of developing countries when the net-zero goal was being negotiated at the Glasgow climate conference in 2021.

*Green hydrogen needs fiscal and regulatory support.* Among the possible solutions for decarbonisation in the industrial and transport sector is green hydrogen, which is likely to be available at economical cost only by the late 2040s. Advancement of this technology and its associated infrastructure in terms of production, storage, distribution, etc. at a massive scale are cost-intensive. Hydrogen-based technologies in steel and other relevant sectors are held under intellectual property rights (IPR) by global majors. Government of India has come up with a green steel taxonomy; this will need to be harmonised with the standards of green steel with its trading partners. India could also ask for the creation of an international investment platform, including governments and corporations, for coordinated production and demand for green hydrogen-based steel.

*Energy transition must be inclusive and just for all stakeholders.* Investment in the process of energy transition is justified because it has climate benefits. However, the process is unlikely to benefit all social groups and regions equally and may, in fact, impose unaffordable social costs in the medium term. The regions and social groups dependent on the fossil fuel industry for employment, income, and growth must be provided with alternative livelihoods and sources of growth. The coal phase-down needs

to be preceded by a well-thought-out and massive programme for a just transition focusing on the creation of economic opportunities, reskilling, and fiscal and financial compensation to states and communities.

### **2.3.4 Adaptation goal**

The NDCs have a specific adaptation goal that aims at addressing the vulnerability of social and economic groups and enhancing their adaptive capacity. This goal is to be achieved through investments in development programmes in vulnerable areas, particularly agriculture, water resources, the Himalayan region, coastal regions, health, and disaster management (UNFCCC, 2022c). Other adaptation-related actions envisaged in the NDCs are raising the finance for adaptation and building capacity and institutional systems for resilience.

The approach outlined in the NDCs is similar to the one followed in the NAPCC. It targets specific sectors to raise their adaptive capacity through enhanced or intensified development programmes. The objective of adaptation actions is to create an institutional system for understanding risks and vulnerabilities, and strengthening of economic and infrastructure development. Individual resilience could be improved through enhanced livelihoods and incomes, new governance capacities, raising resources in the form of adaptation finance, addressing losses and damage, and ensuring equitable and inclusive strategies (UNFCCC, 2022c).

It is notable that the initial NAPCC proposed adaptation activities in agriculture, water, habitat, and the Himalayan ecosystem, whereas the NDCs expanded the ambit of actions to include disaster management, coastal regions, and health. As a result, a new mission on health was added to the NAPCC recently. Coastal management is already covered under a specific programme funded by the central government. On the other hand, disaster management activities are funded under the devolution of the Finance Commission and have a dedicated institutional arrangement, both at the central and state levels.

The adaptation goals are implemented through the central missions as well as state action plans on climate change (SAPCCs). The central government had advised state governments in 2010 to frame such plans keeping in view local climate risks and vulnerabilities. The first version of such plans was mostly patterned after the central missions and was ready by 2013, yet the biggest handicap of the plans was the lack of institutional ability to identify the risks, as well as the non-availability of earmarked or additional resources to implement them.

After the announcement of the NDCs in 2015, states were advised to reframe the SAPCCS in light of the new national goals. An Adaptation Fund was created in 2016 to support the states in carrying out important

adaptation projects but was wound up in 2022. The level of support was not very high but was cross-sectoral in nature. To date, the impact has been minimal.

#### 2.3.4.1 Hits and misses

Some lessons learnt from the implementation of the adaptation policy in India are discussed in the following:

*Adaptation is integral to development.* India's adaptation policy emphasises the role of development as the best form of adaptation, especially for reducing vulnerability (MoEFCC, 2023b). The policy disagrees with the idea of a climate-resilient development that regards climate actions as unidimensional and adaptation as co-benefit of mitigation (MoEFCC, 2023c, p. 270). Addressing adverse impacts is a full-fledged independent dimension of climate change and forms the core of the adaptation policy.

India noted that the adaptation challenge for the country, as for most developing countries, was one that had arisen out of a climate crisis in the making of which it had little or no contribution (MoEFCC, 2023c, p. 270).

While development is the most important instrument of adaptation, it is important to note that the goal of adaptation is defeated if development is not sustainable. For example, the destruction of biodiversity for monoculture plantations, or the destruction of fragile mountains for constructing human settlements, violates the principle of sustainable development and climate adaptation. A convergence of development goals with adaptation goals is best achieved through a comprehensive approach to sustainable development.

*Addressing adverse impacts of climate change needs a larger profile in development policy.* Climate change has significantly intensified uncertainties in the natural system of India and caused large and unanticipated increase in the vulnerability of communities in different regions of the country. Since the middle of the twentieth century, India has witnessed a rise in average temperature; a decrease in monsoon precipitation; a rise in extreme temperature and rainfall events, droughts, and sea levels; and an increase in the intensity of severe cyclones, alongside other changes in the monsoon system. (MoES, 2020, p. 14)

However, the sectoral development policies make no specific financial provision for meeting the additional costs imposed by the physical risks of climate change. Such costs can be minimised if physical risks and vulnerabilities are assessed scientifically and the sectoral development policies mainstream the action plans.

*Mitigation of adverse impacts requires urgent reduction in vulnerability of key sectors.* While there are specific missions in the National Action Plan

on Climate Change for protecting agriculture, water, habitat, and mountain ecosystem from the impacts of climate change, a targeted approach to assess and reduce vulnerability is absent. ‘The first step towards adaptation to future climate change is reducing vulnerability and exposure to present climate variability’ (IPCC, 2014). The need of reducing vulnerability in key sectors has received added urgency after the recent ruling of the Supreme Court (M. K. Ranjitsinh versus Union of India, SC, 2024) stating that “despite . . . some decisions which recognise climate change as a serious threat, and national policies which seek to combat climate change, it is yet to be articulated that the people have a right against the adverse effects of climate change.”

The vulnerability of sectors such as agriculture, which contributes 14% of the gross domestic products (GDP) and sustains nearly 54% of the workforce, is particularly high. In case climate change deepens, long-term crop yields may fall by as much as 12.5–25% in western ghats and coastal areas (MoEFCC, 2010, pp. 19–20), threatening the livelihood of small and marginal farmers having low coping ability. Non-uniform or unpredictable changes in the mean rainfall are likely to further intensify uncertainties in agriculture, which is the largest consumer of water resources. A comprehensive policy for ensuring the growth of agriculture based on scientific and ecological principles, such as crop rationalisation and diversification, reduced fertiliser use, use of drought-resistant and less water-intensive varieties of crops, etc., should therefore be prioritised to reduce the vulnerability of farmers.

*Adaptation is effective when addressed together with building resilience.*

While addressing individual vulnerability is key to building adaptive capacity, it is equally important to address the resilience of the social infrastructure and establish links with the adaptive capacity of individuals. This will help vulnerable communities and stakeholders determine where and what types of activities – adaptation or resilience – need to be prioritised. A convergent framework for ‘adaption-resilience-development’ will also be useful in attracting funding, particularly from international agencies, and facilitating resource allocation at national, state, and local levels.

*Unsustainable development compromises adaptation.* Current development patterns and practices have led to serious environmental degradation and pollution of air, water, and land. The causes of such degradation lie outside the ambit of the climate policy. For example, the increasing use of chemicals and pesticides in agriculture, overuse of groundwater, contamination of water sources, loss of biodiversity, urban spatial congestion, and so on are not the result of the absence,

or inadequacy, of a policy to address climate change; they result from unchecked exploitation of natural resources in violation of the ecological capacity and from unabated pollution. These degrade the environment and affect the sustainability of growth in the long run. But they also pose dangers to the health and the livelihoods of people dependent on agriculture, industries, forests and biodiversity, and an urban habitat for sustenance.

Only a strong policy of environmental management that rewards state governments and communities for sustainability can redress this problem. A good climate policy aiming to increase adaptive capacity will be rendered ineffective in the absence of such a policy.

*Adaptation and resilience are compromised when environmental governance fails.* While reducing vulnerability and building resilience of human systems are key climate goals, they cannot act as safeguards against the failure of environmental governance. Damages arising from landslides, floods, or cloudbursts may be attributed to climate change but cannot be prevented if environmental laws and regulations relating to pollution, construction, urban settlement, and impact assessment are violated with impunity. Recent large-scale damage to economic assets and loss of human lives witnessed in various parts of the country are not merely climate-related disasters but a consequence of disregard for environmental norms and of failure of governance. The NAPCC had envisaged a mission on sustaining the Himalayan ecosystem to protect the fragile region of the Himalayas from human interference, but the mission remained limited to gathering scientific data and never moved to devising norms and enforcing governance systems. India's vulnerability to climate change is high because its lands, mountains, rivers, and environmental commons are not safe from predatory development.

*Adaptation finance needs to be risk-based and provided at scale.* In most cases, adaptation financing is not based on a prior climate risk assessment; the response is post-event and takes the shape of public expenditure largely devoted to meeting losses and damages. On the other hand, disaster management has earmarked resources from the Finance Commission, institutional support from the central and state governments and has a better track record because of statutory arrangements. Climate adaptation and resilience need to be treated similarly. Risk-based provision of finance for adaptation and resilience should be part of government or public budgeting.

*Institutional capacity for climate risk assessment is lacking.* State governments and corporations lack adequate institutional capacity to identify climate risks and integrate them into their climate action strategy. The RBI has, for example, advised financial institutions to assess the physical and transition

risks of climate and integrate them into their plans. It is important to create capacity at the state level to identify risks based on scientific data and make financial provisions to address them in the ongoing programmes.

*A national adaptation plan (NAP) needs to be in place.* The NDCs have multiple goals but no specific action plan for adaptation. Unlike mitigation activities, adaptation has no clear quantifiable target, except when they are related to the Sustainable Development Goals. A national adaptation plan is needed to clarify the links between the NAPCC, the NDCs, and the Sustainable Development Goals (SDGs) and specify the priorities and interventions for adaptation in our country.

There is an international mandate for India to come up with such a plan with its priorities and implementation mechanisms. The Global Goal on Adaptation adopted in Dubai in 2022 lists the key areas and mandates that countries present a plan by 2027. It should lay down the principles and priorities of adaptation actions, a framework for assessment of vulnerability, and instruments for financing, monitoring, reporting, and evaluation of the actions, etc. This should serve as a template of actions and financing for not only government units but also the corporate sector and funding agencies.

*States and communities need to be supported with ecosystem-based financing.* Ecosystem-based adaptation is often the most sustainable and lasting way to improve adaptive capacity and reward the contribution of communities to environmental conservation and maintenance. Green credits launched by the government can help in this process if they are supported and incorporated into the climate plans of the states. It is also possible to mobilise resources for this purpose if the provisions for corporate and social responsibility are modified to recognise this contribution within a business sustainability and responsibility framework.

*Financing climate-induced loss and damage will emerge as a major issue.* The issue of losses and damage caused by climate change and its international financing is likely to overshadow adaptation finance in the years to come. The significance of this issue has increased after the Dubai Climate Conference (COP 28), where the Loss and Damage Fund was launched to support countries suffering from damages caused by climate-induced disasters (MoEFCC, 2023d).

India has argued that ‘reducing vulnerability and exposure is a challenge across the entire economy and society of developing countries and cannot be restricted to only particular categories of vulnerable nations, or particularly marginalized communities’ (MoEFCC, 2023b, p. 329). It needs to be ensured that guidelines and methodologies for attribution of damages to natural phenomena causing climate change, assessment of loss and damage, and identification and coverage of vulnerable countries are based on country-specific vulnerabilities and impacts corresponding to the scale and nature of hazards.

### 2.3.5 Climate finance

Climate finance has been a highly controversial issue in the global climate discourse, right from the beginning, because of unmet expectations and obligations. The failure of developed countries to meet their commitments and support developing countries in implementing climate actions has been a regular complaint, which has bedevilled the climate negotiations. In this context, commitments made by countries like India under the Paris Agreement present an immediate challenge of finding the required resources to implement the committed actions.

Although India had made its NDCs conditional upon the availability of climate finance from international sources as promised under the Convention, it is clear that it will need to stand behind its commitments irrespective of the sources of finance. The country is currently funding its efforts largely with own resources (MoF, 2020). But the gap in the availability of finance and the requirement is large and growing because of the updated NDCs and adoption of the net-zero goal.

The government of India had estimated in 2020 that ‘around US\$ 4.5 trillion worth of investments are required by India till 2040 to develop (*climate resilient*) infrastructure [. . .] cumulative figure for India’s infrastructure investment gap would be around US\$ 526 billion by 2040’. The gap in financing the NDCs was estimated to be roughly USD 14 billion by 2040 (MoF, 2020).

Other studies suggest that these estimates are on the lower side. The total investment for renewable energy-related transition alone is required to be about USD 20–27 billion per year, or USD 200 billion by 2030, only half of which is currently being mobilised (CEEW, 2022). This excludes the costs of just transition. The long-term low-emission development strategy document of the government of India notes that long-term transition entails huge economic costs but stops short of recommending any specific method of financing. It merely refers to the need to implement international finance obligations and promote private sector involvement through debt, equity, and risk-covering instruments. A comprehensive strategy containing specific policy instruments for fiscal support and financial mobilisation for net-zero transition is clearly needed.

#### 2.3.5.1 Hits and misses

Based on the experience of implementing the NAPCC, SAPCCs, and the NDCs, the hits and misses of India’s approach to climate financing are discussed in the following:

*Policy support has raised investments in energy efficiency and renewable energy.*

The policy and regulatory support available from the government has played

a crucial role in attracting investments from the public and private sectors, particularly in the areas of energy efficiency and renewable energy expansion. For example, the expansion of wind energy two decades ago took place largely because of fiscal concessions in the form of feed-in-tariff arrangements, initial income tax exemption, and capital depreciation norms. Private sector investments in solar capacity in recent years have jumped after policy targets were raised and reverse bidding for private sector participation in investments was introduced by the government. LED bulb prices fell when financial resources were made available for production and assured supply through public procurement at scale. Biofuel blending norms have created market support for biofuel production and supply. Statutory norms introduced under the Perform, Achieve, and Trade scheme of the Bureau of Energy Efficiency have pushed major industrial units to invest in energy efficiency systems, although the level of investment is much lower than desired. Thus, policy initiatives have been instrumental in rise of renewable energy and efficiency in the energy system. But, MSMEs have remained untouched by these policies as neither fiscal nor financial support of this kind is available to them.

*An ecosystem of new instruments for green financing is needed to raise the scale of finance.* The central and state governments are considering the use of policy instruments such as green taxonomy, green budgeting, and mandatory priority lending to create a favourable ecosystem for green finance. Some of these suggestions are already under active consideration by policymakers. India has begun to use green bonds in large measure to raise climate finance, although it is still way behind other markets (TERI, 2024). A tentative list of areas considered green has been indicated in the guidelines for green bonds issued by the central government. Green taxonomy is in the works. The RBI has come out with a climate risk assessment framework for financial institutions with advice to assess the climate risk of their exposure and accordingly make provisions for losses and gains. The Securities and Exchange Board of India is already implementing a framework for Business Responsibility and Sustainability Reporting (BRSR) by the top 1,000 listed companies. Essential parameters of the BRSR could be benchmarked and linked to the NDCs or green taxonomy to enable more transparent reporting. SEBI is also considering fixation of transparent norms of environmental, social, and governance rating of corporate investments.

*Lowering the cost of capital is crucial to scaling up climate finance.* The biggest issue in making private or public investments in climate-related projects is the additional risk or cost that makes the investment unworthy of consideration in a competitive market. G20 and the UNFCCC are currently discussing ways of augmenting concessional finance flows through multiple international channels, such as governments, global coalitions, multilateral development banks (MDBs), MFIs, and bilateral agencies,

to meet the needs of climate finance. High-risk premium raises the cost of international debt capital for financing green projects and makes debt finance unviable. The availability of equity capital is not certain and depends on investors' assessment of economic conditions, profitability, and regulations governing investments. Against this background, mechanisms are urgently needed to bear the risk of financial investments in transition-oriented projects where the perceived risks are higher until a policy or some regulations take care of the additional risk.

*The private sector needs to be involved in climate financing.* The challenge of building a climate-resilient infrastructure and improving adaptive capacity is large and unlikely to be met from government resources alone. States and communities have so far largely relied on funds provided in government budgets and international assistance. The private sector must be encouraged to play its part in adaptation. The evolution of a monitoring and evaluation framework can help entities implement outcome-based adaptation financing of public or private infrastructure – say, roads, bridges, transport and traffic systems, or water and land management.

A risk assessment framework for investments by corporate agencies can be mandated by the Securities and Exchange Board of India so that investments in public or private infrastructure can fulfil climate resilience goals.

*India may be affected adversely by a domestic carbon tax.* The use of an economy-wide carbon tax is frequently recommended to raise finance for low-emission growth. Considering the structural inflexibility in India's energy system and the large presence of MSMEs, an economy-wide tax may be counterproductive. Instead, emissions intensity standards for specific sectors based on their energy demand profile and the level of technology may be more equitable and least-cost methods to enforce compliance. Based on the experience gained from existing market-based instruments, the government has recently launched a domestic carbon market to support the transition of major industrial units from an energy efficiency-based regime to a carbon-based regime of obligations and enable them to comply with improved energy emission standards. This is likely to achieve the same results as a carbon tax with much less disruption and greater inclusivity.

## 2.4 Conclusion

India is implementing an ambitious policy to address global climate change, which is articulated in the NDCs presented under the Paris Agreement of 2015. Its climate plan has progressive targets for mitigation even though the country is among the lowest per capita emitters in the world and has less than 5% share in global emissions. It is also among the most vulnerable

countries suffering from adverse impacts of climate change. Still, India has decided to contribute to the global cause and take actions reflecting the principles of equity and common but differentiated responsibility of nations. The commitments made by India have advanced India's global stature in international polity as a responsible global player.

Despite the country's contributions, the progress made by other nations in fulfilling their obligations is slow. The targets declared by developed countries under the Paris Agreement are highly inadequate compared with their share in world emissions and their historical responsibility. The developed countries expect India to raise its ambition further, although there is no assurance of international support in terms of finance or technology. Developing countries are faced with a declining global carbon space for development because of the historical occupation of this space by developed countries.

On the other hand, the threat of unilateral actions in the form of carbon border adjustment measures such as the ones proposed by the EU against India's exports is increasing. Trade being used as an instrument of climate policy by nations to force compliance with their standards is in complete disregard of the international principles under the Paris Agreement. India's policy is to implement its obligations without compromising national interests.

The government has presented a vision to achieve a net-zero economy by 2070 and raise its renewable energy capacity by a quantum leap by 2030. The NDCs include both mitigation as well as adaptation goals.

India's progress in respect of its climate goals is impressive. The emissions intensity of the GDP in the country is declining, and renewable energy capacity has expanded at a remarkable pace. Several market instruments and regulations for climate benefits have been introduced. However, renewable energy suffers from grid integration and systemic issues. Investments in renewable energy capacity must rise further to help the cause of long-term net-zero transition. Sectoral roadmaps for decarbonisation need to be drawn up early to help low-emission development. Hard-to-abate sectors need special attention. Their decarbonisation will depend on the development of alternative fuels and innovative technologies like hydrogen, energy storage, and small modular nuclear reactors. The role of coal in energy transition and the necessity to make the process just and transition is crucial. These are sensitive issues that need to be handled carefully.

The National Action Plan on Climate Change of India includes adaptation actions in vulnerable areas, particularly agriculture, water resources, the Himalayan region, coastal regions, health, and disaster management. States are implementing state-level action plans on climate change. A few gaps in the policy need to be filled urgently to make the efforts effective. There is need for a comprehensive national adaptation plan that could serve as a template of priority actions and adaptation financing for the government as well as corporations and funding agencies. Steps to create institutional capacity for

climate risk assessment are urgently needed. Adaptation finance needs to be scaled up, and states should be supported in their efforts. Rewarding communities for environmental conservation and maintenance may be a good way of strengthening adaptation efforts. At the same time, financing of climate-induced loss and damage at the global level will need to be watched closely to prevent the closure of options for India.

Raising finance for implementing a policy is always the most important question. India's experience shows that policy support can help raise investments in the desired sectors. There are several successful examples of such policy interventions in the fields of energy efficiency and renewable energy. India is trying to create an ecosystem for green financing that could raise the scale of finance eventually. However, it is crucial to lower the cost of capital through appropriate risk guarantee instruments and ESG rating of investments to help mobilise additional domestic and international climate finance. The private sector also needs to be involved in climate financing, particularly adaptation financing, using a mandatory risk assessment framework for corporate investments. India must also view the use of carbon tax for revenue raising or decarbonisation with circumspection, as similar results can be achieved through other market-based instruments at much less systemic cost.

India's climate policy must look at the goals, both in the medium and in the long term. The solution lies in laying out sectoral pathways for a least-cost transition in various time frames and in creating adequate institutional and financial mechanisms to support transition. In the end, transition must not disrupt growth impulses and be orderly and just for all.

## Notes

- 1 Except in the case of the Green India Mission, where a target of 10 million hectares of additional green cover had been proposed. In subsequent years, the Climate Action Tracker revised India's rating to insufficient because of its change in the goal from 2 to 1.5°C as also the change in its methodology based on a globally least-cost emissions trajectory.
- 2 Brazil, China, India, and South Africa formed a negotiating group within the UN-FCCC in 2008. The group played a crucial role in the Copenhagen Accord and in shaping future negotiations.

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# 3

## THE NEED FOR SUB-NATIONAL FRAMEWORKS FOR INCLUSIVE CLIMATE ACTION IN INDIA

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### 3.1 Introduction

India's commitment to become a net-zero country by 2070 at the Conference of the Parties 26 (COP 26) led multiple states to make similar ambitious pledges. India is an interesting study of 'quasi-federalism' (Bhatia, 2022), which is reflected in its climate governance through a National Action Plan on Climate Change and subsequent state action plans on climate change (Somanathan et al., 2014). But essential questions remain regarding the efficacy and the status quo of this arrangement, especially in light of new socio-technical regimes resulting from such an international commitment (Andrews-Speed, 2015).

The expansion and reform of the role of sub-national actors, from executors (Mishra et al., 2011) to players, rests on multiple factors that have drowned this larger role. Despite the Constitution of India granting legislative authority to states on agriculture, water, land, mines, fisheries, and minerals (Constitution of India, 1950), the electricity sector, which sits at the epicentre of emissions, remains on the Concurrent List. This has produced the argument that climate governance is compensatory in the federalist structure of the country (Pillai & Dubash, 2021). This is compounded by a limited and centralised fiscal devolution to the state (Pillai & Dubash, 2021) for a mitigatory agenda, capacity building for frontline workers (Lütkehermöller et al., 2021), and its feeble presence as an electoral agenda (Guha & Joe, 2019).

This chapter, in its first section, evaluates the landscape of environmental federalism in India and highlights the need to refocus on this from a climate change lens. The second section builds a case for the need for an increased

sub-national autonomy and role in climate governance in the country. The third section proposes frameworks as the necessary tools to build a larger role for sub-national actors in line with the federal spirit of the Indian Constitution. It recommends a larger institutional and fiscal role to states in climate change policymaking in the country as an extension of cooperative federalism. By identifying methods for strengthening these roles, the chapter seeks to mainstream sub-national climate governance for inclusive, bottom-up, and federal climate action.

### 3.2 Methodology

Qualitative research, that is, secondary documents, was used to ascertain the efficacy of existing legal, policy, and regulatory instruments concerning federalism and climate change, through doctrinal legal research (Jain, 1982). A qualitative content analysis of these documents (Bhattacharjee, 2012; Kuckartz, 2019) was carried out, with categories based on the relevance of a document to environmental governance, resource management, and fiscal devolution, among other related aspects of climate change governance. A close and comprehensive reading and analysis of the texts helped identify the intent and proposed effect of these statutory instruments.

### 3.3 Changing landscape of environmental federalism in India

Federalism in India can be traced back to the 1919 Montagu–Chelmsford reforms. They were a set of post-war reforms to appease a part of the (now-growing) demands of self-government among nationalists. They introduced a dyarchy through which central and provincial governments were given selected powers (Ghosh, 2020). Education, public health, public works, and agriculture were among the sectors of governance allocated to the provisional state governments in this distribution of power, while the central government retained control over military, revenue, and foreign policy. These reforms were taken a step further through the Government of India Act of 1935. It had created so-called Central, Provincial, and Concurrent Lists, while residuary powers remained with the governor-general of British India. This set the stage ripe for a ‘quasi-federal’ India (TERI, 2014).

The Constitution of India was heavily based on the 1935 Act, cementing a centralisation seen as largely necessary at a time when unification and consolidation of territories were a priority (Bhat, 2019). This central supremacy was extended to environmental protection as well, despite the fact that the word ‘environment’ was missing as a subject matter in any of the three legislative lists of the Constitution. For example, environment-related matters such as interstate rivers, river valleys, mines and minerals, oilfields, and air traffic were covered under the Union List (Constitution of India, 1950).

Article 254 notes that if the legislature of a state makes a law that is repugnant to any provision of a law made by Parliament, then the latter law would prevail, making the state law repugnant (Constitution of India, 1950). Residuary matters are also retained with the Centre under Article 248, in line with colonial laws (Constitution of India, 1950).

In addition to these powers, the states themselves may bestow additional responsibility on Parliament to formulate a law on any subject matter listed in the State List, according to Article 252 (Constitution of India, 1950). The most important of these powers, particularly with regard to climate change and India's national commitments, is found in Article 253. It permits Parliament to make any law for the entire territory of India for the implementation of any treaty, agreement, or convention or any other decision that is made at an international conference, association, or other body (Constitution of India, 1950).

This centralist tendency stemming from constitutional powers extended to legislation and the regulations based on it. This was also by economic design, since the country was a closed economy till 1991, after which it underwent liberalisation, opening up its markets for the world. The Centre primarily determined the pattern and allocation of resources in large projects, making states 'bit' players (Gupta, 2016).

At the same time, there is a larger overview of a central power allocation: Environmental quasi-federalism was structured through the 42nd Amendment to the Constitution in 1976. This amendment resulted in the transfer of 'forests' and 'protection of wild animals and birds' subjects from the State List to the Concurrent List. This implied that both the state and the Centre now had the power to enact legislation on these subjects, but in case of a conflict, the law of the Centre prevailed over that of the state.

About a decade after the Bhopal Gas tragedy (Broughton, 2005), the Environment Protection Act of 1986 stated that legislation on all matters related to the protection and conservation of the 'environment' is the responsibility of the central government. In the realm of the environment, which is also associated with constitutional aspects, the central government exercises authority over water resources. For example, Article 262 of the Constitution places interstate river water within the jurisdiction of the central government. The Article gives Parliament the right to enact a law for the adjudication of any dispute or complaint with respect to the use, distribution or control of water of any interstate river or river valley (Constitution of India, 1950). Similarly, under the Union List, the central government is also responsible for the regulation and development of interstate rivers and river valleys if declared by Parliament by law to be expedient in the public interest (Constitution of India, 1950).

The nature of India's federalism and its history of Centre and state tussles have always begged the question of how much power each of these entities

must hold in order to be called a true federation. From the debates, it has come down to a characterisation in which India is a ‘quasi-federal’ or a ‘semi-federal’ state (Bhat, 2019).

### **3.3.1 *How can climate change fit into green federalism?***

While in an earlier centralised focus on environmental governance the Centre had been largely in charge of the pockets, the quasi-federal nature of the country has begun a slow adaptation to overcome this centrifugal nature. The Centre has been proactively involved in the development of financial mechanisms that can supplement the state’s capacity for climate action (Dutta & Shahani, 2013; Oxford Policy Management, 2017).

The current federal nature of the country is best described as a ‘dynamic process of co-operation and shared action between the two levels of government with increasing interdependence and centrist trends’ (Bhat, 2019). This had been constantly campaigned for since the 1983 Sarkaria Commission recommended a harmonious relationship between the states and the Centre, creating a cooperative, harmonious relationship between them, and so creating cooperative federalism in the country (Saxena, 2021). This cooperative federalism is particularly pertinent with respect to climate change, because it simply concerns all across the different state borders. Besides, a disintegrated approach to the fight against climate change will only result in fractured outcomes (Bhat, 2019).

Despite the distinction of legislative powers, cooperative federalism has been demonstrated through some environment-associated statutes and their implementation. For example, the Biological Diversity Act 2002 (central legislation) created three institutional authorities – the National Biodiversity Authority, state biodiversity boards, and biodiversity management committees – as part of its mandate to protect biological diversity in the country.

The National Biodiversity Authority is required to grant approvals for the use of genetic resources and their associated knowledge for commercial utilisation by foreign nationals and entities. The state biodiversity board is required to grant similar approvals, but to domestic entities. Nevertheless, the National Biodiversity Authority receives and approves applications for intellectual property rights within this domain; there is no stipulated role of the state boards to have a say in the granting of this approval. But more and more often these days, the National Board is sending applications to the appropriate state board for review and approval before granting access to bioresources (Bhat, 2019).

Another non-mandated, cooperative federal approach in the context of environment was the recent ‘Grand Challenge 1’. This was a tender to procure 5,450 buses to replace outmoded internal combustion engines across the cities of Kolkata, Delhi, Bengaluru, Hyderabad, and Surat. The tender

process was fully consultative and characterised by collaboration, pace, and transparency. Its success was shared between five states, five transport ministers, five state secretaries, and the heads of all the state transport undertakings. This cooperative federalism in terms of climate action resulted in a reduced cost of operating these buses at 4% less than diesel and 30% less than CNG (per kilometre) (The Hindu, 2022).

While there have been additional environment-allied initiatives that hinged on Centre–state cooperation, such as the Jawaharlal Nehru Urban Renewal Mission (JNNURM), the cooperation component was mandated by the design of the initiative, whereas the aforementioned instances of state–Centre coordination demonstrate cooperative federalism in the absence of a mandate.

However, despite this continuing shift and growth of Centre–state cooperation with respect to green governance, a longer road does lie ahead with specific reference to climate change. Before concretising that road, it is essential to understand the need for expansion of the role of states and to design inclusive and meaningful climate action.

### 3.4 Why must states be given a larger role?

The Kuznets curve, in its demonstration of the inverse relationship between economic development and income inequality, postulates that as the economy grows (i.e. income grows), environmental degradation continues to increase. Only after this economic growth (i.e. income levels) reaches a certain level will environmental degradation decline, reversing the trend (Ekins, 1997).

With India having an inverted N-shaped environmental Kuznets curve (Farooq et al., 2024), suggesting the increasing phase of environmental degradation, the time is ripe to empower state actors to participate on this road. This is especially relevant in the context of ongoing environmental degradation, because a dip in environmental quality results in the reduced availability of public goods. And this, in turn, is compounded by the inability of the public to afford mitigation technology. This leads to the implication that environmental policy therein is subject to preferences, resulting in demands coming in from the local level while they continue to be framed at the national level (Chakraborty et al., 2024). However, it is not only this implication that necessarily drives the logic of awarding increased autonomy and power to states for addressing environmental and climate issues.

Taking a cue from the national pledge that India made at COP 26, net-zero pledges across the country from non-state and sub-national actors covered 880 million people and 10 Gt CO<sub>2</sub> of global annual emissions in 2021 (Lütkehermöller et al., 2021). In this context, it must be acknowledged that ambitious climate policies cannot exist in isolation from strong domestic support (IPCC, 2023). More so, sub-national commitments only feed into the larger goals that the country has set.

In line with their legislative jurisdictions enshrined in the Constitution of India, states also tend to be closest to the consequences of climate change (Mishra et al., 2011). Additionally, while examining the State List with subjects such as public health, sanitation, agriculture, and land improvement, it is evident that the intersectional effects and understanding of climate change emerge from the interactions of these sectors. When the all-pervasive effects of climate change are on us for a longer period and tend to affect components of everyday living, such as sanitation, access to food, nutrition, and education, then long-term climate policies remaining blind to such intersectional interactions of climate with standards of living would render them moot.

A school of opposition persists that the allocation of more autonomy to individual states will only propel their 'race to the bottom' (Gupta, 2016). This theory cannot apply in India primarily because of the legislative design of the Environment Protection Act 1986. Under the Environment (Protection) Rules formulated under the Act, states can make their standards for the enforcement of environmental guidelines more stringent than those specified by this central act. On the other hand, they cannot water them down below the standards set (The Environment (Protection) Rules, 1986).

States are also best placed to localise climate action further, by virtue of the fact that local government and village administration (Gram Panchayat) also fall within the domain of the State List. Gram Panchayats carry out land improvement, land reform implementation, land consolidation, minor forest production, social forestry, farm forestry, and soil conservation in compliance with the 73rd Amendment of the Constitution. The development of watersheds, water management, and minor irrigation are all vital elements in helping local units of the state become more climate-resilient (NITI Aayog, 2020).

With agriculture being the backbone of rural India and the most affected sector by climate change, it is only right that these bodies, through collective action, are at the helm of climate proofing the agriculture sector (Rajsekhar et al., 2012).

In line with the country's democratic values that seek to enshrine participatory components within its governance, citizen preferences are also better understood and received at the local level (Cattino & Reckien, 2021). It is an additional benefit of local-level citizen participation, where it is easier to link the performance of local services to that of local political representatives. This will result in improved accountability (Bhat, 2019).

### **3.4.1 State action plans on climate change**

As an extension of the National Action Plan on Climate Change (NAPCC), state action plans on climate change (SAPCCs) are considered the first sub-national exercise on climate change planning (Kumar, 2018a, 2018b),

following a 2009 directive from the then prime minister. These SAPCCs essentially serve as a framework of action in response to the effects of climate change in their respective states (Oxford Policy Management, 2017). They propose sectoral strategies and actions pertinent to climate proofing.

Post the initial formulation of the first round of SAPCCs, the Ministry of Environment, Forests, and Climate Change (MoEFCC) published new guidelines requiring a revision of these state plans because socio-economic understanding of climate change has evolved since the first action plan. By this time, many dedicated climate change cells or centres had also been institutionalised across the country in states and union territories (UTs). They had already been seeking to incorporate these enhanced capacities into the refining of existing regional action plans (MoEFCC, 2015). The Ministry published a broad list of guidelines for the structure of the SAPCC, its contents, priorities, the process of creation of the draft, the implementation mechanisms, etc. They also advised that SAPCCs be aligned with the nationally determined contributions, as well as the Sustainable Development Goals.

Despite the pioneering initiative of the creation of SAPCCs for states across the country, their formulation and implementation continue to be fraught with difficulties. In the initial stages of formulation, there continued to be a limited buy-in and ownership by state governments (Oxford Policy Management, 2017). This was prior to the institutionalisation of climate change cells and centres across the country.

This had made clear that states, despite continued support from the Centre, face problems of limited inbuilt capacity, the absence of a blueprint to conduct vulnerability assessments and climate projections, and the non-prioritisation of climate change for line departments (Kumar, 2018a, 2018b). They also grapple with constraints around alignment with annual development plans and budgets (Oxford Policy Management, 2017).

A study by TERI across states that were formulating their SAPCCs also brought to the fore that the problems of conceptualisation and (non-)prioritisation of climate change activities, in addition to other developmental challenges (Pahuja et al., 2020), prevent the plan and its contents from taking centre stage, especially when attempting to mainstream climate change into everyday state governance.

Further, the same study noted that the strategies and activities designed under the SAPCCs were to be implemented via existing state programmes without any budgetary or extra-budgetary allocations (Pahuja et al., 2020). Some states were successful in sourcing additional funds from the Adaptation Fund or the Green Climate Fund, but all states do not possess the same level of technical ability to draft technical proposals, a prerequisite for accessing such funds.

The guidelines of the Ministry also recommend stakeholder engagement to maximise perspectives and increase the robustness of the analysis. A CSE

study found, though, that in the absence of guidelines for stakeholder consultations, their intensity and form largely vary across states, without an adequate say for civil society and vulnerable communities (Kumar, 2018a, 2018b).

### 3.5 How can state capacities be better utilised?

#### 3.5.1 *An SAPCC framework*

SAPCCs are the first excellent step in allowing states to build their perspective-led action plans on climate action, with definitive actions for sectors of predominance. At the same time, it enables them to establish a synergy between national and sub-national actions (Climate Change Knowledge Portal, n.d.; TERI, 2015). These action plans thereby serve as the basis of sub-national climate action, raising a potential risk that, if not formulated or implemented effectively, initiatives that provide scope for state-level action could be rendered moot.

The Ministry has provided ample support in this endeavour by providing funds for the formulation of these plans, and institutional and financial support for the establishment of climate change centres in states, as well as the necessary and regular capacity-building initiatives. The most recent is the establishment of regional facilitating institutions (RFIs). They serve as nodal agencies for climate change across different regions of the country. These are to be trained to empower the states and UTs adequately for the preparation and implementation of their SAPCCs (communication received by EPTRI).

While this is a welcome move and can pave the way for the redressal of challenges that plague the design, monitoring, and evaluation of SAPCCs, we recommend a few initiatives that can ensure better outputs. The strategies and activities outlined in the SAPCCs certainly demonstrate an NDC or SDG linkage adequately. This way, they are able to embed themselves into the larger narrative of the country's ambitions. But they do often lack quantified targets themselves. This may mean there is no demarcation between business-as-usual and additional activities.

In the bargain, to serve the second purpose of effective monitoring of the implementation of SAPCCs, an outcome-oriented design of interventions and strategies in the action plan must be encouraged. These quantifications will not only allow tracking of targets at sub-national level but also provide an incentive to states to track their own climate actions. In doing so, they will be better placed to source external funding for climate and allied actions.

A mechanism that the government of Telangana, through its Telangana State Climate Change Centre at the Environmental Protection Training and Research Institute (EPTRI), has been able to implement successfully was to get a 'climate change nodal officer' appointed at all relevant departments

of the state, including but not limited to agriculture, health, irrigation, and energy. These nodal officers serve as the contact point for the exchange of information (TSAPCC 2.0 in-preparation).

We have noted in our study that the successful implementation of an SAPCC rests heavily on interdepartmental coordination. This requires data sharing mechanisms, a seamless flow of information, and unhindered, mutual fiscal transfers.

In light of this, the absence of an integration of climate change beyond sustainable development poses a significant challenge, in addition to the complexities that govern bureaucratic systems also at the sub-national level. For this reason, it is recommended that SAPCCs also involve departments like planning and finance intensively, reframing climate change into a question of economics (Oxford Policy Management, 2017).

Therefore, the authors recommend that the association of more ‘powerful’ departments, such as those that control the state’s exchequer and wealth of data, could not only associate more weight to the issue of climate change but also bring in more players to enhance its voice through their extended ownership.

### **3.5.2 A fiscal framework**

The MoEFCC disperses funds for the formulation of state action plans, but the implementation of the interventions is to be funded from state-led programmes and schemes (Pahuja et al., 2020). This indicates an urgent need for increased fiscal decentralisation with respect to climate change issues, since research has shown that fiscal decentralisation can be a reliable route to achieve zero emissions (Udeagha & Breitenbach, 2023).

The forest cover of states was first taken up by the 14th Finance Commission that determined the extent of devolution. The 15th Finance Commission increased the preceding Commission’s weightage from 7.5% to 10% (Pillai & Dubash, 2021). This weight distribution has shown that an ecological fiscal transfer share and extremely dense forest cover are positively correlated (Chakraborty et al., 2024).

While the Commissions linked the rationale for weightage to forest cover in response to the NDCs, the latter are not restricted to the creation of carbon sink. This means climate change variables within the Finance Commission must extend beyond forest sector variables and include other crucial ecological variables pertinent to the design of sub-national actions (Chakraborty et al., 2024).

Further, states must be capacitated to create market-based policy instruments. These have been shown to have a greater impact – so much so that with a rise of 1% in environmental policy indicators, the emissions growth falls by 20% (Chakraborty et al., 2024). The creation of these market-based

policy instruments requires more localised action from city-level units and administrators who are more successful in also being able to take on private sector stakeholders to combat emissions within their jurisdictions.

State action plans in their budget allocation, aside from their own schemes and programmes, rely heavily on centrally sponsored schemes (CSSs) for the implementation of climate and associated actions. While it is undeniable that the CSSs will continue to play a role in the climate finance devolution for the states from the Centre, institutional mechanisms also need to be built in to enable states to contribute to the design decisions of the CSSs (Pillai & Dubash, 2021).

### 3.5.3 *Capacity-building framework*

In the absence of a legislation that has a climate nomenclature at the central or state level, the state's recourse to climate action is a 'thicket' of multisectoral plans and other relevant legislations, requiring a creative interpretation to fit in a climate change narrative at the state level (Pillai et al., 2021).

This creative interpretation cannot be successful without an adequately built capacity within the institutions of the state themselves. The Ministry has undertaken initiatives such as the convening of technical advisors from UNDP and GIZ for assistance in the formulation of SAPCCs and their revision (Pillai & Dubash, 2021). While such external support was welcomed to add to their own technical expertise, this has only resulted in the creation of a rampant 'consultant culture', without providing resources to building the capacities of those within state institutions.

The interdisciplinarity of the SAPCCs' interventions requires cross-departmental capacity building across line department personnel to mainstream climate change into administrative decision-making (Dubash & Jogesh, 2014). A uniform capacity-building framework for administrators and frontline staff in the state must be developed to equip these personnel to transform the state institutions into 'imitators' and 'innovators' for combating climate action (Mishra et al., 2011).

## 3.6 **Summary and conclusion**

The birth of the Indian Constitution solidified the country's centralist tendencies, including but not limited to environmental governance. Over the decades since, this environmental governance framework has grappled with challenges ranging from its prioritisation, institutionalisation, and relevance to the emerging challenges of climate change.

While international negotiations and commitments, formulated by the Centre, continue to play a key role in determining sub-national climate actions in the country, the dawn of cooperative federalism is also slowly rising.

Despite this rise, the role of sub-national actors in determining climate policy or its implementation must not be diminished in light of the fact that such policies simply cannot exist in isolation of strong domestic support. Moreover, the intricate linkages between local governance and climate action need to be strengthened because it is necessary for informed, participatory climate policies.

It is important to realise that the creation of robust legal and policy frameworks is critical for a long-term integration of sub-national roles into climate governance. On account of the absence of such frameworks, we developed and recommended in this chapter a policy and regulatory and legal frameworks that painstakingly investigate and advocate for intersectional frameworks to transform the role of sub-national actors, especially as India and its states embark on low-carbon development pathways.

The frameworks for sub-national action spread across elements of fiscal devolution, legal, and policy. Capacity-building components are essential to pave the way for institutionalising strong domestic climate action, an informed policy, and legal interventions.

We recommend the re-envisioning of the SAPCCs by including institutional participation of departments within the state, such as the planning and/or finance departments, to increase fiscal ownership of the action plan and enable a smoother transfer of interdepartmental information and data to address the intersectional components of climate change.

We further argue for increased fiscal decentralisation through the inclusion of other climate-oriented variables (beyond forest cover) when deciding the quantum of devolution to the state by the Finance Commission. We also argue for the increased abilities of sub-national actors to have a say in the design of centrally sponsored schemes.

In the final capacity-building framework, we recommend the adequate building of the capacities of all departments within sub-national governments. Otherwise, the mainstreaming of climate action into decision-making at this level will remain a difficult endeavour.

The Constituent Assembly Debates in 1948 had discussed that the Constitution ‘can [be] both unitary as well as federal according to the requirement of time and circumstances’. With the onslaught of climate change and its effects on us, this is the best time to accommodate the climate aspirations of sub-national actors and empower them with a larger role, to ensure an inclusive and sustainable climate decision-making in the country.

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# 4

## CLIMATE CHANGE IMPACTS, VULNERABILITY, AND ADAPTATION FOR FOOD AND LIVELIHOOD SECURITY

A case study of Maharashtra

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### 4.1 Introduction

In India, 69% of the population lives in rural areas, and 55% of the total workforce is engaged in agriculture (Census of India, 2011). Women account for 37% of this agricultural workforce, playing a major role in agricultural production. The agriculture sector contributes 12% of the country's gross domestic product (GDP) (Government of India, 2016). Despite its declining share in the nation's GDP, it remains the backbone of the Indian economy, since it is the major source of food and livelihood security for the vast majority of the country's rural poor, women and men alike.

The government of India, recognising the importance of this sector to the livelihood security of millions of people, developed various programmes to strengthen the sector. The initiative to 'double farmers' income' (Chand, 2017) underlines its commitment to make farming a viable livelihood option. Agricultural performance and growth are imperative to ensure food and livelihood security. In consequence, any assessment of this security calls for an in-depth analysis of the vulnerability of the agriculture sector as such.

Climate change predictions of extreme events – such as those regarding frequency and intensity of droughts, floods, and erratic rains – are expected to have a great impact on agriculture as also on the food and livelihood security of millions of resource-poor rural populations (World Bank, 2012; IPCC, 2023). A vulnerability assessment of the agricultural sector will give insights into the capacity of agricultural systems to adapt to climate change.

It is widely recognised that climate change has differential impacts on countries, regions, and even sectors and geographies. Also, sectors vary widely in their degree of vulnerability to climate change. It is further recognised that ‘even within regions [ . . . ] impacts, adaptive capacity and vulnerability will vary’ (IPCC, 2001, p. 15). The differential impacts are mainly because changes in climatic patterns are not evenly distributed across geographies.

India has a wide range of climatic conditions, from the Himalayan winters to the tropical climate of the southern peninsula. The 28 states and 8 union territories in the country and the 707 districts within the states fall under different agroecological and agroclimatic regions (Gajbhiye & Mandal, 2000). They also have very different natural resource endowments and are at different levels of socio-economic development. They are bound to experience a disproportionate impact on the food and livelihood security of their populations. Their ability to cope with climate vulnerabilities also differs widely.

Household vulnerability is largely an outcome and consequence of macro- (country-level) and meso- (state- and district-level) vulnerability. Understanding macro- and meso-vulnerability at the national, state, and district levels is key to designing development and adaptation plans. Climate change adaptation plans in India should consider the regional and state-level differences in impacts and coping capacities. A sound strategic adaptation plan needs to be based on a disaggregated and detailed analysis of vulnerabilities across the states with sensitivity to spatial scale. This chapter is an attempt to have a meso-level disaggregated vulnerability analysis for the state of Maharashtra. The analysis has been carried out across all its districts.

## 4.2 Methodology

The Intergovernmental Panel on Climate Change (IPCC, 2001) described three dimensions of vulnerability: (1) sensitivity, (2) adaptive capacity, and (3) exposure. *Sensitivity* is defined as the degree to which a system is affected by disaster, *adaptive capacity* is the system’s ability to resist and absorb disaster, and *exposure* is the magnitude and duration to which a population is exposed to disaster (Ebi et al., 2006).

$$\text{vulnerability (V)} = f(\text{sensitivity, adaptive capacity, exposure}) \quad (1)$$

IPCC came up with a framework that forms the basis of a Livelihood Vulnerability Index (LVI) proposed by Hahn et al. (2009). They calculated a new variable, LVI-IPCC. This takes into consideration IPCC’s definition of *vulnerability*. Here, instead of putting all the major components together in equation 1, the major components are first combined according to three

categories, namely, exposure, sensitivity, and adaptive capacity, as in equation 2:

$$CF_d = \frac{\sum_{i=1}^n w_{Mi} M_{di}}{\sum_{i=1}^n w_{Mi}} \quad (2)$$

Where:

$CF_d$  = IPCC-defined contributing factors (exposure, sensitivity, or adaptive capacity) for district  $d$

$M_{di}$  = major components for district  $d$  indexed by  $i$

$w_{Mi}$  = weight of each major component

$n$  = number of major components in each contributing factor

After these factors are calculated separately, they are combined as in equation 3:

$$LVI - IPCC_d = (e_d - a_d) \times s_d \quad (3)$$

Where:

$LVI - IPCC_d$  = the LVI for district  $d$  expressed using the IPCC vulnerability framework

$e_d$  = is the calculated exposure score for district  $d$  (weighted average of the climate variability and exposed population and area)

$a_d$  = the calculated adaptive capacity for district  $d$  (weighted average of livelihood capacity, socio-demographic capacity, economic capacity, infrastructure capacity, and resource capacity)

$s_d$  = the calculated sensitivity score for district  $d$  (weighted average of system sensitivity, human sensitivity, and ecological sensitivity)

The LVI-IPCC is scaled from  $-1$  (least vulnerable) to  $1$  (most vulnerable).

The preceding methodology is adapted from Hahn et al. (2009, p. 76).

#### 4.2.1 Ranking and sub-categorisation

Districts were ranked on the basis of the index values following Shukla et al.'s (2016) methodology, as in Table 4.1. The vulnerability indexes (VI) of

**TABLE 4.1** Classified ranking of vulnerability index values

Vulnerability index value $> (M + SD)$	Highly vulnerable
$(M + SD) >$ vulnerability index value $> (M)$	Moderately vulnerable
$(M) >$ vulnerability index value $> (M - SD)$	Less vulnerable
Vulnerability index value $< (M - SD)$	Extremely less vulnerable or non-vulnerable

Source: Shukla (2016).

Note:  $M$  = mean;  $SD$  = standard deviation.

districts were ranked from lower to higher order according to an index value. Thereafter, districts were classified into four different groups with the help of mean (M) and standard deviation (SD):

- 1 Districts with a VI value higher than M plus SD are considered highly vulnerable.
- 2 Districts with a VI value less than M plus SD but more than M are moderately vulnerable.
- 3 Districts with a VI value less than M but more than M minus SD are less vulnerable.
- 4 Districts with a VI value less than M minus SD are considered extremely less vulnerable.

#### 4.2.2 Data

Table 4.2 gives details of the sub-components used to construct the Livelihood Vulnerability Index (LVI) and the contributing factors in the LVI-IPCC framework.

**TABLE 4.2** Components used to construct the Livelihood Vulnerability Index (LVI) and the contributing factors in the LVI-IPCC framework

<i>Component</i>	<i>Input profile</i>	<i>Indicators</i>
<b>Exposure</b>	Climate variability	Coefficient of variation (COV) of south-west rainfall deviation COV of north-east rainfall deviation COV of max temperature COV of min temperature
	Exposed population Exposed area	% rural population % rain-fed area
<b>Sensitivity</b>	System sensitivity	% area under food grain to total cropped area (TCA) Average size of operational holding % net sown area to total geographical area
	Human sensitivity	% labour force in agriculture % marginal and smallholders
	Ecological sensitivity	% of blocks over-exploited in terms of groundwater extraction

(Continued)

TABLE 4.2 (Continued)

<i>Component</i>	<i>Input profile</i>	<i>Indicators</i>
<b>Adaptive capacity</b>	Economic capacity	% share of non-agriculture sector to NDDP
	Livelihood capacity	% non-agriculture labour force Livestock population
	Socio-demographic capacity	% of technical diploma and graduate and above-level holder by operational holders % rural literacy rate
	Infrastructure capacity	% rural population served by transport, communication % rural population served by pucca road
	Resource capacity	% rural population served by agricultural credit societies Crop intensity Fertiliser consumption per hectare % electric consumption for agriculture to total electricity consumption

*Source:* Census of India (2011), GoI (2021), and GoI (2016).

### 4.3 Description of study areas

The state of Maharashtra accounts for 12% of India's net sown area (NSA) and contributes 8% of India's agricultural gross value added (GVA). The gross domestic product (GDP) for agriculture Maharashtra amounted to Rs 2.28 trillion in the financial year 2024. The sector accounts for 50% of the state's working population and provides a total monthly income of Rs 11,492 (GoI, 2021). The average outstanding loan per agricultural household in the state is Rs 82,085, with about 54% of agricultural households reporting indebtedness. Climate change, in the form of fluctuations in temperature and rainfall patterns, is predicted to have detrimental impact on the major crops in the state, like wheat, gram, soybean, and cotton (Sen et al., 2021). This has impact on farmers as income from crops accounts for a major share of the farmers' income (IPCC, 2023; Bawne & Patil, 2024). Table 4.3 gives a basic profile of the state of Maharashtra compared to the overall situation in India.

The proportion of the state's rural population is 52%. Of its total workforce, 53% are engaged in agriculture. The contribution of this sector to the state's economy is significant, with crop production alone accounting for 6% of its gross domestic product. The state is vulnerable to climate

**TABLE 4.3** Basic profile of Maharashtra compared to India

<i>Data</i>	<i>Maharashtra</i>	<i>India</i>	<i>Data reference year</i>
Total population	112,374,333	1,210,854,977	2011
Proportion of rural population (in %)	55	69	2011
Total workers	49,427,878	481,888,868	2011
Proportion of agricultural workforce (in %)	53	55	2011
Proportion of small- and marginal operational holdings (OHs) to total operational holdings of land (proportion in bracket)	10,761,351 (79)	117,605,129 (85)	2011
Proportion of small- and marginal operational holding of land (proportion in bracket)	8,924,981 (45)	71,152,325 (45)	2011
Gross cropped area (GCA)	24,069,231	193,759,280	2011
Proportion of gross irrigated area to GCA (in %)	20	45	2011
Proportion of area under food grains to GCA (in %)	49.1	62.2	2013–2014
Frequency of drought in the last five years (2010 to 2015)	4		2010–2015
State net domestic product at constant prices (year)	132,930,760		
% contribution of agriculture (crop production alone) to NSDP (net state domestic product)	6		

*Source:* Census of India (2011), GoI (2021), and GoI (2016).

change, which is evident by the increase in frequency of extreme events in the last decade. In Annexure 1 is a detailed socio-economic profile of its 33 districts.

## 4.4 Results and discussion

### 4.4.1 Description of sub-component indices

The climate variability index ranges from 0.14 to 0.76 (Table 4.4). A high level of climate variability was reported in Ahmednagar, Gondia, Pune, and Wardha, while Nashik, Ratnagiri, Sangli, and Sindhudurg showed very low levels of climate variability. Among the climate variables, the south-west monsoon showed the highest variability, followed by the north-east monsoon.

TABLE 4.4 IPCC contributing factors to vulnerability major components, Maharashtra districts

District	Exposure		Sensitivity			Adaptive capacity				
	Climatic variability	Exposed population	System sensitivity	Human sensitivity	Ecological sensitivity	Economic capacity	Socio-demography	Infrastructure capacity	Livelihood strategy	Resource capacity
Ahmednagar	0.68	0.86	0.55	0.73	0.00	0.63	0.66	0.89	0.49	0.55
Akola	0.41	0.57	0.62	0.59	-0.33	0.61	0.77	0.51	0.29	0.37
Amravati	0.57	0.62	0.50	0.62	1.00	0.62	0.98	0.57	0.31	0.33
Aurangabad	0.52	0.50	0.45	0.67	-0.33	0.74	0.40	0.84	0.53	0.48
Beed	0.47	0.87	0.54	0.78	-0.33	0.36	0.67	0.88	0.45	0.69
Bhandara	0.57	0.87	0.58	0.88	-0.33	0.71	0.78	0.63	0.52	0.39
Buldhana	0.59	0.85	0.53	0.70	0.03	0.51	0.62	0.52	0.28	0.43
Chandrapur	0.51	0.63	0.51	0.50	-0.33	0.81	0.40	0.37	0.51	0.37
Dhule	0.25	0.74	0.65	0.57	-0.33	0.48	0.36	0.69	0.52	0.59
Gadchiroli	0.54	1.00	0.50	0.68	-0.33	0.60	0.17	0.00	0.52	0.30
Gondia	0.68	0.91	0.44	0.88	-0.33	0.78	0.63	0.69	0.59	0.34
Hingoli	0.39	0.94	0.59	0.68	-0.33	0.29	0.46	0.86	0.34	0.77
Jalgaon	0.45	0.69	0.55	0.58	0.29	0.59	0.60	0.60	0.37	0.64
Jalna	0.47	0.87	0.52	0.73	-0.33	0.28	0.36	0.91	0.45	0.55
Kolhapur	0.30	0.69	0.23	0.78	-0.33	0.67	0.68	0.91	0.61	0.59
Latur	0.28	0.78	0.62	0.62	-0.33	0.41	0.66	0.96	0.47	0.68
Nagpur	0.57	0.13	0.57	0.25	-0.33	0.93	0.68	0.57	0.38	0.21
Nanded	0.56	0.75	0.50	0.70	-0.33	0.57	0.34	0.46	0.41	0.46
Nandurbar	0.49	0.91	0.57	0.56	-0.33	0.45	-0.07	0.68	0.39	0.47
Nasik	0.28	0.52	0.55	0.58	-0.33	0.54	0.38	0.90	0.53	0.52
Osmanabad	0.42	0.91	0.70	0.56	-0.33	0.25	0.73	0.94	0.33	0.76
Parabhani	0.49	0.70	0.65	0.64	-0.33	0.35	0.42	0.89	0.22	0.75

(Continued)

TABLE 4.4 (Continued)

<i>District</i>	<i>Exposure</i>		<i>Sensitivity</i>			<i>Adaptive capacity</i>				
	<i>Climatic variability</i>	<i>Exposed population</i>	<i>System sensitivity</i>	<i>Human sensitivity</i>	<i>Ecological sensitivity</i>	<i>Economic capacity</i>	<i>Socio-demography</i>	<i>Infrastructure capacity</i>	<i>Livelihood strategy</i>	<i>Resource capacity</i>
<b>Pune</b>	0.67	0.24	0.44	0.42	-0.33	0.88	0.60	0.86	0.79	0.47
<b>Raigadh</b>	0.40	0.61	0.38	0.55	-0.33	0.95	0.44	0.70	0.78	0.21
<b>Ratnagiri</b>	0.14	0.92	0.26	0.69	-0.33	0.85	0.40	0.84	0.63	0.16
<b>Sangli</b>	0.14	0.78	0.56	0.69	-0.33	0.44	0.58	0.94	0.51	0.53
<b>Satara</b>	0.52	0.88	0.34	0.86	-0.33	0.61	0.58	0.85	0.54	0.50
<b>Sindhudurg</b>	0.17	0.98	0.27	0.74	-0.33	0.63	0.63	0.86	0.66	0.25
<b>Solapur</b>	0.38	0.68	0.68	0.45	0.09	0.66	0.33	0.91	0.53	0.58
<b>Thane</b>	0.29	0.00	0.45	0.31	-0.33	1.00	0.28	0.85	0.69	0.22
<b>Wardha</b>	0.76	0.67	0.56	0.39	-0.33	0.63	0.76	0.68	0.47	0.25
<b>Washim</b>	0.49	0.90	0.64	0.64	-0.33	0.00	0.65	0.67	0.21	0.49
<b>Yavatmal</b>	0.48	0.84	0.58	0.47	-0.33	0.54	0.76	0.48	0.35	0.30

Source: Authors' estimation.

The coefficient of variation (COV) of the south-west rainfall ranged from 57 to 263%, with the lowest values in the districts of Bhandara, Nagpur, Sindhudurg, and Thane. The Ahmednagar, Nasik, Pune, and Satara districts reported a COV in the range of 115–263%, the last reported for Pune. The COV of the north-east rainfall ranged from 55 to 106%, with the lowest in Beed, Hingoli, Latur, and Sangli. The districts of Amravati, Buldhana, Nanded, and Wardha reported the highest rainfall, with 106% given for Wardha.

As rainfall in both seasons is directly related to rain-fed-based production, its variation has implications for both food production and livelihoods. The variance in minimum temperature was in the range of 1.3% in Sindhudurg to 2.4% in Wardha. A variance of more than 2% in minimum temperatures showed up in 18 out of 33 districts. This can have serious consequences for agriculture and food production in Maharashtra, as fluctuation or increase in night temperatures was already estimated to have a detrimental effect on the yield of rice and wheat in India in 2003 (Pathak et al., 2003). Rice yield is estimated to decline by 10% for each 1°C increase in minimum temperature during the growing season (Peng et al., 2004). The maximum temperature shows relatively low variance, with values ranging from as low as 0.7% in Sangli, Sindhudurg, Kolhapur, and Ratnagiri and as high as 1.2% in Gondia, Parbhani, Nagpur, and Wardha.

The districts of Ahmednagar, Beed, Bhandara, Jalna, Satara, Washim, Gondia, Osmanabad, Nandurbar, Ratnagiri, Hingoli, Sindhudurg, and Gadchiroli have an index value above 0.85 of the exposed population. This indicates their susceptibility to risk due to climate variability and impacts on agriculture and rural livelihoods.

The variable proportion of rain-fed area was dropped from the sub-component 'exposed area' since Thane, a predominantly urban district, showed the highest percentage of rain-fed area, and this could, in a way, affect the outcomes of the vulnerability calculation. The lowest values of the exposed population were reported in Thane, Nagpur, and Pune, as expected, while Gondia, Osmanabad, Nandurbar, Ratnagiri, Hingoli, Sindhudurg, and Gadchiroli have very high values for the exposed population index.

System sensitivity values ranged from 0.23 to 0.70. Kolhapur, Ratnagiri, and Sindhudurg have very low system sensitivity values, while Parbhani, Solapur, and Osmanabad have a very high system sensitivity index. The proportion of net sown area to geographical area ranges from 12 to 80%, with Akola reporting the highest proportion. The Gadchiroli, Thane, Raigad, Sindhudurg, Ratnagiri, Gondia, Chandrapur, and Nandurbar districts have less than 50% of their geographical area under crops. The average size of landholding is also very small, with 2.4 ha the largest, in Wardha district. Less than 0.85 ha are reported from Satara and Kolhapur.

The districts with very high human sensitivity values are Beed, Satara, Gondia, and Bhandara, because they have a very high proportion of marginal and smallholder farmers, and a high proportion of their total workforce is engaged in agriculture. Farmers in districts across Maharashtra are predominantly marginal and smallholders. Particularly in Gadchiroli, Buldhana, Nadurbar, Hingoli, and Washim, many are working in agriculture. So this is an important means of livelihood for the rural population in these districts.

The districts reporting high ecological index values are Amravati, Jalgaon, and Solapur. They have taluks with over-exploited blocks in terms of groundwater extraction. The maximum is in Amravati, where 28% of taluks report groundwater exploitation. Ahmednagar and Buldhana also show some level of stress in this regard.

In all the 33 districts considered in the analysis, sectors other than agriculture contribute more than 70% of the net domestic product of a district. The districts with a very low economic capacity are Osmanabad, Jalna, Hingoli, Parabhani, Beed, and Washim. These have relatively low contributions from non-agricultural sectors to the district's domestic product. Not surprisingly, those with a higher share of the non-agricultural sector to the district domestic product, like Thane, Nagpur, Pune, Raigad, and Ratnagiri, come out high on the economic capacity index.

Variables used to measure socio-demographic capacity were the proportion of farmers with some technical education or higher level, and rural literacy. Akola, Bhandara, and Amravati had high values for socio-demographic capacity, in contrast with Gadchiroli, Thane, and Nandurbar. In these last three districts, less than 3% of farmers have an academic and/or technical education. They also show relatively low values for rural literacy, with a count of few farmers with a high technical level of education or beyond. Very low rural literacy was particularly reported in Nandurbar, Dhule, Jalna, and Parbhani, while Wardha, Sindhudurg, Amravati, and Akola had high levels of rural literacy.

The resource capacity index was measured in terms of fertiliser and electricity use in agriculture, cropping intensity, and coverage by agricultural credit societies. Thane, Nagpur, Raigadh, and Ratnagiri come low in this index. They have a low cropping intensity and also report very little electricity consumption for agriculture. The districts that give high resource capacity values are Beed, Parabhani, Osmanabad, and Hingoli. They report an electricity consumption for agriculture of 70% and above. They also have a high cropping intensity and high level of fertiliser consumption, as well as an extensive coverage by agricultural credit societies. Aurangabad, Amravati, Akola, Ahmednagar, Yavatmal, Wardha, and Thane use relatively very little fertiliser, less than 10,000 t (metric tonnes) per year. On the other hand, Gadchiroli, Dhule, Jalgaon, and Chandrapur use annually more than 5 lakh metric tonnes of fertiliser.

On the whole, agriculture appears to account for more than 50% of electricity consumption in 12 out of 33 districts in Maharashtra. Less than 5% consumption of electricity for agriculture was reported from Ratnagiri, Raigad, and Thane.

Infrastructure capacity was measured in terms of the extent of coverage by pucca roads, transport facilities, and communication. Gadchiroli, Chandrapur, Nanded, and Yavatmal have very low infrastructure capacity index values, while Sangli, Osmanabad, and Latur have very high values in this regard.

The percentage of the rural population served by agricultural credit societies ranges from 34% in Gadchiroli to 97% in Solapur. The proportion served by pucca roads in rural areas ranges from 76% in Gadchiroli to 99% in Ratnagiri. Coverage by communication and transport is 99.7% in Solapur and Sangli, while it is 76.7% in Gadchiroli.

Livestock is an integral and important component in the farming systems in Maharashtra, with all 33 districts reporting more than 90% livestock population; only Nagpur had about 88%. The indicator driving the values of the livelihood strategy index was the proportion of the non-agricultural labour force. Districts with high levels of urbanisation – Pune, Thane, and Raigadh – come out high on this index, while those with a predominantly high proportion of agricultural labour force have a low livelihood strategy index.

#### 4.4.2 *Livelihood Vulnerability Index (LVI)*

The sub-components of the LVI are aggregated to arrive at the IPCC dimensions of vulnerability, namely, exposure, sensitivity, and adaptive capacity (Table 4.5). Further, using the IPCC vulnerability framework, the dimensions of vulnerability or, alternately, the contributing factors are combined to arrive at composite LVI-IPCC index values of vulnerability. The index value of the individual indicators used to calculate the exposure index is given in Annexure 2.

The overall exposure index for Maharashtra ranges from 0.23 in Thane to 0.75 in Wardha (Figure 4.1). Nanded, Bhandara, Gadchiroli, Buldhana, Ahmednagar, Gondia, and Wardha show exposure index values of 0.60 to 0.75.

Six indicators were used to estimate the sensitivity index. The index value of the individual indicators used to calculate the sensitivity index is given in Annexure 3.

The overall sensitivity index takes values in the range of 0.27 in Thane to 0.62 in Amravati (Figure 4.2). Buldhana, Solapur, Jalgaon, Ahmednagar, Bhandara, and Amravati show values of more than 0.50. Thane, Pune, Ratnagiri, and Nagpur report very low values, in contrast.

The index value of the individual indicators used to calculate the adaptive capacity index is given in Annexure 4. The adaptive capacity index ranges from 0.29 in Gadchiroli to 0.68 in Kolhapur (Figure 4.3). The districts with less than 0.50 values are Gadchiroli, Nandurbar, Nanded, Chandrapur, Washim, Nagpur, Yavatmal, Buldhana, Akola, Ratnagiri, and Wardha.

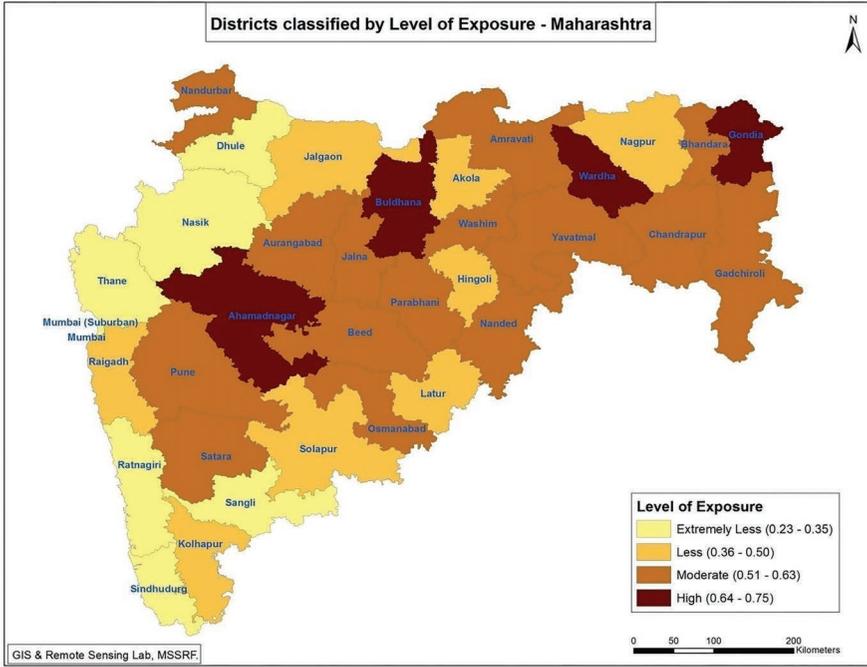


FIGURE 4.1 Districts classified by level of exposure of vulnerability – Maharashtra.  
 Source: Authors' estimation.

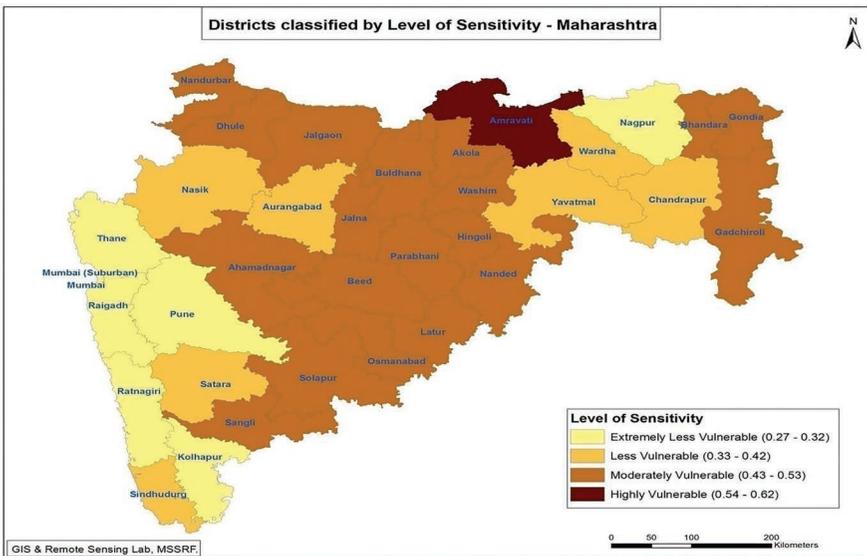


FIGURE 4.2 Districts classified by the level of sensitivity of vulnerability – Maharashtra.  
 Source: Authors' estimation.

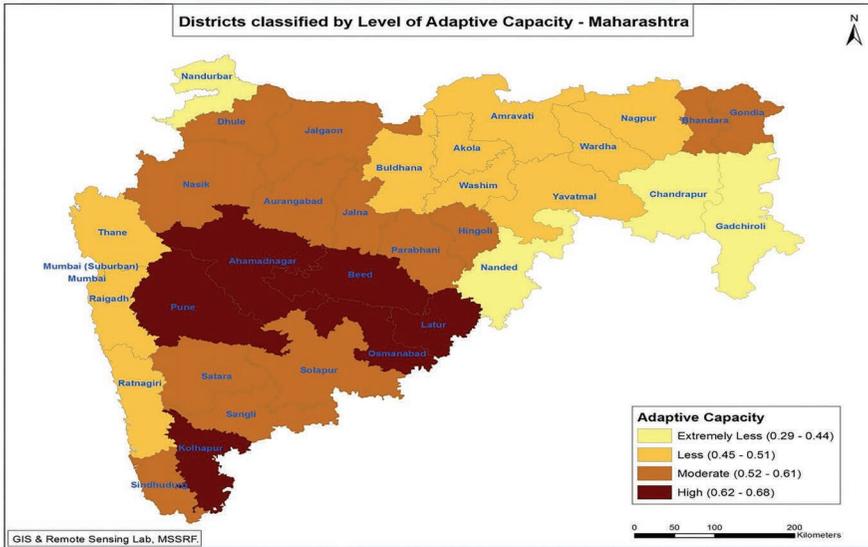


FIGURE 4.3 Districts classified by level of adaptive capacity – Maharashtra.

Source: Authors’ estimation.

The LVI-IPCC index takes values from  $-1$  to  $+1$ , with  $-1$  being least vulnerable and  $+1$  being the most vulnerable. The districts that appear ‘extremely low’ vulnerable here are Sangli, Latur, Nasik, Kolhapur, and Dhule (Figure 4.4). Washim, Nanded, Nandurbar, Gondia, Wardha, Buldhana, and Gadchiroli are in the ‘highly’ vulnerable category. Values of ‘low’ vulnerability show up for Solapur, Thane, Osmanabad, Sindhudurg, Ratnagiri, Hingoli, Beed, Jalgaon, Parabhani, Pune, Raigadh, Aurangabad, and Akola. Satara, Jalna, Nagpur, Chandrapur, Bhandara, Yavatmal, Amravati, and Ahmednagar report ‘moderate’ vulnerability.

#### 4.4.3 Ranking and vulnerability sub-categorisation

Adopting the methodology used by Shukla (2016), the districts were categorised by extent of vulnerability. Table 4.6 shows the ranking and categorisation of districts according to the extent of vulnerability across the two methods of integrated vulnerability assessment.

Sangli, Latur, Nasik, Kolhapur, and Dhule fall in the ‘extremely low vulnerability’ category. Washim, Nanded, Nandurbar, Gondia, Wardha, Buldhana, and Gadchiroli are ‘highly vulnerable’. The results of the study, with a couple of exceptions, are mostly in conformity to a socio-economic vulnerability analysis carried out by Adhav et al. (2021).

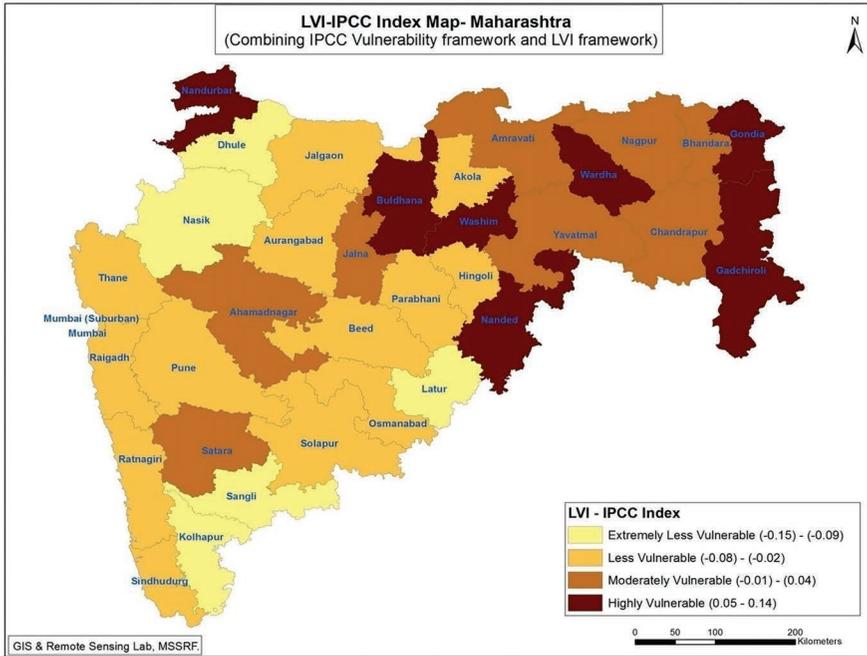


FIGURE 4.4 LVI-IPCC index – Maharashtra.

Source: Authors' estimation.

TABLE 4.5 Major component index contributing to LVI-IPCC index in Maharashtra districts

<i>District</i>	<i>Exposure index</i>	<i>Sensitivity index</i>	<i>Adaptive capacity index</i>	<i>LVI – IPCC index</i>
Sangli	0.27	0.46	0.60	-0.15
Latur	0.38	0.46	0.66	-0.13
Nasik	0.33	0.42	0.57	-0.10
Kolhapur	0.38	0.32	0.68	-0.09
Dhule	0.35	0.46	0.54	-0.09
Solapur	0.44	0.50	0.59	-0.08
Thane	0.23	0.27	0.50	-0.07
Osmanabad	0.51	0.48	0.66	-0.07
Sindhudurg	0.33	0.32	0.54	-0.07
Ratnagiri	0.29	0.31	0.48	-0.06
Hingoli	0.50	0.47	0.61	-0.05
Beed	0.55	0.47	0.65	-0.05
Jalgaon	0.49	0.52	0.57	-0.04
Parabhani	0.53	0.48	0.58	-0.02

(Continued)

TABLE 4.5 (Continued)

<i>District</i>	<i>Exposure index</i>	<i>Sensitivity index</i>	<i>Adaptive capacity index</i>	<i>LVI – IPCC index</i>
Pune	0.58	0.31	0.66	-0.02
Raigadh	0.44	0.32	0.51	-0.02
Aurangabad	0.52	0.39	0.56	-0.02
Akola	0.44	0.45	0.48	-0.02
Satara	0.59	0.40	0.59	0.00
Jalna	0.55	0.45	0.54	0.01
Nagpur	0.48	0.31	0.46	0.01
Chandrapur	0.53	0.37	0.44	0.04
Bhandara	0.63	0.53	0.56	0.04
Yavatmal	0.55	0.39	0.45	0.04
Amravati	0.58	0.62	0.51	0.04
Ahamadnagar	0.71	0.52	0.63	0.04
Washim	0.57	0.48	0.46	0.06
Nanded	0.60	0.43	0.44	0.07
Nandurbar	0.58	0.42	0.39	0.08
Gondia	0.72	0.46	0.54	0.08
Wardha	0.75	0.36	0.49	0.09
Buldhana	0.65	0.50	0.46	0.09
Gadchiroli	0.63	0.42	0.29	0.14

Source: Authors' estimation.

TABLE 4.6 Categorical ranking of LVI-IPCC index for Maharashtra districts

<i>District</i>	<i>LVI-IPCC</i>	<i>Ranking</i>
Sangli	-0.15	<b>Hardly vulnerable</b> (districts with vulnerability index value lower than M – SD)
Latur	-0.13	
Nasik	-0.10	
Kolhapur	-0.09	
Dhule	-0.09	<b>Less vulnerable</b> (districts with vulnerability index value higher than M but less than M + SD)
Solapur	-0.08	
Thane	-0.07	
Osmanabad	-0.07	
Sindhudurg	-0.07	
Ratnagiri	-0.06	
Hingoli	-0.05	
Beed	-0.05	
Jalgaon	-0.04	
Parabhani	-0.02	
Pune	-0.02	
Raigadh	-0.02	
Aurangabad	-0.02	
Akola	-0.02	

TABLE 4.6 (Continued)

<i>District</i>	<i>LVI-IPCC</i>	<i>Ranking</i>
Satara	0.00	<b>Moderately vulnerable</b> (districts with vulnerability index value higher than M but less than M + SD)
Jalna	0.01	
Nagpur	0.01	
Chandrapur	0.04	
Bhandara	0.04	
Yavatmal	0.04	
Amravati	0.04	
Ahamadnagar	0.04	<b>Highly vulnerable</b> (districts with vulnerability index values higher than M + SD)
Washim	0.06	
Nanded	0.07	
Nandurbar	0.08	
Gondia	0.08	
Wardha	0.09	
Buldhana	0.09	
Gadchiroli	0.14	

*Source:* Authors' estimation.

Table 4.7 gives the sub-categorisation of districts by individual dimensions of vulnerability as also the integrated vulnerability indices. Washim, Nanded, Nandurbar, Gondia, Wardha, Buldhana, and Gadchiroli districts fall in the 'highly vulnerable' category. This result, to an extent, is in contrast to those reported by Swami and Parthasarathy (2020), where Gadchiroli and Gondia came out as least agriculturally vulnerable.

Three out of the seven 'highly vulnerable' districts, Gondia, Wardha, and Buldhana, reported 'high vulnerability' on the exposure index, indicating a high climate vulnerability in these districts. Gondia and Buldhana report 'moderate vulnerability' on the sensitivity index and 'moderate' and 'low' adaptive capacity. These make them vulnerable to climate change. Districts with 'extremely low' vulnerability are Sangli, Nasik, Latur, Kolhapur, and Dhule. They also have 'extremely low' to 'low' climate variability. Sangli, Nasik, and Dhule have moderate adaptive capacity, in contrast to Latur and Kolhapur with high adaptive capacity.

#### 4.4.4 *Adaptation strategies to reduce vulnerability of agriculture to climate change – Maharashtra*

Washim, Nanded, Nandurbar, Gondia, Wardha, Buldhana, Gadchiroli, Amravati, Ahmednagar, Beed, and Osmanabad report a 'high vulnerability' of agriculture to climate change. Policies and programmes aimed at strengthening the agriculture sector and reducing its vulnerability to climate change should consider the individual contributing factors for vulnerability in these districts and design interventions that would help address this vulnerability.

**TABLE 4.7** Sub-categorisation of districts in Maharashtra by dimensions of vulnerability and integrated vulnerability indices

<i>District</i>	<i>Exposure index</i>	<i>Sensitivity index</i>	<i>Adaptive capacity index</i>	<i>LVI-IPCC index</i>
Sangli	EL	M	M	EL
Latur	L	M	H	EL
Nasik	EL	L	M	EL
Kolhapur	L	EL	H	EL
Dhule	EL	M	M	EL
Washim	M	M	L	H
Nanded	M	M	EL	H
Nandurbar	M	L	EL	H
Gondia	H	M	M	H
Wardha	H	L	L	H
Buldhana	H	M	L	H
Gadchiroli	M	L	EL	H

*Source:* Authors' estimation.

*Note:* EL = extremely low; L = low; M = moderate; H = high. Districts included in the table are those that reported either 'extremely low' or 'high' vulnerability in any of the integrated vulnerability assessment methods.

A major factor contributing to the vulnerability of agriculture to climate change in Gadchiroli, Nanded, Bhandara, Amravati, Bhuldana, Ahmednagar, Gondia, and Wardha is a high climate variability. The findings conform to other climate modelling results projecting a rise in temperature and rainfall across the state with regional variations (TERI, 2014).

Strengthening the natural resource base through soil and water conservation and rainwater harvesting, adopting water-efficient micro-irrigation technologies, and adopting climate-resilient agronomic practices would help address issues of climate variability in these districts. Temperature and rainfall fluctuations are bound to have serious implications for soybean, cotton, wheat, and gram, which are major crops in most parts of Maharashtra. Also, jowar, bajra, and pulses are projected to decline due to temperature variability, a phenomenon that is only going to aggravate. Experience has taught us that weather-based agromet advisory services contribute to strengthening on-farm capacity to deal with climate-related risks (Lobo et al., 2017).

High system sensitivity is prevalent in Wardha, Nandurbar, Bhandara, Washim, and Osmanabad. High human sensitivity occurs in Amravati, Washim, Gadchiroli, Buldhana, Nanded, Ahmednagar, Beed, Gondia, and Bhandara. These are districts with a high proportion of marginal and smallholders and agricultural labour force. Institutional initiatives aimed at collectivising marginal and smallholders would reduce the vulnerability of these districts to human sensitivity.

High ecological sensitivity is reported in Beed, Gondia, Bhandara, Ahmednagar, Buldhana, and Amravati. Almost 87% of the area in Ahmednagar is prone to extreme groundwater vulnerability (Thomas & Duraisamy, 2018). The most affected are small and marginal farmers, because they end up taking loans at high interest rates from private moneylenders (Kuchimanchi et al., 2018).

Technological interventions aimed at groundwater augmentation and recharge would reduce the vulnerability to ecological sensitivity of these districts (Srinidhi & D'Souza, 2018). Also, watershed development programmes help build overall capacities of farming communities, but its sustenance is dependent on the intensity of social capital availability (Singh et al., 2018, 2019).

The Maharashtra government has been encouraging the use of drip and sprinkler irrigation by providing subsidies. These techniques can help address many issues related to water availability, especially in the drylands of the Marathwada region. This is in keeping with the goal of increasing water efficiency by 20% under the National Water Mission (TERI, 2014).

Livelihood diversification and promotion of off-farm and non-farm enterprises would strengthen the economic capacity in Washim, Osmanabad, Beed, Buldhana, and Nandurbar. Increasing the technical capacity of the rural population, especially the smallholders, would improve the socio-demographic capacity in Nandurbar, Gadchiroli, and Nanded. Improving and strengthening rural infrastructure in Gadchiroli, Nanded, Buldhana, and Amravati is important to deal with the vulnerability of these districts. Facilitating access to institutional credit, improving irrigation capacity, and facilitating access to agricultural inputs would reduce the vulnerability of Washim, Buldhana, Amravati, Osmanabad, Nandurbar, Nanded, Beed, Wardha, and Ahmednagar.

The Maharashtra State Action Plan for Climate Change (MSAPCC) aims at making rain-fed and dryland agriculture more productive. The development of drought- and pest-resistant crop varieties, adopting resource-conserving technologies, providing institutional support to farmers, and capacity building of stakeholders to realise the potential of dryland agriculture are all interventions designed to build the general and specific capacities of specific communities and ecosystems. The state could draw lessons from the drought mitigation and water conservation efforts in other, similar agroecology areas and have a combination of measures for the protection as well as recovery from drought (Bandyopadhyay et al., 2020).

Apart from dryland farming, measures to enhance agricultural productivity through customised interventions such as biotechnology to develop improved varieties of crops and livestock, promoting efficient irrigation systems, demonstration of appropriate technology, capacity building, and skill development are also thrust areas in the MSAPCC. There is mention

of efforts at promoting citizens' and state actions for water conservation, augmentation, and preservation. The plan has provisions to empower and involve the Panchayati Raj, water users' associations, and primary stakeholders. Other than this, the largely rain-fed nature of the water resources of the state mandates the conservation of water for consumption and irrigation purposes.

District-level analysis gives insight into vulnerabilities in a more disaggregated form. Complementing this with an analysis at lower spatial scales, differentiated by communities, gender, and size, would be helpful in designing adaptation strategies that are inclusive and robust. Participatory approaches, like a community-based vulnerability evaluation, are also useful tools that help assess and map vulnerabilities at village, landscape, and community levels (Kuchimanchi et al., 2019).

#### 4.5 Conclusion and the way forward

The study attempted to obtain a disaggregated understanding of the nature of the livelihood vulnerability faced by the districts of Maharashtra. The LVI-IPCC method helps classify the districts into high-, moderate-, and low-vulnerability categories. Interestingly, districts reporting low to extremely low vulnerability on the exposure index showed overall livelihood vulnerability. This indicates the importance of climate variables in determining livelihood vulnerabilities. Districts with the highest vulnerability to climate variables are Amravati, Bhandara, Buldhana, Gadchiroli, Gondia, Nanded, and Wardha. High system sensitivity is experienced in Wardha, Nandurbar, Bhandara, Washim, and Osmanabad. Districts with very high system sensitivity report high dependence on agriculture and have a large number of marginal and smallholder farmers. Districts with high ecological sensitivity had a large majority of taluks reporting severe groundwater exploitation.

Strengthening the natural resource base through soil and water conservation and rainwater harvesting efforts, adopting water-efficient micro-irrigation technologies, and adopting climate-resilient agronomic practices are suggested as ways to address climate variability. Institutional initiatives aimed at collectivising marginal and smallholders, livelihood diversification and promotion of off-farm and non-farm enterprises, facilitating access to institutional credit, improving irrigation capacity, and facilitating access to agricultural inputs are other suggestions to build the capacities of districts to cope with the vulnerability of farmers and the farming community to climate change. The district-level analysis needs to be complemented with an analysis at lower spatial scales, differentiated by communities, gender, and size. Such a cross-sectional and finer analysis would contribute to design adaptation strategies that are inclusive and robust.

# ANNEXURES

## Annexure 1

**TABLE 4.8** Maharashtra socio-economic profile

<i>Districts</i>	<i>Total population person (2011–2012)</i>	<i>Total rural population person (2011–2012)</i>	<i>% rural population (2011–2012)</i>	<i>Total worker population person (2011–2012)</i>	<i>% agri labour force (2011–2012)</i>	<i>Proportion of marginal and smallholders to overall holders (2011–2012)</i>	<i>TCA (2015–2016) (in 00' HA)</i>	<i>% area under total food grain to TCA (2015–2016)</i>	<i>Total NDDP (2013–2014) (in cr.)</i>	<i>NDDP (agriculture, 2013–2014) (in cr.)</i>	<i>% NDDP (agriculture, 2013–2014)</i>	<i>% of total irrigated area to gross cropped area (2015–2016)</i>	<i>% net sown area to gross total geographical area (2015–2016)</i>
Ahmednagar	4,543,159	3,630,542	80	2,204,590	71	82	14,202	62	22,811	2,609	11	31	61
Akola	1,813,906	1,094,165	60	768,154	67	74	6,761	30	9,189	1,125	12	14	79
Amravati	2,888,445	1,851,158	64	1,236,322	70	75	9,838	37	13,548	1,541	11	13	61
Aurangabad	3,701,282	2,081,112	56	1,575,079	60	83	10,760	50	21,423	2,133	10	14	66
Beed	2,585,049	2,070,751	80	1,255,548	78	81	10,408	64	8,709	1,698	19	6	73
Bhandara	1,200,334	966,503	81	597,305	73	91	2,531	93	5,397	423	8	36	52
Buldana	2,586,258	2,037,398	79	1,219,641	81	75	9,215	32	9,403	1,454	15	14	68
Chandrapur	2,204,307	1,428,929	65	1,058,172	66	69	5,338	49	12,805	809	6	26	42
Dhule	2,050,862	1,479,826	72	936,370	71	71	5,419	71	9,693	1,548	16	33	59
Gadchiroli	1,072,942	954,909	89	584,237	81	73	2,108	84	3,096	253	8	33	12
Gondia	1,322,507	1,096,577	83	665,419	70	92	2,405	88	5,266	250	5	32	31
Hingoli	1,177,345	998,612	85	569,182	82	72	5,762	45	3,173	537	17	1	71
Jalgaon	4,229,917	2,887,206	68	1,863,571	71	72	11,629	36	20,369	2,765	14	29	73
Jalna	1,959,046	1,581,617	81	930,886	77	78	8,755	40	7,245	1,630	22	9	74
Kolhapur	3,876,001	2,645,992	68	1,704,054	54	93	5,918	30	29,789	2,717	9	34	56
Latur	2,454,196	1,829,216	75	1,046,857	71	74	7,218	52	9,959	1,919	19	3	75
Mumbai	3,085,411	0	0	1,284,396	1				189,159	1,041	1		#DIV/0!
Mumbai – Suburban	9,356,962	0	0	3,735,021	1							0	0

(Continued)

**TABLE 4.8** (Continued)

<i>Districts</i>	<i>Total population person (2011–2012)</i>	<i>Total rural population person (2011–2012)</i>	<i>% rural population (2011–2012)</i>	<i>Total worker population person (2011–2012)</i>	<i>% agri labour force (2011–2012)</i>	<i>Proportion of marginal and smallholders to overall holders (2011–2012)</i>	<i>TCA (2015–2016) (in 00' HA)</i>	<i>% area under total food grain to TCA (2015–2016)</i>	<i>Total NDDP (2013–2014) (in cr.)</i>	<i>NDDP (agriculture, 2013–2014) (in cr.)</i>	<i>% NDDP (agriculture, 2013–2014)</i>	<i>% of total irrigated area to gross cropped area (2015–2016)</i>	<i>% net sown area to gross total geographical area (2015–2016)</i>
Nagpur	4,653,570	1,474,811	32	1,868,560	34	68	6,498	50	38,703	706	2	23	56
Nanded	3,361,292	2,447,394	73	1,493,953	72	79	8,595	39	11,988	1,516	13	0	68
Nandurbar	1,648,295	1,372,821	83	792,065	82	65	3,662	49	4,601	633	14	17	42
Nashik	6,107,187	3,509,814	57	2,763,328	61	77	9,946	54	36,568	5,621	15	42	55
Osmanabad	1,657,576	1,376,519	83	773,916	77	68	7,748	45	6,341	1,515	24	13	56
Parbhani	1,836,086	1,266,280	69	822,797	74	74	8,254	49	6,861	1,426	21	1	76
Pune	9,429,408	3,678,226	39	4,048,993	32	81	11,212	50	91,241	3,500	4	28	55
Raigarh	2,634,200	1,664,005	63	1,072,969	37	87	2,155	65	19,887	275	1	59	27
Ratnagiri	1,615,069	1,351,346	84	714,076	63	83	2,625	35	10,236	365	4	53	31
Sangli	2,822,143	2,102,786	75	1,215,104	63	83	7,653	50	18,153	2,735	15	46	69
Satara	3,003,741	2,433,363	81	1,354,947	65	93	6,611	67	17,295	2,145	12	33	51
Sindhudurg	849,651	742,645	87	347,178	60	88	1,592	47	5,442	454	8	0	28
Solapur	4,317,756	2,918,665	68	1,898,395	63	67	11,594	70	23,726	2,127	9	36	67
Thane	11,060,148	2,545,470	23	4,492,767	17	80	2,420	26	111,238	359	0	1	25
Wardha	1,300,774	877,474	67	608,235	68	61	4,625	27	7,182	696	10	7	58
Washim	1,197,160	985,747	82	569,792	84	70	5,249	31	4,643	1,285	28	2	73
Yavatmal	2,772,348	2,174,195	78	1,355,999	79	60	9,926	30	10,456	1,155	11	14	63
Maharashtra	<b>112,374,333</b>	<b>61,556,074</b>	<b>55</b>	<b>49,427,878</b>	<b>53</b>		<b>22,8632</b>	<b>49</b>	<b>805,593</b>	<b>50,965</b>	<b>6</b>	<b>20</b>	<b>56</b>
<i>Sources:</i>	Census of India (2011)	Census of India (2011)	Census of India (2011)	Census of India (2011)	Census of India (2011)	Agriculture Census database, district table	Dept. of Agriculture, Govt. of Maharashtra	Dept. of Agriculture, Govt. of Maharashtra	Directorate of Economics and Statistics	Directorate of Economics and Statistics	Directorate of Economics and Statistics	Dept. of Agriculture, Govt. of Maharashtra	Dept. of Agriculture, Govt. of Maharashtra

## Annexure 2

**TABLE 4.9** Indicators used to build exposure index – Maharashtra districts

<i>District</i>	<i>COV south-west monsoon deviation</i>	<i>COV north-east monsoon deviation</i>	<i>COV temperature max</i>	<i>COV temperature min</i>	<i>% rural population</i>
Ahamadnagar	0.40	0.72	0.81	0.77	0.86
Akola	0.04	0.21	0.77	0.61	0.57
Amravati	0.06	0.73	0.94	0.55	0.62
Aurangabad	0.08	0.72	0.52	0.76	0.50
Beed	0.10	0.07	0.73	0.97	0.87
Bhandara	0.04	0.32	0.99	0.91	0.87
Buldhana	0.07	0.84	0.77	0.70	0.85
Chandrapur	0.11	0.38	0.90	0.65	0.63
Dhule	0.05	0.11	0.27	0.56	0.74
Gadchiroli	0.08	0.47	0.90	0.70	1.00
Gondia	0.12	0.73	0.99	0.87	0.91
Hingoli	0.09	0.01	0.86	0.60	0.94
Jalgaon	0.15	0.29	0.67	0.68	0.69
Jalna	0.08	0.24	0.71	0.83	0.87
Kolhapur	0.27	0.59	0.16	0.18	0.69
Latur	0.07	0.02	0.61	0.43	0.78
Nagpur	0.00	0.43	0.99	0.86	0.13
Nanded	0.22	0.91	0.86	0.24	0.75
Nandurbar	0.11	0.58	0.65	0.64	0.91
Nasik	0.28	0.20	0.29	0.35	0.52
Osmanabad	0.04	0.57	0.48	0.57	0.91
Parabhani	0.08	0.39	0.99	0.52	0.70
Pune	1.00	0.37	0.66	0.63	0.24
Raigadh	0.10	0.47	0.65	0.37	0.61
Ratnagiri	0.06	0.15	0.16	0.18	0.92
Sangli	0.21	0.08	0.01	0.28	0.78
Satara	0.62	0.64	0.49	0.32	0.88
Sindhudurg	0.00	0.57	0.09	0.00	0.98
Solapur	0.06	0.39	0.48	0.58	0.68
Thane	0.04	0.46	0.29	0.36	0.00
Wardha	0.05	1.01	0.99	1.00	0.67
Washim	0.06	0.44	0.86	0.60	0.90
Yavatmal	0.04	0.40	0.96	0.52	0.84

*Source:* Authors' estimation.

## Annexure 3

**TABLE 4.10** Indicators used to build sensitivity index – Maharashtra districts

<i>Districts</i>	<i>% area under food grain to TCA</i>	<i>% net sown area to total geographical area</i>	<i>Average size of land-holding</i>	<i>Proportion of marginal and smallholders to overall holders</i>	<i>Agriculture labour force</i>	<i>% taluks over-exploited in terms of ground-water extraction</i>
Ahmednagar	0.49	0.77	0.39	0.65	0.82	0.00
Akola	0.20	1.00	0.66	0.42	0.76	-0.33
Amravati	0.10	0.73	0.66	0.45	0.80	1.00
Aurangabad	0.14	0.83	0.39	0.69	0.65	-0.33
Beed	0.35	0.86	0.40	0.64	0.92	-0.33
Bhandara	1.00	0.59	0.15	0.92	0.84	-0.33
Buldhana	0.15	0.84	0.59	0.44	0.96	0.03
Chandrapur	0.40	0.44	0.70	0.27	0.73	-0.33
Dhule	0.55	0.69	0.70	0.33	0.82	-0.33
Gadchiroli	0.87	0.01	0.61	0.39	0.96	-0.33
Gondia	0.94	0.28	0.10	0.96	0.80	-0.33
Hingoli	0.29	0.86	0.63	0.37	0.98	-0.33
Jalgaon	0.07	0.90	0.69	0.35	0.81	0.29
Jalna	0.18	0.91	0.47	0.54	0.91	-0.33
Kolhapur	0.04	0.64	0.00	1.00	0.56	-0.33
Latur	0.36	0.89	0.61	0.43	0.82	-0.33
Nagpur	0.30	0.64	0.78	0.25	0.25	-0.33
Nanded	0.20	0.83	0.46	0.57	0.83	-0.33
Nandurbar	0.43	0.44	0.85	0.15	0.98	-0.33
Nasik	0.48	0.65	0.53	0.50	0.67	-0.33
Osmanabad	0.54	0.76	0.80	0.22	0.90	-0.33
Parbhani	0.40	0.95	0.60	0.41	0.86	-0.33
Pune	0.22	0.69	0.42	0.62	0.23	-0.33
Raigadh	0.66	0.23	0.24	0.81	0.30	-0.33
Ratnagiri	0.17	0.28	0.34	0.69	0.69	-0.33
Sangli	0.51	0.82	0.35	0.69	0.70	-0.33
Satara	0.44	0.57	0.02	1.00	0.72	-0.33
Sindhudurg	0.39	0.23	0.18	0.83	0.64	-0.33
Solapur	0.44	0.83	0.77	0.21	0.69	0.09
Thane	0.68	0.21	0.45	0.61	0.00	-0.33
Wardha	0.01	0.67	1.00	0.01	0.77	-0.33
Washim	0.23	0.91	0.78	0.28	1.00	-0.33
Yavatmal	-0.01	0.75	0.98	0.00	0.93	-0.33

Source: Authors' estimation.

## Annexure 4

**TABLE 4.11** Indicators used to build adaptive capacity index – Maharashtra districts

	<i>% share of non-agri sectors in NDDP</i>	<i>% of technical diploma and graduate to overall education done by operational holders</i>	<i>% non-agri labour force</i>	<i>Rural literacy rate</i>	<i>% of rural livestock population</i>	<i>% of rural population served by different amenities (agri credit society)</i>	<i>% of rural population served by different amenities (pucca road)</i>	<i>% of rural population served by different amenities, 2011 (transport communication)</i>	<i>Crop intensity</i>	<i>Consumption of chemical fertilisers (in Mt)</i>	<i>% electricity consumption for Agri (in MWh)</i>
Ahmednagar	0.63	0.78	0.18	0.55	0.79	0.96	0.78	1.00	0.34	0.05	0.88
Akola	0.61	0.54	0.24	1.00	0.35	0.55	0.30	0.73	0.53	0.02	0.37
Amravati	0.62	1.00	0.20	0.96	0.42	0.49	0.45	0.68	0.32	0.00	0.52
Aurangabad	0.74	0.46	0.35	0.35	0.71	0.86	0.78	0.90	0.72	0.00	0.35
Beed	0.36	0.90	0.08	0.44	0.81	0.84	0.81	0.94	0.37	0.67	0.90
Bhandara	0.71	0.75	0.16	0.81	0.87	0.55	0.58	0.68	0.44	0.27	0.30
Buldhana	0.51	0.44	0.04	0.80	0.52	0.51	0.23	0.81	0.42	0.20	0.57
Chandrapur	0.81	0.31	0.27	0.48	0.74	0.23	0.24	0.49	0.17	1.00	0.07
Dhule	0.48	0.65	0.18	0.08	0.87	0.74	0.41	0.96	0.23	0.77	0.60
Gadchiroli	0.60	0.00	0.04	0.34	1.00	0.00	0.00	0.00	0.24	0.77	0.21
Gondia	0.78	0.38	0.20	0.88	0.99	0.38	0.73	0.66	0.32	0.40	0.26
Hingoli	0.29	0.37	0.02	0.55	0.66	0.87	0.79	0.92	0.69	0.53	1.00
Jalgaon	0.59	0.76	0.19	0.45	0.54	0.69	0.21	0.99	0.38	0.80	0.68
Jalna	0.28	0.55	0.09	0.17	0.80	0.91	0.85	0.96	0.40	0.56	0.31

(Continued)

TABLE 4.11 (Continued)

	<i>% share of non-agri sectors in NDDP</i>	<i>% of technical diploma and graduate to overall education done by operational holders</i>	<i>% non-agri labour force</i>	<i>Rural literacy rate</i>	<i>% of rural livestock population</i>	<i>% of rural population served by different amenities (agri credit society)</i>	<i>% of rural population served by different amenities (pucca road)</i>	<i>% of rural population served by different amenities, 2011 (transport communication)</i>	<i>Crop intensity</i>	<i>Consumption of chemical fertilisers (in Mt)</i>	<i>% electricity consumption for Agri (in MWh)</i>
Kolhapur	0.67	0.74	0.44	0.62	0.79	0.93	0.86	0.96	0.54	0.70	0.20
Latur	0.41	0.85	0.18	0.46	0.75	0.92	0.95	0.97	0.51	0.51	0.76
Nagpur	0.93	0.57	0.75	0.80	0.00	0.33	0.63	0.51	0.16	0.26	0.09
Nanded	0.57	0.33	0.17	0.34	0.64	0.59	0.05	0.87	0.35	0.19	0.70
Nandurbar	0.45	0.16	0.02	-0.30	0.75	0.34	0.50	0.87	0.23	0.45	0.85
Nashik	0.54	0.20	0.33	0.57	0.73	0.88	0.83	0.96	0.12	0.70	0.40
Osmanabad	0.25	0.91	0.10	0.55	0.57	0.91	0.90	0.97	1.00	0.18	0.94
Parbhani	0.35	0.62	0.14	0.22	0.31	0.86	0.87	0.91	0.90	0.34	0.90
Pune	0.88	0.45	0.77	0.75	0.80	0.89	0.80	0.92	0.28	0.53	0.17
Raigad	0.95	0.24	0.70	0.65	0.85	0.48	0.80	0.60	0.13	0.22	0.01
Ratnagiri	0.85	0.09	0.31	0.71	0.96	0.47	1.00	0.68	0.03	0.14	0.02
Sangli	0.44	0.46	0.30	0.70	0.73	0.98	0.88	1.00	0.16	0.32	0.65
Satara	0.61	0.39	0.28	0.78	0.81	0.78	0.87	0.83	0.20	0.51	0.50
Sindhudurg	0.63	0.33	0.36	0.93	0.95	0.56	0.97	0.76	0.12	0.25	0.07
Solapur	0.66	0.25	0.31	0.41	0.75	1.00	0.82	1.00	0.13	0.32	0.86
Thane	1.00	0.32	1.00	0.24	0.39	0.77	0.79	0.91	0.00	0.10	0.00
Wardha	0.63	0.59	0.23	0.92	0.71	0.45	0.67	0.70	0.30	0.08	0.16
Washim	0.00	0.50	0.00	0.81	0.43	0.56	0.51	0.83	0.43	0.20	0.76
Yavatmal	0.54	0.78	0.07	0.73	0.64	0.35	0.26	0.69	0.16	0.07	0.60

Source: Authors' estimation.

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## **PART 2**

# Community perspectives and vulnerabilities



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# 5

## UNCOVERING THE SILENT FACTORS RESPONSIBLE FOR CROP RESIDUE BURNING

Evidence from peninsular India

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### 5.1 Introduction

Agriculture is crucial to the Indian economy because it is the primary source of livelihood for more than 70% of rural families. The agrarian sector is facing substantial strain in meeting the food requirements of the swiftly expanding Indian population. Consequently, cropping intensities, already at a maximum of 141.3% (NFSM report, 2020), are expected to rise further to meet the demands of a growing population as well as industrial requirements. Due to the rising frequency of crop cultivation and the narrower windows for sowing and harvesting, farmers have resorted to burning crop residue, especially rice, wheat, and maize. This method allows them to quickly clear fields for the next round of crops (Ahmed et al., 2015; Anjum et al., 2021).

Burning crop residue (CRB) is the process of lighting remaining plant debris after harvest. It is a practice used by farmers to prepare their land for the next cropping cycle. It usually occurs in open fields.

Even though CRB is illegal in India under IPC Section 188, it shows a consistent pattern of occurrence that raises atmospheric ammonia levels (Kuttippurath et al., 2020). The ramifications of CRB are global and have a variety of consequences, like increasing greenhouse gas emissions (Sharma & Mishra, 2001; Sun et al., 2016) and adverse health impacts, including respiratory problems, reduced visibility, and tuberculosis (Khokhar et al., 2016; Ramanathan et al., 2001; Solomon, 2007). Given the seriousness of the issue, governments are compelled to take immediate, severe remedial action to save lives.

Some laws in operation pertaining to crop residue burning are:

- Section 144 of the Civil Procedure Code to ban the burning of paddy
- The Air Prevention and Control of Pollution Act 1981
- The Environment Protection Act 1986
- The National Tribunal Act 1995
- The National Environment Appellate Authority Act 1997

Notably, in the states of Haryana, Punjab, Rajasthan, and Uttar Pradesh, stringent measures have been taken by the National Green Tribunal to limit crop residue burning (Lohan et al., 2018; Kumar et al., 2015a, 2015b). Although these attempts have lessened the intensity of the problem, it still exists.

CRB causes a significant increase in air pollution, with severe environmental and public health consequences (Keil et al., 2021; Kumar et al., 2019; McDonald et al., 2020). The polluted air disperses to adjacent rural and urban regions from its origin (Bajracharya et al., 2021; Bikkina et al., 2019; Hanley & Lingard, 1987; Liu et al., 2020; Ojha et al., 2020; T. Singh et al., 2020). Augmented air pollution results in multiple respiratory ailments and increased expenditures on public health (Agarwal et al., 2012; Chakrabarti et al., 2019).

Moreover, the burning of agricultural residue also harms crop yield, as it adversely impacts soil health, organic matter, plant nutrients, and the local microbial community (Carvalho et al., 2017; Gupta et al., 2004; Heard et al., 2006; Kumar et al., 2015a, 2015b; Thakur et al., 2021; Zhao et al., 2017). Generally speaking, the CRB poses a grave danger to global endeavours to mitigate climate change (Keywood et al., 2013; Victor et al., 2015).

Various environment-friendly practices (like mulching, nitrogen fixation, soil conservation, and zero tillage) have been proposed occasionally to manage agricultural residue worldwide. The government of Andhra Pradesh recently announced a plan to switch 6 million farms and 8 Mha (million hectares) of land from conventional chemical farming to Zero Budget Natural Farming by 2024. This makes Andhra Pradesh India's first state to grow crops naturally.

These environmentally friendly agricultural initiatives help farmers increase their output and overall revenue, but they are not yet compelling enough to address the pressing problem of agricultural residue burning (Galieni et al., 2017). For instance, almost 7% of cereal stubble produced on the farm is incinerated following harvest (Cao et al., 2008), while 43% of the total crop residue produced in India is burned on the field (Singh & Kaskaoutis, 2014).

In 2020–2021, India cultivated paddy and maize on 43.90 and 9.4 Mha and produced 114.45 and 27.78 Mt (million tonnes) of paddy and maize,

respectively. Among the non-traditional maize states in India, Andhra Pradesh (AP) stands second in terms of area under maize cultivation (3.01 lakh ha) and production (17.84 lakh tonnes). AP stands out at fifth on India's list of major rice producers. Rice production in the state expanded from 7.45 Mt in 2017 to 8.64 Mt in 2020, developing at an average yearly pace of about 5%. Rice and wheat contribute nearly 70% of the crop residues.

Out of the total waste generated, *surplus residue* refers to waste that remains after the residue is utilised for various other purposes. A part of this surplus is burned, while the remains are left in the field.

In view of these alarming numbers, there is an urgent need to dive deep into the real issues of farmers to gain a deeper understanding of the determinants causing them to carry out CRB. Our specific objective was to identify these determinants. We believe the findings of this study can assist policy-makers and implementing organisations in going beyond current regulations and further refining existing policies that sustainably enhance farm productivity (He et al., 2019).

## 5.2 Methodology

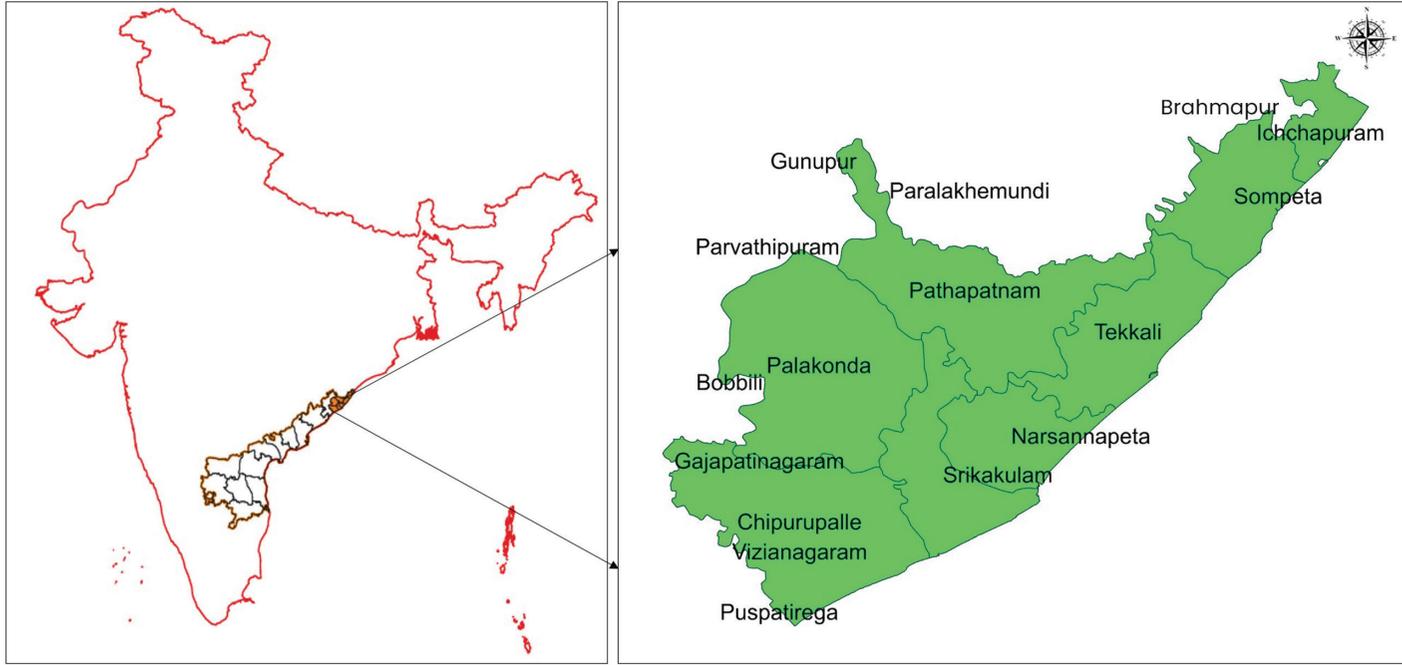
### 5.2.1 Ethics statement

We collected the data in a survey through personally administered questionnaires at peoples' homes or in the field. All respondents gave their consent verbally, before the interview. There were two reasons for obtaining consent this way. First, we anticipated a significant percentage of respondents to be illiterate, so they would be uneasy signing written documents. Second, the socio-economic survey did not capture any biological data. The interviewers communicated the procedure and emphasised peoples' involvement would be optional; the data gathered would be used for research only.

### 5.2.2 Study area and sample size

In Andhra Pradesh, out of 81 districts, Srikakulam District stands third in maize production (2.61 lakh tonnes in 2019–2020), and more than 80% of the farmers are involved in it during the *rabi* season. Similarly, more than 72% of farmers grow paddy in the *kharif* season. This means there is a high probability of torching the crop residue in the field after harvest in this region. That is why we selected this district as our study area (Figure 5.1).

In 2011, the district counted 2,266,411 persons in the rural population (Census of India, 2011). Out of the total, the number of farmers who owned land and were directly involved in agriculture was 145,576. We employed



**FIGURE 5.1** Study area for questionnaire survey.  
*Source:* Authors.

Yamane's (1967) sample size calculation formula (equation 5.1) to calculate an adequate sample size for the study:

$$n = \frac{N}{1 + N(e^2)}, n = \frac{2266411}{1 + 2266411(0.1^2)}, n = 100 \quad (5.1)$$

Where:

$N$  = size of the population (2,266,411)

$n$  = size of the sample population

$e$  = margin of error (10%)

We found that data from 100 households would be sufficient for this study. But to be sure, we purposively surveyed a total of 201 small and marginal farmers (with a land size of less than 2 ha, average landholding size of 1.31 ha) from 20 villages of Srikakulam District. They produce paddy in the kharif season and maize in the rabi season.

### 5.2.3 Regression framework

The study adopted a *probit regression analysis* to determine the factors of the farmers' decision to choose CRB (equation 5.2).

$\rho(\text{CRB})$  represents the probability that the farmer has burned maize/paddy residue in the last three years, and  $Y_1, \dots, Y_n$  are independent regression covariates.

$$\rho(\text{CRB}) = \frac{\exp(\alpha_0 + \sum_{n=1}^N \alpha_n Y_n)}{1 + \exp(\alpha_0 + \sum_{n=1}^N \alpha_n Y_n)} \quad (5.2)$$

Here,  $\sum_{n=1}^N \alpha_n Y_n$

$$\begin{aligned} &= \alpha_1 (\text{Paddy or Maize CRB}) + \alpha_2 (\text{Age}) + \alpha_3 (\text{Gender}) + \alpha_4 (\text{Education}) \\ &\quad + \alpha_5 (\text{Family size}) + \alpha_6 (\text{Farm experience}) + \alpha_7 (\text{Off - farm income}) \\ &\quad + \alpha_8 (\text{Landholding size}) + \alpha_9 (\text{sowing method}) \\ &\quad + \alpha_{10} (\text{residue removal cost}) + \alpha_{11} (\text{livestock owned}) \\ &\quad + \alpha_{12} (\text{Average number of livestock}) \\ &\quad + \alpha_{13} (\text{Soil health degradation awareness}) \\ &\quad + \alpha_{14} (\text{Environmental awareness}) + \alpha_{15} (\text{Cost of cultivation}) \\ &\quad + \alpha_{16} (\text{Yield}) + \alpha_{17} (\text{Window period for next sowing}) \\ &\quad + \alpha_{18} (\text{Harvesting method}) \end{aligned}$$

In equation 5.2,  $\alpha$  denotes the coefficient of the parameters to be estimated. The coefficient of parameters indicates the direction of the impact of the independent factors on the dependent variable.

Our study calculated the marginal effect or marginal likelihood. The marginal effect quantifies the anticipated alteration in the probability of the outcome variable when there is a unit modification in an independent variable.

#### **5.2.4 Description of dependent and independent variables**

An examination of existing literature revealed many factors that significantly affect the decision of farmers to resort to residue burning in the field. The factors examined in our study include age, gender, educational status, farm size, farm experience, off-farm income, landholding size, sowing method, residue removal cost, livestock owned, average number of livestock, soil health degradation awareness, environmental awareness, cultivation cost, yield, sowing window period, and harvesting method.

In the case of maize, all farmers do manual harvesting; in paddy, they may opt for manual and combine harvesting, based on their choice. That is why we used the harvesting method as an independent variable for paddy farmers. The dependent variable is whether the farmer burns the residue in the field.

Table 5.1 represents the description of the variables and the hypothesised expected effect of each variable on the CRB decision. (+) shows the variable increases the probability of residue burning, while (-) shows the variable reduces the probability of CRB, and (+/-) shows the variable can either increase or decrease the likelihood of CRB.

### **5.3 Model diagnostics**

#### **5.3.1 Multicollinearity**

Wooldridge (2016) states that having a low correlation across independent variables is ideal when estimating regression results. He advises using variance inflation factors (VIFs) to test for multicollinearity, with a recommended threshold of VIF below 10.

We calculated the VIFs for all the explanatory variables (Table 5.2). The average VIFs for the explanatory variables included in the probit model for maize and paddy models were 1.28 and 1.42, respectively.

#### **5.3.2 Heteroscedasticity**

The study performed the Breusch–Pagan (BP) test to assess whether heteroscedasticity (unequal variance of error terms) exists in a linear regression model. It uses the following hypotheses. Null hypothesis (H0): Homoscedasticity is

**TABLE 5.1** Description of independent variables used in the study

<i>Variables</i>	<i>Description and measurement of variable</i>	<i>Expected sign</i>
Age	Of head of family, in years	(+/-)
Gender	Dummy: 1 = household head male, 0 = otherwise	(+/-)
Educational status	Number of years of formal education	(+/-)
Family size	Individuals living together in one residence and purchasing or preparing meals together	(+/-)
Farm experience	Number of years in agricultural activities	(+/-)
Off-farm income	Whether non-agricultural income is main source of income in household	(+/-)
Landholding size	Total size of land owned by household, in acres	(+/-)
Sowing methods	Dummy: 1 = sowing machine, 0 = manual sowing	(+/-)
Residue removal cost	Amount required to remove residue from field	(+/-)
Livestock owned	Dummy: 1 = yes tropical livestock units, 0 = otherwise	(+/-)
Average number of livestock	Continuous: number of tropical livestock units	(+/-)
Diminishing soil quality	Dummy: awareness of negative effects of burning residue on soil; yes = 1, no = 0	(+/-)
Environmental awareness	Dummy: awareness of negative effects of burning residue on environment; yes = 1, no = 0	(+/-)
Cost of cultivation	Total cultivation cost of crop, in Rs/acre	(+/-)
Yield	Amount produced per unit area, in quintal/acre	(+/-)
Sowing window period	Number of days field remains fallow from harvesting to next sowing	(+/-)
Harvesting method	Dummy: 1 = harvesting machine, 0 = manual harvesting	(+/-)

Source: Authors' compilation.

**TABLE 5.2** Multicollinearity test: VIF and tolerance value for maize and paddy farmers

<i>Variables</i>	<i>Maize farmers</i>		<i>Paddy farmers</i>	
	<i>VIF</i>	<i>Tolerance</i>	<i>VIF</i>	<i>Tolerance</i>
Age	1.28	0.78	1.33	0.75
Gender	1.46	0.68	1.42	0.70
Educational status	1.17	0.85	1.57	0.64
Family size	1.35	0.74	1.61	0.62
Farm experience	1.27	0.79	1.39	0.72
Off-farm income	1.22	0.82	1.48	0.68
Landholding size	1.39	0.72	1.41	0.71
Sowing methods	1.16	0.86	1.3	0.77
Residue removal cost	1.28	0.78	1.27	0.79
Livestock owned	1.47	0.68	1.36	0.74
Average number of livestock	1.33	0.75	1.49	0.67

(Continued)

TABLE 5.2 (Continued)

Variables	Maize farmers		Paddy farmers	
	VIF	Tolerance	VIF	Tolerance
Diminishing soil quality (yes = 1/otherwise = 0)	1.29	0.78	1.53	0.65
Environmental awareness (knows negative impact = 1/otherwise = 0)	1.12	0.89	1.24	0.81
Cost of cultivation (Rs/acre)	1.08	0.93	1.62	0.62
Yield (Q/acre)	1.34	0.75	1.44	0.69
Sowing window period	1.2	0.83	1.32	0.76
Harvesting method			1.39	0.72

Source: Authors' compilation.

present (residuals have equal variance). Alternative hypothesis (H1): Heteroscedasticity is present (residuals do not have equal variance). The test was conducted for both maize and paddy.

When conducted on probit models (for maize and paddy), it gave evidence to reject the null hypothesis based on variance across the error terms. Interestingly, the chi-square value obtained was 1.53, with a corresponding p-value of 0.231, which indicated the null hypothesis cannot be rejected in this case.

## 5.4 Results and discussion

### 5.4.1 Descriptive analysis

The descriptive analysis in Table 5.3 shows that 32% of maize farmers opt for residue burning to clear the field against 23% of paddy farmers to get rid of paddy stubbles. The decision of farmers regarding CRB is significantly affected by the number of livestock owned by the farmers ( $p = 0.012$  in maize, and 0.022 in paddy). This means maize stovers in the study region are not significantly used as a feedstock for cattle. Farmers with a larger number of livestock may keep them, though, as possible feed in unforeseen circumstances of scarcity of paddy. This was observed in the results for an average number of livestock.

Notably, when farmers know the importance of soil and environmental health under both categories (i.e., paddy and maize), they do not burn field residues. Further, the cost of cultivation and crop yield harvesting methods also came up as decisive factors in CRB. Particularly in the case of paddy, family size, off-farm income sowing methods, and sowing window period significantly affected farmers' decisions regarding CRB.

We conducted a probit analysis to dive deep into the determinants of CRB.

**TABLE 5.3** Descriptive analysis for maize and paddy farmers

<i>Variables</i>	<i>Maize farmers</i>					<i>Paddy farmers</i>				
	<i>Farmers burning residue (33)</i>		<i>Farmers not burning residue (70)</i>		<i>p-value</i>	<i>Farmers burning residue (23)</i>		<i>Farmers not burning residue (77)</i>		<i>p-value</i>
	<i>Mean</i>	<i>Standard error</i>	<i>Mean</i>	<i>Standard error</i>		<i>Mean</i>	<i>Standard error</i>	<i>Mean</i>	<i>Standard error</i>	
Age	39.62	2.47	40.93	1.83	0.236	42.19	1.88	41.16	1.72	0.187
Gender	0.96	0.24	0.95	0.31	0.214	97.11	0.24	96.43	0.27	0.137
Educational status	5.23	0.49	6.37	0.31	0.094	5.91	0.62	7.03	0.72	0.113
Family size	4.18	0.32	4.73	0.27	0.117	4.43	0.25	5.02	0.31	0.104
Farm experience	18.67	1.33	20.28	1.42	0.145	19.16	1.01	18.45	0.83	0.187
Off-farm income	0.31	0.09	0.34	0.12	0.426	0.28	0.04	0.2	0.03	0.023
Landholding size	3.22	0.17	3.28	0.19	0.382	3.35	0.28	3.12	0.19	0.128
Sowing methods	0.48	0.127	0.609	0.11	0.106	0.341	0.13	0.669	0.11	0.002
Residue removal cost	0.187	0.029	0.213	0.032	0.184	0.165	0.03	0.139	0.06	0.189
Livestock owned	1555	39.17	1448.19	37.16	0.012	1847	43.21	1621	49.18	0.022
Average number of livestock	0.612	0.12	0.734	0.08	0.091	0.634	0.12	0.717	0.08	0.101
Diminishing soil quality	1.63	0.08	1.81	0.07	0.023	1.52	0.19	1.73	0.12	0.031
Environmental awareness	0.278	0.058	0.36	0.039	0.082	0.281	0.049	0.391	0.051	0.042
Cost of cultivation	0.23	0.06	0.37	0.04	0.042	0.239	0.081	0.447	0.11	0.001
Yield	19556	24.16	19372	26.18	0.065	21257	182.13	19864	167.15	0.021
Sowing window period	32.99	0.26	33.03	0.29	0.215	26.13	1.42	25.94	1.29	0.415
Harvesting method	0.39	2.21	54.35	3.17	0.001	22.35	1.82	32.18	2.04	0.001
						0.762	0.231	0.523	0.192	0.001

*Source:* Authors' compilation.

### 5.4.2 Determinants of CRB

The results from our probit analysis (Table 5.4) show that the age of farmers plays a decisive role in CRB. Remarkably, the direction of the relationship between age and CRB is opposite for maize and paddy farmers. While an average increase in age by one year from the mean age reduces the chance of maize residue burning by 1.4%, for paddy growers, it increases the likelihood of residue burning by 2.7%. This might be because relatively aged farmers are better aware of the perils of crop burning. As a consequence, when farmers get a relatively longer period for land preparation for the next crop after harvesting maize, they opt for sustainable crop residue removal. But after the paddy harvest in the kharif season, farmers get limited time for land preparation. Also, the manual harvesting cost is relatively high for paddy due to the high demand for labour. That is a reason that more senior-aged farmers (usually the family head), trying to balance economics, opt for the cheapest solution – to burn the field.

The education level of farmers also plays a vital role in CRB's decision-making. The results indicate that with an increase in education level by one additional year from the average, the likelihood of maize and paddy residue burning decreases by 6.3% and 4.4%, respectively. This can be correlated with an awareness of the negative consequences of CRB and the knowledge about soil health benefits. They know that CRB may have short-term benefits, but in the long run, it can harm the environment and soil quality, decreasing yield. Hu's (2018) observation of a negative correlation between the farmers' level of education and sustainable residue management is an interesting deviation in this regard.

Like education, family size negatively affects CRB for maize. An increase in one member of the family size results in a 3.4% decrease in maize residue burning. Usually, farm families with relatively more members use family labour to harvest maize and remove the residue, thereby saving harvesting cost and rescuing the farm and the environment from the harmful impact of burning.

On the other hand, manual paddy harvesting is relatively tricky, requires specific skill sets, and cannot be managed by family labour. Hence, the correlation of family size and paddy residue burning is insignificant.

In paddy, off-farm income plays a negative but significant role in CRB. With the increase in the average number of farmers engaged in off-farm activities by 1%, the likelihood of crop residue burning increased by 2.6%. As it is, when farmers engaged in diversified income-generating activities face labour shortages during harvesting, residue burning is the first option (Hu, 2018). Our findings align with those of Hu (2018), who reported that farmers whose primary source of income is agriculture are less likely to burn in-field paddy residues than those with other income sources.

**TABLE 5.4** Determinants of CRB for maize and paddy farmers

<i>Variables</i>	<i>Maize farmers</i>			<i>Paddy farmers</i>		
	<i>Coefficients</i>	<i>Marginal effect</i>	<i>Standard error</i>	<i>Coefficients</i>	<i>Marginal effect</i>	<i>Standard error</i>
Age	-0.062	-0.014**	0.029	0.083	0.027**	0.018
Gender	0.317	0.059	0.036	0.243	0.038	0.041
Educational status	-0.303	-0.063***	0.002	-0.218	-0.044***	0.004
Family size	-0.121	-0.034**	0.019	-0.084	-0.017	0.011
Farm experience	-0.052	-0.011**	0.005	0.041	0.013*	0.003
Off-farm income	0.148	0.031	0.088	0.187	0.026*	0.028
Landholding size	0.18	0.037	0.107	0.281	0.051**	0.083
Sowing methods	-0.609	-0.127*	0.078	-0.869	-0.223***	0.041
Residue removal cost	0.783	0.091***	0.014	0.663	0.123***	0.021
Livestock owned	-0.327	-0.087***	0.039	-0.593	-0.143***	0.025
Average number of livestock	-0.241	-0.037***	0.007	-0.377	-0.111***	0.004
Diminishing soil quality	-0.304	-0.063*	0.006	-0.266	-0.044**	0.003
Environmental awareness	-0.962	-0.201**	0.087	-0.539	-0.124***	0.042
Cost of cultivation	0.183	0.045**	0.032	0.192	0.041*	0.021
Yield	-0.091	-0.0189**	0.007	0.191	0.042	0.013
Sowing window period	-0.679	-0.213***	0.012	0.764	0.279***	0.018
Harvesting method				0.832	0.247***	0.101

*Source:* Authors' compilation.

*Note:* \* = significant at 10%; \*\* = significant at 5%; \*\*\* = significant at 1%.

Similarly, land size also distinctly pushes CRB in paddy. Our results show that an increase in farm size by 1% from the mean enhances the likelihood of residue burning by 5.1%. This finding is similar to data by Ahmed et al. (2015) and Fang et al. (2020). In contrast, Gupta et al. (2004) and Haider (2013) reported that the impact of land size was insignificant to decide on CRB. In our study area, over 95% of farmers put 98% of their land under paddy cultivation in the kharif season. As a result, they experience a vast labour shortage at harvest and are forced to use machines (combine or chain harvesters) to harvest and burn the leftover residue in the fields.

Farmers with less landholding manage the harvesting with family labour and do not go for the burning. However, the impact of farm size on residue burning is typically contingent upon additional variables, including the number of animals per unit area and the straw's suitability as animal fodder (Lin & Begho, 2022). An increase in farm size is associated with fewer animals per unit area, resulting in reduced fodder for livestock and increasing residue burning (Ahmed et al., 2015). It is also probable that the difficulty of using straw as feed is reason that expanding farm size is thought to be a more critical factor in CRB (Fang et al., 2020).

Our results show that the sowing method also influences farmers' decision to burn residue. For both maize and paddy, with a 1% increase in farmers using machines for sowing, the likelihood of CRB decreases by 12.7% and 22.3%, respectively. When farmers use mechanisation for sowing, it saves both time and cost associated with it, which varies between 10 and 15% of the cost of cultivation. In such a scenario, they can afford manual labour for harvesting and the removal of the residue.

For paddy, using the machine for sowing saves the cost of nursery bed preparation, some part of land preparation, and transplanting costs. They can save significantly by choosing machine sowing in paddy, which they can use for manual harvesting and straw removal and keeping it for livestock feed for prolonged periods. Hence, machine sowing affects sustainable residue management under paddy better than maize.

A statistically significant relationship exists between the cost of residue removal and CRB for paddy and maize. The increase in maize and paddy residue removal cost by 1% from the mean increases the probability of residue burning by 9.1% and 12.3%, respectively. The benefit–cost analysis revealed that the financial burden associated with residue collection and transporting crop residue to livestock markets discourages farmers from implementing ecologically sustainable residue management methods.

To be sure, a farmer's decision on CRB is significantly influenced by their livestock ownership and the average number of owned livestock. Our results show that with a 1% increase in livestock ownership, maize and paddy crop residue burning reduces by 8.7% and 14.3%. This means farmers harvest the

crop manually and avoid burning it to use the residue for livestock feed and bedding purposes (Ferraz et al., 2020).

Similarly, with an increase in the number of livestock, the requirement for feed and bedding material increases, further reducing the chance of crop burning. In this context, it is important to note that maize stovers are rich in less-digestible, non-starchy substances, such as crude cellulose and lignin, which makes them less palatable for livestock. Meanwhile, paddy leaves and stalks contain more starchy substances and less lignocellulosic biomass (McKendry, 2002). This is easily digestible, and livestock consumes it more than maize. This is why a 1% increase in average livestock number reduces the chance of maize residue burning by 3.7%, while it is reduced by 11.1% in the case of paddy.

In order to reduce CRB, farmers need to know alternative and sustainable uses of stubbles, with case stories of small action research trials and examples of best practices. When farmers know they can convert this residue, other than into livestock feed, into valuable products, like compost, vermicompost, and biochar, and apply them to the field, it will reduce fertiliser requirement and enhance yield and economic returns. As a result, the likelihood of crop residue burning will reduce (Ahmad et al., 2021; Lin & Begho, 2022).

It will also support approaches like circular economy and waste to wealth. Regrettably, most farmers fail to use crop residue in alternative ways, as it incurs huge transportation and transaction costs. Farmers need to come together and form a farmer producer company/organisation and process the stubbles collectively to minimise the costs associated with the conversion of crop residue into valuable products.

In addition, our findings indicate that an increase in farmers' awareness of CRB's negative implications for soil health and environmental outcomes by 1% reduces the likelihood of CRB by 6.3% and 20.1% for maize and 4.4% and 12.4% for paddy, respectively. CRB contributes to air pollution and harms soil quality by diminishing organic matter (Mittal et al., 2009).

Consequently, this can decrease agricultural productivity over extended durations (Singh & Kaskaoutis, 2014). Farmers, knowing the detrimental environmental consequences and their poor impact on soil quality, seem to be deterred from burning residue. On the other scale of the spectrum, some are more inclined to CRB if they see it as a prevalent practice in their community.

As for cultivation cost, with an increase in it of 1%, the probability of CRB for maize and paddy goes up by 4.5% and 4.1%, respectively. This actually means, when farmers spend more on input purchase, mechanisation, and labour to get more production, they are reluctant to invest in labour for residue gathering and transportation to take the produce to the livestock market. Instead, such farmers prefer to burn the crop in the field and make it ready for the next crop. Notably, with an increase in yield, the chance of residue burning decreases in the case of maize.

The time available from the harvest of one crop to the sowing of the next crop acts as the most critical determinant for CRB. The results indicate that an increase in 1 day from harvest to the next sowing reduces the chance of residue burning more maize and paddy by 21.3% and 27.9%, respectively. Nowadays, most farmers opt for long-duration crops and are involved in production even in the zaid season to get more production and income from agriculture. As a result, they get less time to remove the residue from fields and minimum time for land preparation. For this reason, most farmers opt for residue burning, since it minimises residue removal cost and saves time for land preparation for the next crop.

Obviously, both central and state governments, along with NGOs, need to promote a zero-till or no-till conservational approach to land preparation. The government of Andhra Pradesh has been at the forefront of promoting natural farming as an ecologically sustainable approach for crop production. The state government established the Rythu Sadhtikara Samstha (Organisation for Farmer Empowerment), a not-for-profit company, to implement natural farming with a zero budget. This approach will not only minimise crop cultivation costs and time but also improve soil health.

Our study, lastly, brought out that the selected method of harvesting significantly affects the decision regarding CRB. It also found that combine harvester-using farmers tend to fire paddy residue. This is due to the time and investment required to remove the residue after employing a combine harvester, given its propensity to disperse it throughout the field.

## 5.5 Conclusion

The issue of crop residue burning in India, particularly in the peninsular region, has become a growing environmental concern. While the practice provides a quick and inexpensive way for farmers to clear their fields, its detrimental effects demand a multifaceted approach to overcome the problem. Our study investigated socio-economic and demographic factors that influence crop residue burning in maize and paddy farming. We found several variables playing a critical role in farmers' decision to burn or not to burn.

They include age, education, family size, off-farm income, land size, sowing method, cost of residue removal, livestock ownership, awareness, cultivation cost, and time available for land preparation.

We have come to the conclusion that sustainable residue management practices are a feasible answer to this deeply entrenched practice. But these require a holistic approach that takes into account the interplay of these variables and the specific context of each farming system.

Government-regulated extension services providers, such as the Agricultural Technology Management Agency, Krishi Vigyan Kendras, agriculture clinics and agriculture business centres, and Kisan call centres, should

encourage small-scale farmers not to opt for residue burning. More so, they should inform them about the negative environmental consequences of CRB. The importance of creating awareness among farmers regarding the benefits of soil health and clean air may act as a catalyst to current efforts and bell the cat of CRB.

*Krishi Melas* can be organised to facilitate the interaction between farmers, extension agents, service organisations, and institutions to exchange knowledge about alternative sustainable uses of crop residue. Also, government agencies and NGOs can train farmers about these alternative uses (e.g. compost, vermicompost, biochar, bio-oil). In addition, they should motivate farmers to form farmers' organisations or companies and convert the residue into valuable, sustainable products as a collective, thereby cutting costs and increasing yields.

Practically speaking, by partnering with private sectors and NGOs, both central and state governments can implement capacity-building strategies, such as demonstration plots, cross-visits, study tours, and farmer's field schools, to strengthen the ability of smallholder farmers to embrace crop residue management. The central and state governments should incentivise the use of agricultural machinery and expand subsidies for farmers to purchase and rent machinery like Happy Seeders, smart seeders, double-wheel markers, rotavators, and balers. They should focus on establishing more custom hiring centres to increase access to these machines. The Indian government should facilitate the establishment of biomass-based power plants, biofuel production facilities, and other industries that utilise crop residue. Private players and NGOs, along with central and state governments, need to create a robust supply chain for the collection and transportation of crop residue. Gram Panchayats should promote the usage of crop residue for things like mushroom cultivation and cardboard production. Gram Panchayats can raise public awareness about the health and environmental impacts of crop residue burning.

The research was conducted in a representative region of peninsular India, specifically Andhra Pradesh. It can be replicated in other agroclimatic zones to assess the different contextual variables for that region. Future research should also focus on farmers' behavioural attributes, since they play other, critical roles in farmers' decision-making regarding burning crop residue.

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# 6

## GENDER MAINSTREAMING IN THE WATER SECTOR

Challenges and a way forward for  
semi-arid rural India

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### 6.1 Introduction

Climate change impacts, globally as well as locally, have become a severe threat today. They affect everyone, but not everyone equally. Climate vulnerabilities and risks are exacerbated by inequity and marginalisation linked to gender, ethnicity, low income, and other social and economic factors.

Water resources have a direct link with climate change, as they alter the overall rainfall regime, rainfall volume, and groundwater recharge processes in mainly semi-arid regions in India. In climate change discourse, 'climate justice' has become an important term, with moral, ethical, and activist dimensions to foreground those people and communities who, contributing least to the problem, are suffering its most intense impacts, women in particular. Climate justice brings a gender lens by showing how climate and environmental breakdowns are also structural drivers of gender inequalities (Newell, 2022).

In this context, access to water and its governance is not gender-neutral (Bennett et al., 2008; Brenda et al., 2020). Although women traditionally have played (essential) roles in facilitating water for drinking and sanitation needs, a broader perspective on women's fair rights to participation and the benefits of productive water use is, in practice, a mere verbal acknowledgement (Kulkarni, 2011; Ray, 2007).

To engage all gender identities in water management meaningfully and effectively, a perspective that seeks to include the gendered relation to water is vital. That means an understanding of gender-based roles and how these affect, and are affected by, water-related interventions.

It has been amply demonstrated that interventions addressing the views and inputs of both women and men generally work better (Acosta et al.,

2019; SDC, 2005). Further, data show that water resource management is incomplete without a gender perspective since women share half the world. After all, women and men do have different, and changing, gender roles, and each side has differing access to power and assets (Kangas et al., 2014; SDC, 2005).

In the water sector and beyond, it is observed that spaces of participation and access are divided into masculine and feminine aspects, linked to relations of unequal power at home and in public places (Khandker et al., 2020; Parpart et al., 2000). At a wider level, men's identities are associated with the public sphere, money, and power. In contrast, women's identities revolve around the home, nurturing, and subsistence. Such categorical, dual thinking has worked to confine women's roles and restrict their participation in decision-making on domestic water management. Till today, water management programmes, including that of drinking water, are dominated by men (Kulkarni, 2011).

Women's problems in the water sector are diverse. They range from participation in management and control to water availability, accessibility, and affordability. This is of special relevance in India. The Global Gender Gap Index (GGGI), an annual measurement of gender-based gaps, has ranked India 112th (out of 153 countries) in the overall index for 2020 (GoI, 2020).

Stakeholders in each country set priorities relevant to their respective economic, political, and cultural contexts based on that ranking, so the challenges for our country are huge. Of extra importance is the GGGI report's stress on the growing urgency for action; without the equal inclusion of 'half of the world', we will not be able to achieve the UN Sustainable Development Goals (World Economic Forum, 2020). Moreover, without women, the feminine perspective in development would be left out, so results will be incomplete and inadequate.

Water is a public good, and for basic human needs, it should be available, accessible, and affordable to everyone (Almeida et al., 2019; Kulkarni, 2011). It has become more precious in times of increasing drought and low rainfall. To enable a positive outcome, appropriate implementation of water governance is essential. Ensuring adequate participation by giving powers to local communities to manage their resources is an important step towards equity and equality (D'Souza & Lobo, 2004).

Women's particular concerns in India were not adequately addressed in the post-colonial period. It was assumed that the country's overall development would automatically percolate down and reach women and people with low incomes through a trickle-down effect. In reality, this process did not materialise, for several reasons (Bisaliah, 2010; Watson, 2005). Local communities are not homogeneous, and in a hierarchical society driven by caste and class discrimination, women would suffer even more because of patriarchy (Kasuri, 1996; Mosse, 2018).

These dynamics resulted in maintaining, if not widening, wealth and power gaps between rich and poor, men and women (Kale, 2011, 2018). Given prevailing patriarchal relations, women are largely responsible for care and nurture within the household (Beall, 2007). As a result, they are physically less mobile. In the bargain, they also suffer many socio-cultural restrictions that go with patriarchy (Kulkarni, 2011). They are not only denied the agency to make independent decisions and exercise authority in important spheres but also have a very low voice in the collective affairs of society, such as in the management of local natural resources (Evans & Nambiar, 2013).

In contrast, it has become widely accepted among scholars and activists that women are the best managers of domestic water. This has been mainly derived from eco-feminism, a discipline that presents women as the ideal caretakers of nature (Mukherjee, 2013). But this notion has confined women's participation to schemes and programmes related to drinking water and sanitation and kept them away from decision-making and management of productive water resources in a wider sense (Rao, 2012; Roach, 1991).

Notably, although women's important relationship with domestic water is now acknowledged, no local government programme like the Maharashtra State Water Policy (Government of Maharashtra, 2019), let alone the National Water Policy (Government of India, 2012), makes any specific mention of gender-differentiated water needs or women's roles in water management, apart from some numerical representation in different committees.

To add to caste, class, gender, and culture-related hurdles in participation, water is no longer seen as a free good. Commodification and privatisation of scarce water resources are at the core of new water policy reform processes and proposed solutions (Johnson et al., 2016; Joy et al., 2014). Many nationally supported programmes and state laws (for example, the Maharashtra Water Resource Regulatory Authority Act, Government of Maharashtra, 2005) articulate this global shift, from perceiving water as a social good to be provided free by the government to acknowledging that it is a scarce economic resource to be provided according to a standard of service which users are willing to operate, maintain, and pay for (Wagle et al., 2009).

Further, it is evident that women, even if allowed to participate (to some extent) in a water management process, are often still not heard in consultations. When processes are not sensitive to the question of gender, women may feel constrained to speak out in public places. Since men are usually in control of budgets and planning, women's water use, and control, is generally given less importance than men's (Kangas et al., 2014).

Yet ample evidence substantiates the fact that interventions are less impactful if women are not involved in planning (SDC, 2005). As a case in point, in many watershed development programmes across countries, the effective participation of women has increased transparency in projects and made watershed benefits more sustainable (D'Souza, 1998). Closer to home, in

Maharashtra, evidence from the World Bank–supported *Apale Pani* and *Jal Swarajya* (drinking water supply programmes) show that women played a vital role in the success of these schemes.

On the other hand, most water users' associations for canal water are still not very successful, because they are mainly in the hands of men, with only a token physical representation of women (Khandker et al., 2020; Narain, 2003).

### 6.1.1 Research gap

We may conclude, then, that the reality of gender mainstreaming in the water sector is dismal and remains far from positive, despite the several policies and programmes in the water sector that have adequate provisions for women's participation. Study of the underlying causes will contribute to address this situation.

Literature indicates there are a good number of studies and assessments regarding the role of women and the dimensions of gender mainstreaming in the canal irrigation system in Maharashtra (Khandker et al., 2020; Kulkarni, 2011; Van Eerdewijk, 2016). On the other hand, the subject of engaging women in groundwater management has not been adequately researched and documented yet (Ray, 2007). This is significant because more than 80% of agriculture, which falls in the non-command area of canals and is very sensitive to climate, is groundwater-dependent.

More so, the overall irrigation sector has apparently completely missed out on women's needs regarding managing groundwater in arid and semi-arid areas. This is apart from overlooking the role of women in developing watershed projects. In sum, the roles, strengths, and potential of women with respect to managing local groundwater resources are not studied properly or presented fairly.

To fill this gap, we explore in this chapter key barriers to women's participation in groundwater management in arid and semi-arid regions. This dimension is unpacked by analysing how feminine and masculine notions are constructed and at work in the management of changing groundwater dynamics.

Along with an attempt at understanding these perspectives through the lens of gender mainstreaming, we examine case studies and narratives of success in the promotion of mainstreaming gender. These cases are useful to understand what made it possible for women to come forward and face the challenges in performing their roles.

## 6.2 Research approach

The chapter follows the qualitative discipline with triangulation of data from a different set of respondents, exploring the different dimensions of women's participation in groundwater management.

### 6.2.1 *Theoretical and conceptual framework*

To explore the research concerns, gender mainstreaming and gender and development (GAD) approaches are applied. These approaches provide the conceptual framework for analysing the research issue. The United Nations Economic and Social Council (ECOSOC) in 1997 defined *gender mainstreaming* as ‘the process of assessing the implications for women and men of any planned action, including legislation, policies or programmes, in all areas, and at all levels’ (Acosta et al., 2019, p. 9). It is seen as a strategy for making women’s as well as men’s concerns and experiences an integral dimension of the design, implementation, monitoring, and evaluation of policies and programmes in all political, economic, and societal spheres so that women and men benefit equally and inequality is not perpetuated (ECOSOC, 1997). In a nutshell, *gender* takes into account the perspectives, roles, and responsibilities of both women and men in development initiatives, with an integrated understanding of gender-based power relations at all levels, rather than projects that target women exclusively (ECOSOC, 1997; SDC, 2005).

The Gender and Development (GAD) approach to gender mainstreaming has taken this up in a holistic manner. It integrates issues of women into the development process and challenges gender-based roles and divisions of labour and power. It focuses on both productive and reproductive roles and intends to meet both practical gender needs and strategic requirements (Rathgeber, 1990; Reeves & Baden, 2000).

The GAD approach emerged in the 1980s as an alternative to earlier thinking of ‘women in development’ (WID) and ‘women and development’ (WAD) (Rathgeber, 1990). It has its theoretical roots in socialist feminism and has bridged the gap left by modernisation theorists, linking production relations to relations of reproduction and taking into account all aspects of women’s lives (Jaquette, 1982). That is to say, socialist feminists identified the social construction of production and reproduction as the basis of women’s oppression and focused attention on the social relations of gender, questioning the validity of roles ascribed to both women and men in different societies (Rathgeber, 1990).

In GAD’s holistic perspective, ‘the totality of social organisation, economic and political life in order to understand the shaping of particular aspects of society’ is essential (Young, 1987; Thibault, 2001, p. 20). To be sure, this approach is not concerned with women per se but with the social construction of gender and the assignment of specific roles, responsibilities, and expectations regarding women and men (Miller & Razavi, 1995). Interestingly, in contrast to the emphasis on the exclusively female solidarity radical feminists highly prize, the GAD approach welcomes the potential contributions of men who share a concern for issues of equity and social justice (Sen & Grown, 2013).

The GAD approach is appropriate in our presentation also because it analyses the nature of women's contribution within the context of work done at all levels, both inside and outside the household, including non-commodity production (Miller & Razavi, 1995). Using the lens of these two frameworks, this chapter explores the level at which women are engaged in water management in rural Maharashtra and the barriers in their way, along with tracing the opportunities to overcome these barriers.

### 6.2.2 *Research methodology*

Our research took place in two particularly semi-arid regions of Maharashtra, Western Maharashtra (Ahmednagar District) and Marathwada (Jalna District), from February to May 2019. A total of 14 villages were purposively selected from these two groundwater-dependent regions, where the Watershed Organisation Trust (WOTR) had initiated a water stewardship initiative (WSI) to promote water management at village level in 2016 (D'Souza et al., 2019; Kale & D'Souza, 2020).

The execution of the WSI and the different interventions initiated in the villages formed the context of our study. In our multi-method and multi-respondent approach, we used in-depth interviews, focused group discussions, and case studies. The data collected were triangulated for a comprehensive understanding.

A total of 100 in-depth interviews (50 women, 50 men) gave an insight into enablers of and barriers to participation in water management. We interviewed actively engaged respondents, those participating in water management at village level, and people not actively involved in such activities.

Five focused group discussions (FGDs) revolved around key respondents from various study villages. In addition, three case studies captured women's detailed experiences and challenges in leading the front in water management. These cases proved crucial to understanding the capacities women can bring to transform overall water management in villages.

All primary data were transcribed, coded, and analysed thematically by using ATLAS.ti, a widely used qualitative data analysis software.

### 6.3 Findings and discussion

The findings and discussion of the chapter are distributed in four subsections: (1) the quality and levels of women's participation, (2) the various barriers to mainstreaming gender, (3) the analysis of how men perceive the participation of women, and (4) the strengths and the valuable contribution that women can offer to improve overall groundwater management.

### 6.3.1 *Women's participation in local water management*

Participation is key to decentralisation (Kulkarni, 2011). Most of the literature on this subject has been dichotomised into participation as 'means' or 'ends' (Seabrook, 1991). That is, the former sees participation as an efficient tool or means to achieve better project outcomes, while the latter argues that the process of participation is empowering in itself (Cleaver, 1999).

To participate meaningfully in water management, actors (women and men) need to be aware of the different water management activities taking place in their villages. They should also make an effort to engage with these ongoing processes in the village or at least demonstrate an interest in them.

#### 6.3.1.1 *Awareness and approach to water management activities in the village*

Notably, most men and women were aware of the larger water issues in their villages, given the activities there regarding water management under WSI and various government and NGO programmes. The project-implementing NGO had been using interesting tools for community mobilisation, such as *Prabhat Pheris* (or rallies by school children and villagers) and audio-video shows in the villages.

The level and nature of awareness varied among individuals, though: Men in water management were more aware of activity details. In watershed-treated villages, men evinced more interest in constructing more water-harvesting structures. On the other hand, women expressed concern regarding management aspects, such as stopping water wastage, planting trees, and promoting water-saving measures. The orientation and awareness of these different respondents are important, because they largely dictate their attitude and actions regarding water use and management.

#### 6.3.1.2 *Levels of women's participation*

Data showed very few women participated in meetings and stakeholder engagement processes at the WSI. Yet they proved active in contributing voluntary labour for the construction and repair of water-harvesting structures. As part of the WSI, the construction of water-harvesting structures calls for *shramdaan* (a contribution in the form of labour) from the community.

In the context, women reported they had participated in constructing *Vanrai bandharas* (bunds of sags filled with sand to arrest water flow) in the village, constructing soak pits within their house premises, digging pits for plantations, and desilting check dams. A few women in our group meetings recalled they had been preparing different plans for water budgets, crop planting, water harvesting, water-saving, and vermicomposting, among others.

A few also told us later that, after a workshop/group meeting, they had shared information obtained with other women in their villages. One respondent

thought this shows that women, when they receive the right information on water management, even technical, can grasp, apply, and even transfer it.

In the WSI, village water management teams (VWMT) were formed in each village. They comprised eight to ten key persons, including at least two to four women members. Many meetings at village level and stakeholder engagement workshops at cluster and block levels had been organised. Besides VWMT members, a small number of women, including *Jal Sevaks* (water caretakers) and local leaders, attended these workshops. When we asked why so few, the women explained that household responsibilities such as cooking, caring for children and domestic animals, and working on the farm made it difficult for them to go to such sessions.

We analysed our qualitative field observations and the quality of participation on the whole at various levels using a typology developed by Bina Agarwal (2001, 2009), as in Table 6.1. This typology analyses and ranks various layers of participation rather than simply examining people's participation in binary terms as 'participated or not' (Agarwal, 2001, 2009).

This way, we could explore the extent to which women and men had been participating in and contributing to water management at the local level.

Men were apparently mainly involved at consultative, activity-specific, and active levels. Not surprisingly, women's participation was mainly at passive and activity-specific levels.

We would point out at this stage that the VWMTs under study did show a representation of women across different social groups. Yet while many attended meetings and workshops, they were largely silent at these events. Remarkably, a few women who had been attending meetings showed a lack of awareness of their role as members of a VWMT. More so, at times, women

**TABLE 6.1** Participation in water management according to gender

<i>Layers of participation</i>	<i>Description of layer</i>	<i>Female members</i>	<i>Male members</i>
<b>Nominal</b>	Only aware about membership	**	*
<b>Passive</b>	Being informed of decisions ex post facto, or listening in meetings without speaking up	***	**
<b>Consultative</b>	Being asked an opinion in specific matters without guarantee of influencing decisions	**	****
<b>Activity-specific</b>	Being asked to (or volunteering to) undertake specific tasks	***	*****
<b>Active</b>	Expressing opinions, whether or not solicited, or taking initiatives of other sorts	**	**
<b>Interactive</b>	Having voice and influence in the group's decisions	*	**

*Note:* Each layer is on a scale of 1 to 5, where 1 is the lowest and 5 is the highest; asterisk-marked.

nominated in a VWMT turned out to be mere proxies: Their male counterparts (usually husbands) represented them in meetings and workshops.

The same situation occurs in the *panchayats*, the village councils and centres of local power.<sup>1,2</sup> This is particularly true when it comes to involving women, who have the benefit of reservation. Here, local vested groups act as ‘gatekeepers’ to select women on committees (Sharma, 1998).

Evidently, then, although the policy of introducing quotas for women in public bodies is welcome and necessary, it is certainly not sufficient to achieve fair decentralisation in a society ridden with discrimination based on class, caste, and patriarchy. Especially so where a culture of political patronage is dominant (Joshi, 2011; Mukhopadhyay, 2005).

However, some female members of VWMTs had good self-images and exuded confidence. They thought they had been selected because the villagers thought they were active and capable. Surely a changing self-perception among women.

### 6.3.2 *Barriers to women’s participation in water management*

For an enabling environment that promotes women’s participation, it is essential to interpret and analyse different layers and shades of barriers that restrict their participation. This section discusses these issues and provides positive case studies of women who challenged significant obstacles and have opened the path for other women.

#### 6.3.2.1 *Socio-cultural barriers*

We spoke to two women, one active, the other inactive in water management. They narrated their experiences of how socio-cultural norms in the family and wider society were discouraging them from doing something in water management.

##### 6.3.2.1.1 Gendered roles and responsibilities – the cost of participation

Studies have shown that in several cases, participation has placed an additional burden on women. It has reinforced gender stereotypes without commensurate economic or social benefits in terms of income or status gains (Baden, 1999).

Existing water programmes are full of committees mainly formed to appease different political interests and constituencies. In our study area, for many women, this was their first opportunity to participate in public matters. So interestingly, they did not view it as a burden.

A most obvious question in this connection would be: Who, then, shared her work at household level? While there was some amount of consent in male and female respondents for women to participate in the WSI, they did have to negotiate getting their housework done. We heard a large number of women say they often had to spend extra hours to complete household chores. A few told that their work was transferred to other female members

in the family, usually a sister-in-law, daughter-in-law, or daughter. In one village, a woman shared her feelings about the burden of participation this way:

*‘To participate in the meeting, we have to leave the house in the morning and return in the evening. In this situation, all of our household chores and other work are kept for us till we return; the male members of the family do not like this. At times, they scold us for not completing the household tasks. The male members of the family do not think about sharing in the household workload.’*

In most cases, social norms (patriarchy) that define women’s roles in the household and the community foreclose options for them to come out and participate in meetings. Women were found so burdened with domestic and agricultural work that they barely had time to know the world beyond their homes.

Irrigated agriculture increases the burden on women in terms of time and energy. The gendered division of labour is not questioned within the framework of sectoral reforms, which are resource-focused rather than people-centred.

We felt optimistic to learn that not all women respondents were having such discouraging narrations. In several instances, young women, and those from nuclear families and married to well-educated husbands, informed us their husbands do cooperate with them and share the household workload – to some extent. This means their husbands are helping with domestic chores, such as fetching water, taking care of the children, making tea, and serving food. They even openly allow their wives to go to public events.

#### 6.3.2.1.2 ‘Fetching drinking water is a woman’s task, while water management is a man’s business’

Men and women respondents considered water management a man’s responsibility, because it is ‘technical’ in nature. Prevalent gender norms and stereotypes encourage this notion.

Both sides pointed to the following activities as technical:

- 1 Physical surveying of soil and of water-harvesting structures that need moving about in the fields
- 2 Monitoring levels of groundwater
- 3 Calculating water budgets
- 4 Applying tools and techniques for the efficient use of water, such as micro-irrigation

People also observed that institutions and staff implementing projects gave little or no attention to explaining and demystifying technology and methodologies so that women would understand these activities better.

On the other hand, we also observed that women's participation in the public sphere is slowly increasing. Despite the various constraints women face, there is an apparent shift for at least some of them from complete absence to a gradually increasing presence in decision-making related to water. Their participation is more visible in the domestic water sector because fetching water for the household is culturally considered women's work.

There is also a long history of civil society organisations working with women in the water sector and shaping public acceptance of women's participation.

The comparison between domestic water and irrigation or productive water use is worthy of attention. The latter are still seen as a male domain, although mostly women provide irrigation-based agricultural labour. Productive water use has a greater value in market terms, with its own culture and rules of participation (Kulkarni, 2011).

Not only such rules but also the way programmes are designed reflect this dichotomy. For example, the WSI had supported 50% of women's participation in the VWMT and the appointment of female Jal Sevikas. Yet they were found not very active in preparing water budget plans, monitoring data, and in discussions and decision-making around water. They were basically doing community labour or participating in activities related to the supply of drinking water, such as installing RO plants or water purifiers or using water tankers, and the like.

#### 6.3.2.1.3 Social taboos

Prevalent social taboos and norms perpetuating gender bias are evidently important reasons for the low participation of women in the WSI and stakeholder engagement workshops. To be sure, women did express their willingness to participate in WSI activities. Some, though, thought the prevalent notion of men being 'superior to women' continues everywhere, also in water management, so they would keep to themselves. Moreover, when women attend water-related meetings outside their villages along with men who are not from their households, gossip about their character would circulate in their communities. This, in turn, would discourage other women from stepping out.

A women respondent shared:

*'The present norms in society do not permit women to go out and talk to other male members of committees. Women are questioned as to where and why they are going out or why they are roaming in the village. Therefore, in a male-dominated society, it is difficult for women to even contribute to good causes, like water management in the village.'*

We asked young village women if they would perform the role of Jal Sevika, usually assigned to young men. Following prevailing notions, some replied

that the role was best suited to their husbands or male family members. In their turn, a few young male water caretakers reported they also did not feel very comfortable themselves approaching women directly. When they have to pass on messages meant for women about meetings, they would address the men in the family. According to these young men, this was because going inside someone's house and talking to women is not socially acceptable.

#### 6.3.2.2 Programme/project-level barriers

Apart from the preceding discussed socio-cultural barriers, the programme design and mode of its execution also decide the level of women's participation in water management projects. Here, we discuss these programme-related issues and barriers.

##### 6.3.2.2.1 Project design

The approach, design, and strategies of any programme, project, or initiative in water management are crucial factors in determining the level of women's participation. Discussions and interviews with respondents revealed that insufficient female field staff, poor communication strategies, and less focus on women's concerns in stakeholder engagement workshops, training, and exposure visits contributed to the poor participation of women in meetings and workshops.

Female project team members are widely found to have a more effective outreach to women. They feel more comfortable discussing issues and concerns with female staff. This is evident in the very open and easy interaction of female workers like the ASHA, Anganwadi workers, and *Vasundhara Sevikas* (volunteers in watershed development) with women in watershed projects.<sup>3</sup>

It is important to realise here that designations developed in the water sector, like *Jal Sevak*, *Jal Nayak* (water hero), *Jal Purush* (water man), and *Jal Yoddhe* (water warriors), actually promote the continuation of male dominance, re-emphasising patriarchy. Sensitively developed communication practices and methods meant for an inclusive behavioural change are crucial for reaching specific target groups, such as women, and men, in village areas.

##### 6.3.2.2.2 Low numerical strength of women in institutions

We have seen that relatively few women participate in water-related activities. This is clearly a major constraining factor, for themselves and indirectly also for their families.

A few women who do frequently participate in WSI workshops told us they nevertheless did not feel confident and comfortable enough to express themselves in a group of mainly men. As it is, many women are not used to speaking in front of men or a large, mixed group. In contrast, some pointed out, they

would participate actively at meetings of women self-help groups and *Gram Sabhas* exclusively for women, also because of their sheer numerical strength.

A female member of a VWMT from the Jalna region put her experience with a workshop this way:

*‘If there were more women, we would have spoken our minds. It is difficult to speak out in a room full of men, with only two or three other women around. More numbers would have led to a better articulation of our concerns.’*

Another important factor is at play here: Women who are indeed active and vocal and have leadership abilities often do not get a chance to be appointed to committees or contribute adequately, because women from families of influential men in their village get nominated instead. But such women from influential families are often just dummies; the men in their families carry out all functions on their behalf.

#### 6.3.2.2.3 No tangible and direct benefits

Some women, but also some men, categorically mentioned they find it difficult to participate in workshops because they would lose their daily wages. Or some would then be unable to attend to important work on their farm – mainly during kharif and rabi seasons.

To quote a woman respondent:

*‘Many women choose not to attend workshops and meetings outside the village because they lose wage labour for the day, amounting to Rs 200 to Rs 250.’*

This is particularly relevant in the Marathwada region, where cotton is a main cash crop and women’s labour for cotton picking is very high. Obviously, they would not want to take even one day off to attend a meeting or workshop. To deal with this, the WSI project team put in much effort to include active and outspoken women with leadership qualities. They happily reported success in mobilising them to participate many times.

### 6.3.3 *Perspectives of men on women’s participation in water management*

Since men hold power in the family and society, understanding the male perspective on women’s participation is essential. On the surface, it looks as if both men and women recognise women are closely connected with water affairs, so they ought to play a role in water management. Going deeper, it turns out socio-cultural norms consider men the decision-makers. Gender roles and responsibilities have become major deterrents to the participation of women in water management.

Men, who see women's roles as confined to the home, find it difficult accepting their participation outside the house. A predominant male perspective is that women lack the required technical skills and decision-making capabilities. And institutional culture reinforces this. It tends to assign what are perceived as 'female tasks' to women in committees, such as record-keeping and managing drinking water supply (considered non-productive), rather than village-level planning, taking decisions about soil and water conservation, or water budgeting.

In many families, only the men communicate information from public events and training sessions to the women. So it is just by hearsay from their menfolk that they come to know about initiatives going on in the village. Men believe that though women are closely connected with water, indeed, their roles at home and in agricultural work should come first. So it is difficult for women to take out enough time for village water management activities. A few men also observed that women cannot participate in meetings, training sessions, and workshops, because such events are generally planned outside the house, at other locations or even other villages. Travel and spending the night outside the home – that, too, involving places with male participants who are not relatives – are not seen as socially acceptable for women.

Evidently, this culture of sociopolitical male dominance and a prevailing gender-based mindset to accept women's exclusion, or at least non-participation, are at the root of the problem. This mindset, we saw, is also reflected in popular practices in the *Panchayati Raj* system: An elected female *sarpanch* or other female functionaries may have the formal designations, but the husband or other male relatives rule the roost. Terms such as *Sarpanch Pati* ([female] sarpanch's husband) or *Sadasya Pati* (husband of lady member) are common among people.

Apparently, using women functionaries as proxies by men is accepted in almost all institutions and agencies of governance; water management is no exception. Although the WSI has made efforts to ensure 50% membership and participation of women in the VWMTs, the number of female participants in WSI meetings, workshops, and training sessions was not fully commensurate with their actual representation in the VWMTs.

Challenging cultural norms to achieve mainstreaming gender in water management and in overall development is not an easy task. For decades, men have been in positions of power and control decision-making at all levels. Educating and making men aware of their responsibility to share women's workload at home and sensitising them to treat women as equal partners in water management are showing up as major strategic goals.

#### **6.3.4 Women's strength as a contribution to water management**

Experience worldwide affirms that projects are more successful in terms of sustainability, transparency, and judicious benefits wherever serious efforts to

mainstream gender have been made (Castaneda et al., 2012; UNDP, 2006). Also, where women have received full freedom, indeed, to make plans and choose the course of action, more exciting and meaningful results in water management are visible. We refer in this context to the capability approach of Amartya Sen (Sen, 2000).

A few encouraging case studies illustrate how women can play inspiring roles and make a breakthrough in water management. They substantiate women's untapped potential and capabilities to bolster water management practices and transform a system.

### **Case study 1: The power of women's collective strength – implementing a micro-watershed project**

*Bhoyre*, a tiny, rain-dependent village in Ahmednagar District.

How a women-only group implemented sustainable land management measures in a micro-watershed project.

Bhoyre Village has two distinct sections: *Bhoyre Khurd* (712 ha) and *Bhoyre Pathar* (160 ha). A watershed development initiative under the Indo-German Watershed Development Project (IGWDP) began in *Bhoyre Khurd* in 1996 and was completed in 2001. The project consisted of two phases, a capacity-building phase (CBP) and a full implementation phase (FIP).

In the CBP, project staff used a hands-on method to improve the capacities of local committees and village-level workers. This involved training in technical planning and the implementation of sustainable land management (SLM) measures. Also, a federation of women self-help groups in the village (*Samyukt Mahila Samiti*, SMS) was formed.

After completion of the project in *Bhoyre Khurd* in 2001, it became possible to do the same in *Bhoyre Pathar*. With the recent experience of implementing SLM interventions, the SMS of *Bhoyre Khurd* considered taking up the challenge. An amazing step!

For the first time in the history of watershed development in India, women took the lead in assuming overall responsibility to treat a micro-watershed involving soil and water conservation interventions and mobilising the community for that purpose. Despite obstacles and doubts raised by village men, the women-only group stood firm together. They finished the job as planned.

This experience boosted the confidence of the village women. They had learned they can make decisions themselves for a public good, even at village level.

And so this event challenged the cultural understanding that women are incapable of this so-called technical work of soil and water resources conservation.

### **Case study 2: Leading from the front – a story of building trust and confidence in women**

*Sundarwadi village, Paithan taluka, Aurangabad District.*

How an illiterate village woman brought together a large number of women for village water management.

‘We have nothing, and we are nothing without water. The government may give us food grain through the public distribution system (PDS), but where will the water come from?’ says *Parubai Rathod*.

Unsurprisingly, as a woman, she truly understands the preciousness of water in our lives. Parubai lives in Sundarwadi Village. For her, unity among all people in the village, all men and women, is extremely important. There was a watershed project, implemented by the WOTR almost 20 years ago. The challenge was to involve women in these watershed activities.

Parubai’s journey began when she became a member of a self-help group (SHG) in her village during the project. She found the SHG really helped women become more financially independent in many ways.

Although she had had no formal education, her passion for engaging women and her skills in mobilising them turned out to be incredible. Since all families in the village belong to the *Banjara* community (which fall under the category of Vimukta Jati and Nomadic Tribes [VJNT] in India), there is freedom for women to move around. The men do not stop them also from participating in public meetings.

Parubai was able to raise a cadre of women to support watershed development and water management in the village in a special, ingenious way. She realised that mobilising women for village development is difficult, unless there is an emotional bond and common goal.

So with a few women, she started a movement to ban liquor in the village. Gradually, several women joined in. The group would reach out to women facing problems at home, such as ill-health of family members, financial constraints, and family disputes. According to Parubai, these small initiatives forged a bond of trust among the women.

Then, men and women together, with the guidance of WOTR, built a special farm pond in the village to meet their drinking and domestic water needs in times of water scarcity. Parubai played an outstanding role in mobilising women to be involved in planning and providing shramdaan (voluntary labour) to construct the pond and take care of its subsequent maintenance.

She truly believed that women and men must work as equals to address their common interests, including water management. She also realised that women’s confidence cannot be built up without continuous and committed efforts over the years, as her group had been doing in her village.

This story of a motivated yet uneducated woman underscores that formal education and charisma are not the only preconditions to become a leader. Her passion and capability for building trust and confidence among the women in her community are also equally important.

### **Case study 3: A self-motivated woman mobilising groundwater users**

Godri village in Bhokardan taluka of Jalna District.

*Lilabai Sonune* of the Godri village is a *Gram Panchayat* member, SHG head, and WSI-formed VWMT member. The village belongs to a cluster of villages that share an aquifer. The WOTR had started a participatory groundwater management project at aquifer level in this cluster. An aquifer management committee was formed in 2018 to manage groundwater, a common pool resource.

In addition to her other public tasks, Lilabai is an active member of this committee also. She is instrumental in mobilising village people and even spreading aquifer literacy in surrounding villages. How did she do that? By discussing water issues with other committee members regularly and motivating people to manage water better. More importantly, Lilabai's engagement in the groundwater management initiative brought many women from surrounding villages into the fold. Though women's participation over the years has increased, still, she acknowledges, persistent effort is required to empower women for effective participation. For her valuable contribution, Lilabai received the distinguished Woman Water Champion Award from UNDP in 2021.

The story of Lilabai Sonune demonstrates how a woman can challenge gender roles and contribute to improve water management, not only in her village, but also in several neighbouring villages. As in the previous case, this one shows how achievement is possible when the passion and commitment of a woman elected into a public function is given an opportunity to improve water management in her village.

Similar experiences of mainstreaming gender in water management elsewhere in India and abroad bring out a few important lessons, as following:

- 1 Wherever women are involved meaningfully in water management, more focus is given to resource conservation rather than further development and exploitation of resources.
- 2 By women's effective involvement in this regard, concerns of equity (benefits to all, especially the most vulnerable) and transparency are given higher priority.
- 3 Of utmost importance and without the slightest doubt, community participation of men as well as women in its truest sense makes projects really impactful and sustainable.

## 6.4 Conclusions

For effective gender mainstreaming in water management, a number of points need to get attention:

- There is urgent need to adopt concrete pathways and purposeful strategies in the planning and execution of interventions for achieving the goal of gender mainstreaming in the water sector. Interventions are needed to increase the visibility, confidence, and skills of women in institutions across areas of water management.
- A gender-balanced team in all stages, from programme planning through execution and monitoring to evaluation, is a must to incorporate the concerns and perspectives of women members at different programme levels.
- In addition to involving women in sufficient numbers in a project team, fostering gender sensitivity is equally important, that is, ensuring an environment of respect and valuing their views and ideas.
- While selecting women from a community for local water management committees, avoiding dummy or proxy female representatives is challenging, more so since project staff and teams face enormous excuses, difficulties, and pressure due to village dynamics.

Finding and selecting active and vision-driven women from SHGs and organising special *Gram Sabhas* to select and nominate women representatives from weaker sections appear as useful strategies to ensure their true representation.

- While building awareness and capacities of women and men for water management, the interventions need to address negative social beliefs regarding decision-making powers, the division of labour, and people's gender-based behaviour. Since all women and locations, including those in remote villages, are to be reached, gender-sensitive information and gender-responsive communication are essential. Also, appropriate communication outreach mechanisms are required to ensure all groups have adequate information about programmes and projects.
- These various changes are key to establishing an enabling environment where women are more comfortable sharing their thoughts and ideas in meetings, in training sessions, and during practical activities of water management. Achieving these transformations is not easy, but as several case studies demonstrate, this is certainly doable when practitioners, implementers, donors, volunteers, project staff, and teams share a common understanding of gendered challenges and are committed and incentivised to address them successfully.

Worldwide experience shows these steps promoting overall gender mainstreaming are achievable, and the adoption of gender budgeting and auditing tools proves immensely useful too.

However, apart from this, the fundamental challenges of power dynamics and structural inequities of caste, class, and wealth/resource distribution patterns that affect society in general highly impact the marginalised communities. These are also important factors affecting women's participation and opportunities in water management. These principles, therefore, must be acknowledged while setting gender-equal goals. As women belong to different socio-economic strata and are divided into the previously discussed categories, it is these factors that dictate which categories of women will get opportunities to participate at different levels. The issue of women's independent access to water, like that of independent land titles, is fundamental. Currently, water access being linked to land ownership is unfavourable for women. Therefore, the de-linking of access to water from land ownership is equally important.

Our study indicates that, till date, women are largely involved in water management practices at the level of activity-specific participation (participating in *shramdaan*, transfer of some managerial tasks); by and large, these projects do not transfer the decision power to design activities and making such initiatives relevant to them.

Future research needs to pay more attention to locally crafted initiatives that help gender mainstreaming strategies and support the building of a gender-just, enabling environment for men and women equally.

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### Notes

- 1 The Managed Aquifer Recharge and Sustaining Groundwater Use through Village-level Interventions project is implemented in Rajasthan and Gujarat. More details available at <https://www.marvi.org.in/welcome-to-marvi>.
- 2 The Andhra Pradesh Farmers' Managed Groundwater System Project is implemented in seven districts of Andhra Pradesh, supported by the World Bank. More details available at <https://documents1.worldbank.org/curated/en/272661468267911138/pdf/516760ESW0P0951round0Water129101110.pdf>.

- 3 An accredited social health activist (ASHA) mobilises the community and facilitates their access to health-related services available at anganwadis/primary health centres/sub-centres.

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# 7

## GENDERED VULNERABILITIES IN THE SUNDARBANS, INDIA

A case of climate change–induced menstrual and reproductive health risks

*Jayati Chourey*

### 7.1 Introduction

#### 7.1.1 *The Sundarbans*

The Sundarbans, a UNESCO World Heritage site shared between India and Bangladesh, is home to the largest mangrove forest in the world. The Indian Sundarbans Delta is part of the Ganga–Brahmaputra–Meghna basin in Asia. Extending between 21°32' and 22°40' north latitude and between 88°05' and 89°00' east longitude, this region is bordered by the Hooghly River to the west, the Bay of Bengal to the south, the Ichamati–Kalindi–Raimongal rivers to the east, and the Dampier–Hodges line to the north (The Department of Sundarbans Affairs, Government of West Bengal). The Sundarbans comprise a mosaic of low-lying islands interconnected by a complex network of tidal waterways, estuaries, creeks, and mudflats (Figure 7.1). During high tide, the entire area is inundated with brackish water that mixes with freshwater from the inland rivers (Pramanik et al., 2019). The total land area of the Sundarbans measures 9,629 km<sup>2</sup>, of which 4,493 km<sup>2</sup> are inhabited, while the remaining is designated as reserve forest (The Department of Sundarbans Affairs, Government of West Bengal).

The Sundarbans play a crucial role in supporting both terrestrial and aquatic biodiversity. Its mangrove forests serve as vital habitats for numerous rare and globally threatened wildlife species. This region not only is rich in biodiversity but also supports a human population of over 4.5 million individuals who inhabit 54 of the 102 islands. These communities primarily engage in fishing, agriculture, and the collection of wood and honey for their livelihoods.



island villages of the Sundarbans, affecting both ecosystems and human communities. Beyond salinity increases, environmental pollution severely affects water quality, with pollutants transported from upstream industrial areas and agricultural runoff containing chemical fertilisers and pesticides. Combined, these factors exacerbate water insecurity in the Sundarbans.

Traditionally, residents of the Sundarbans have adapted to saline conditions by constructing inland freshwater ponds. But frequent storm surges and floods regularly inundate island villages, leading to the salinisation and contamination of these freshwater sources. Ongoing threats from sea level rise, salinisation, and flooding have rendered daily life in the area increasingly difficult (Sánchez-Triana et al., 2018).

Many villages continue to rely on contaminated water due to a lack of alternatives. With no treated piped water available, communities depend on hand pumps and ponds for drinking and household use. Although groundwater is generally less contaminated, high irrigation demands place additional stress on these sources.

The lack of safe water, compounded by food insecurity and limited health-care access, has triggered a public health crisis, with women and marginalised communities bearing the brunt of these situations. The complex effects of climate change in the Sundarbans are different for men and women, with the latter having to deal with unique problems that warrant closer examination. In this chapter, we explore these challenges, particularly the ones concerning menstrual and reproductive health, highlighting the gender dynamics of climate change effects.

Through a regional case study, we bring out the need for comprehensive, gender-responsive, and inclusive strategies to address these challenges. It points to initiatives that prioritise the health and well-being of all community members, particularly those women who are among the most vulnerable.

## 7.2 Literature review

### 7.2.1 *Water quality threats in the Sundarbans*

Groundwater salinisation of coastal aquifers in the Sundarbans due to climate change and anthropogenic activities poses significant problems, most of all rendering drinking water unpotable (Mondal et al., 2024). Salinity issues are exacerbated by frequent storms, sea level rise, and shoreline erosion, reducing freshwater availability and threatening agricultural productivity and local livelihoods (CGWB, 2023; Choudhury et al., 2021; Prusty & Farooq, 2022; Salam & Sultana, 2022).

Surface water salinity ranges from 9.4 to 30.8 PSU (practical salinity units), with higher levels in summer (Sarkar & Bhattacharya, 2010). Choudhury et al. (2021) report post-monsoon salinity averaging 10.58 PPT (parts per

thousand) compared to 27.31 PPT pre-monsoon, while tube well groundwater salinity ranges from 0.42 to 5.16 PPT, and river water salinity is between 13 and 27 PPT. Alarmingly, 17 of 50 hamlets exceed 1 PPT, raising health and agricultural concerns (Basar, 2012; Biswas, 2022).

Agricultural practices are severely affected by rising salinity, variable rainfall, and recurrent cyclones (Nath et al., 2021). Climate change contributes to low irrigation efficiency and worsens waterlogging issues (Ghosh & Mistri, 2020). Rising sea levels could cause salinity to reach oceanic levels (approx. 32 PPT) by 2050, posing health risks such as dehydration (Dasgupta et al., 2020). High total dissolved solids and electrical conductivity in groundwater in areas like South 24 Parganas further threaten community health (see Figure 7.2).

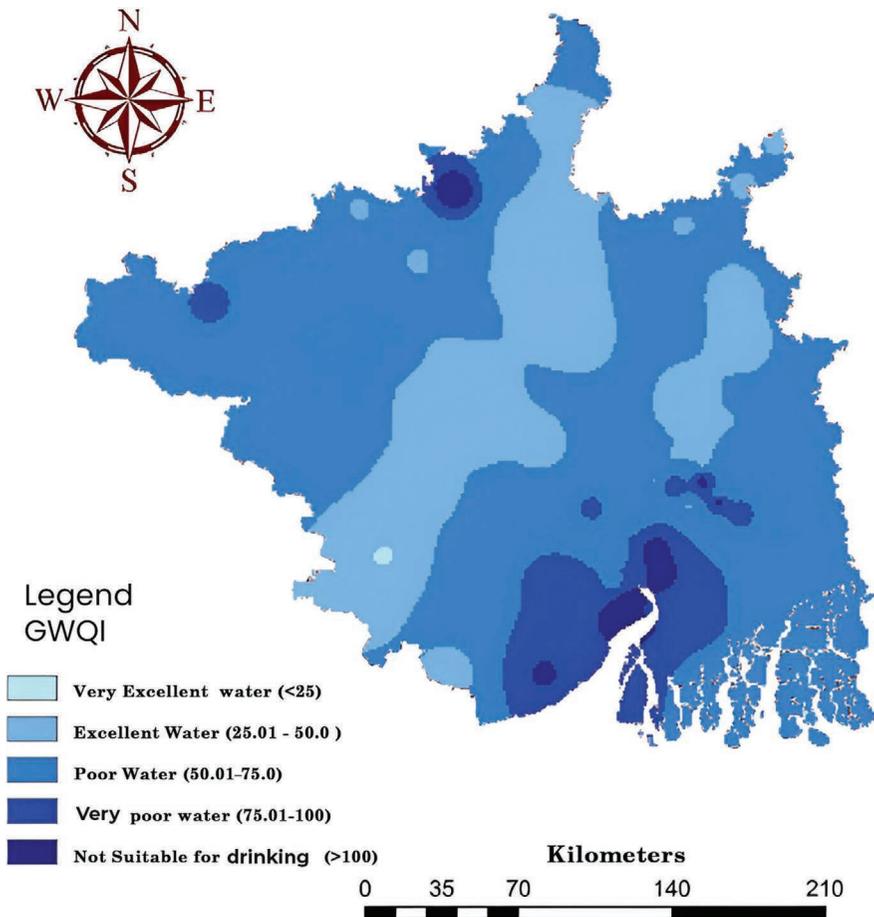


FIGURE 7.2 WQI for drinking water suitability in South Bengal.

Source: Figure redrawn based on Soren et al. (2023).

Pollution from industrial activities and sewage increasingly compromises the western Sundarbans delta, with heavy metals accumulating in shellfish (Mitra et al., 2014). The Bidyadhari river basin suffers from water quality deterioration due to industrial effluents mixed with sewage, causing biological magnification (Das & Datta, 2014). After cyclone Amphan in 2020, over 56 t of plastic waste were found, largely from unregulated relief efforts (Kumar et al., 2022).

Heavy metal concentrations in estuarine waters are causing concern in the Sela River, with lead ranging from 20 to 148 µg/L, cadmium from 18.2 to 53.6 µg/L, and chromium from 23.3 to 53.5 µg/L (Choudhury et al., 2021). In the Passur River, variations in heavy metal concentrations indicate significant water quality disparities (Rahman et al., 2011). Emerging contaminants, including phenols, triclosan, and non-steroidal anti-inflammatory drugs (NSAIDs), reflect ongoing ecological effects.

The Sundarbans faces urgent challenges from rising salinity and pollution, intensified by climate change and human activities. Integrated management strategies are essential to address these issues and ensure ecological integrity and community resilience in the delta.

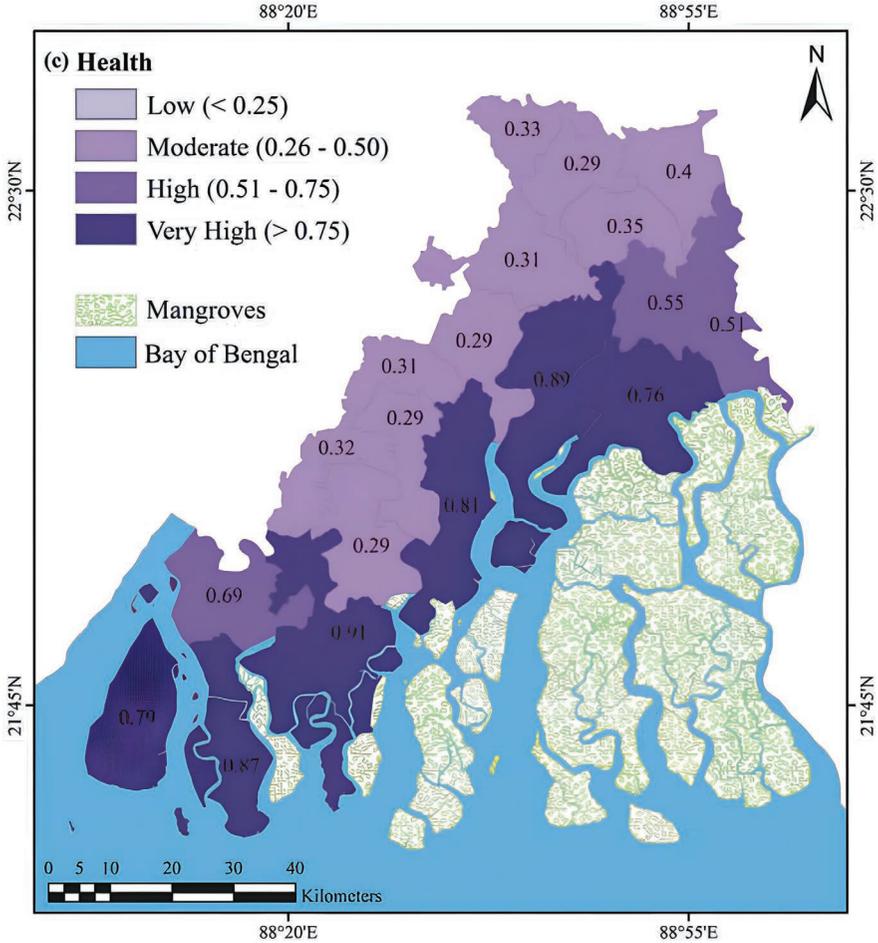
### ***7.2.2 Impact of water quality deterioration on women's menstrual and reproductive health***

The Indian Sundarbans Biosphere Reserve is particularly vulnerable to cyclones, floods, and storm surges, with a very high health-related socio-economic vulnerability noted in certain blocks, including Gosaba and Patharpratima (see Figure 7.3).

The increasing salinity and contamination of water sources due to climate change significantly affect women's health, particularly in vulnerable coastal regions, such as the Sundarbans in India and Bangladesh. Climate change exacerbates saltwater intrusion into freshwater sources, raising salinity levels in drinking water, posing considerable health risks for women, especially during pregnancy.

Women consuming highly saline water in coastal Bangladesh experience higher rates of hypertension during pregnancy, particularly in the dry season (Khan et al., 2011). Excessive salt intake contributes to adverse maternal health outcomes, including pre-eclampsia and premature deliveries (Khan et al., 2011; Women and Gender Constituency etc., n.d.).

In the Sundarbans, daily exposure to saline water adversely affects women's health (Sen, 2023). Carrying out activities such as catching tiger prawn seeds subject women to a prolonged exposure to high salinity. This leads to chronic health issues, including excessive menstrual bleeding, severe pain during sexual intercourse, and increased susceptibility to infections like pelvic inflammatory disease (Bhattacharya, 2021). Women



**FIGURE 7.3** Health-related socio-economic vulnerability, with Gosaba and Patharpratima as very high-vulnerability zones.

Source: Figure redrawn based on Sahana et al. (2019).

report higher rates of miscarriage, child mortality, and infertility due to saline water exposure. A study published by the International Centre for Diarrhoeal Disease Research, Bangladesh, tracked 12,867 women from conception to delivery from 2012 to 2016, showing that those residing within 20 km of the sea had a significantly higher risk of miscarriage (ICCCAD, 2024).

Cultural practices and socio-economic factors exacerbate their vulnerability, because many women lack access to adequate healthcare and sanitation

facilities (Karmakar, 2022). The increased salinity and contamination of water also affect menstrual hygiene management. Women and girls in these regions often lack access to sanitary products and rely on clothes, which are unsuitable for menstrual hygiene due to insufficient clean water for washing. This practice is associated with abnormal excessive vaginal discharge, skin irritations, and urogenital infections, compounding reproductive health problems (Mondal & Chakraborty, 2022). Studies emphasise the need for improved access to sanitary products and better menstrual hygiene practices to mitigate these risks (Deccan Herald, 2022; Mondal & Chakraborty, 2022).

Water pollution, particularly through the contamination of water sources with endocrine-disrupting chemicals, poses significant risks to women's reproductive health. A variety of pollutants, including heavy metals, pesticides, and industrial chemicals, disrupt hormonal functions and are linked to reproductive disorders, such as endometriosis, infertility, and menstrual irregularities (Canipari et al., 2020; Hassan et al., 2024; Vallée et al., 2023).

The effect of climate change on women's health is complex and multifaceted. In the Sundarbans, women's livelihoods are closely linked to natural resources, making them particularly vulnerable to environmental changes. The migration of male family members in search of better job opportunities often leaves women responsible for the management of household and subsistence, further straining their health and well-being (Priyadarshini, 2015; Sahana et al., 2019).

Cultural norms frequently restrict women's mobility and access to healthcare, hindering timely medical attention. This, combined with the economic burdens of caregiving roles, leaves women vulnerable to climate-induced health challenges (Bradshaw & Fordham, 2014; Parry et al., 2019).

Climate change is exacerbating health challenges for marginalised women and children, leading to malnutrition, depression, increased cervical cancer, and STDs (Ghosh & Dutta, 2024). In the Indian Sundarbans, socio-ecological misgovernance and patriarchal structures worsen these risks, underscoring the need for integrated governance that empowers vulnerable populations.

To be sure, existing studies do establish connections between high salinity levels, environmental pollution, and women's menstrual health. But the literature review reveals that research specifically focused on the Indian Sundarbans is limited. Our study aimed to address this gap by exploring how rising salinity and deteriorating water quality uniquely affect women's health in this vulnerable region.

Notably, our research has highlighted the need for awareness creation and capacity building among community members to empower them to deal with

these challenges. Moreover, by prioritising gender-responsive and gender-inclusive strategies for adaptation, we attempt to provide valuable recommendations which can inform local policy and practice.

Ultimately, our work is aimed at contributing to a better understanding of the intersection of climate change, water quality deterioration, and women's health to enhance community resilience in the Sundarbans.

### 7.3 Materials and methods

#### 7.3.1 Study area

Our study focused on the Sundarbans region in the South 24 Parganas district of West Bengal. We selected it for its climate vulnerability, menstrual and reproductive health risks, and water salinity issues. The most affected blocks, Patharpratima and Gosaba, were chosen because of their high vulnerability (Figure 7.3). Within these blocks, four villages were randomly selected: Chandipur and Hetalbari from Gosaba, and Mahendra Nagar and Durbachati from Patharpratima (Figure 7.4). Table 7.1 presents the demographic characteristics of these villages.

The area under study has been designated as a high-risk zone according to climatic hazard and disaster study parameters of the India Meteorological Department on account of frequent cyclones, flooding, embankment breaching, and storm surges, along with a high density of population (Halder & Debnath, 2014). The Patharpratima and Gosaba blocks exhibited very high exposure to flood inundation and storm surges (Figure 7.5). The primary factors contributing to this heightened exposure were high drainage density, proximity to drainage channels, and significant storm surge heights (Sahana et al., 2019).

#### 7.3.2 Research method

For our research, we employed the method of participatory action, involving community members, particularly women, to gain insights into their lived experiences and perceptions regarding water quality and health issues, particularly concerning menstrual and reproductive health.

We used a combination of quantitative and qualitative methods in our study. Data collection methods included semi-structured interviews, focus group discussions, and field observations. Also, we formed a participatory action research group (PARG). The objective was to co-create knowledge and to empower marginalised communities to develop resilience-building solutions.

Household surveys were conducted via the Kobo Collect app. We interviewed 400 women (100 from each village) on climate change effects,

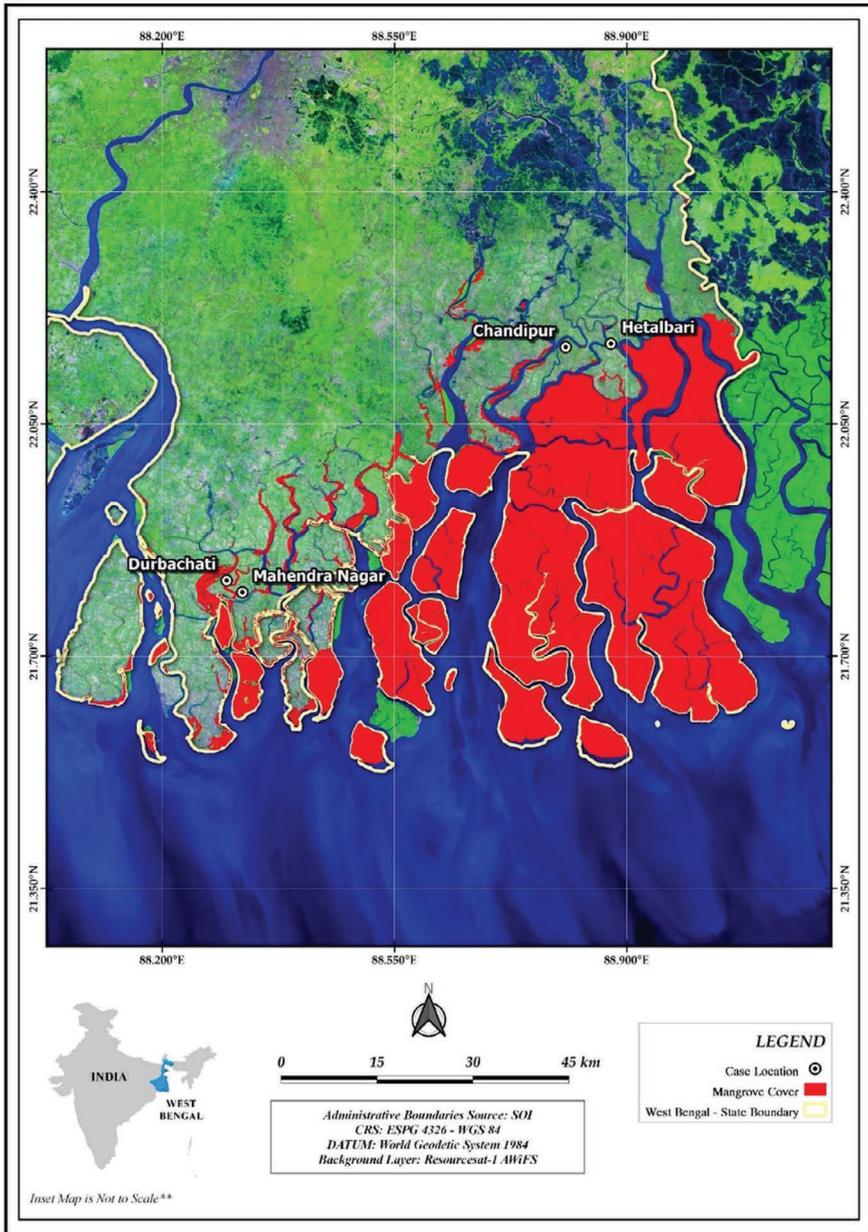


FIGURE 7.4 Study area location map.

Source: Aluri Sai Vardhan, SaciWATERS.

**TABLE 7.1** Demographic characteristics of the study villages

<i>Village</i>	<i>Panchayat</i>	<i>No. of households</i>	<i>Total population</i>	<i>Men</i>	<i>Women</i>	<i>Scheduled castes</i>	<i>Scheduled tribes</i>	<i>Area (ha)</i>
Chandipur	Bipradaspur	1,392	5,456	2,781	2,675	1,153	357	716.2
Hetalbari	Chotomollakhali	984	3,975	2,019	1,956	3,592	138	512.79
Durbachati	Durbachati	1,130	3,830	1,936	1,894	718	119	393.05
Mahendra Nagar	Gopalnagar	613	2,192	1,117	1,075	62	0	280.7

*Source:* Census of India (2011).

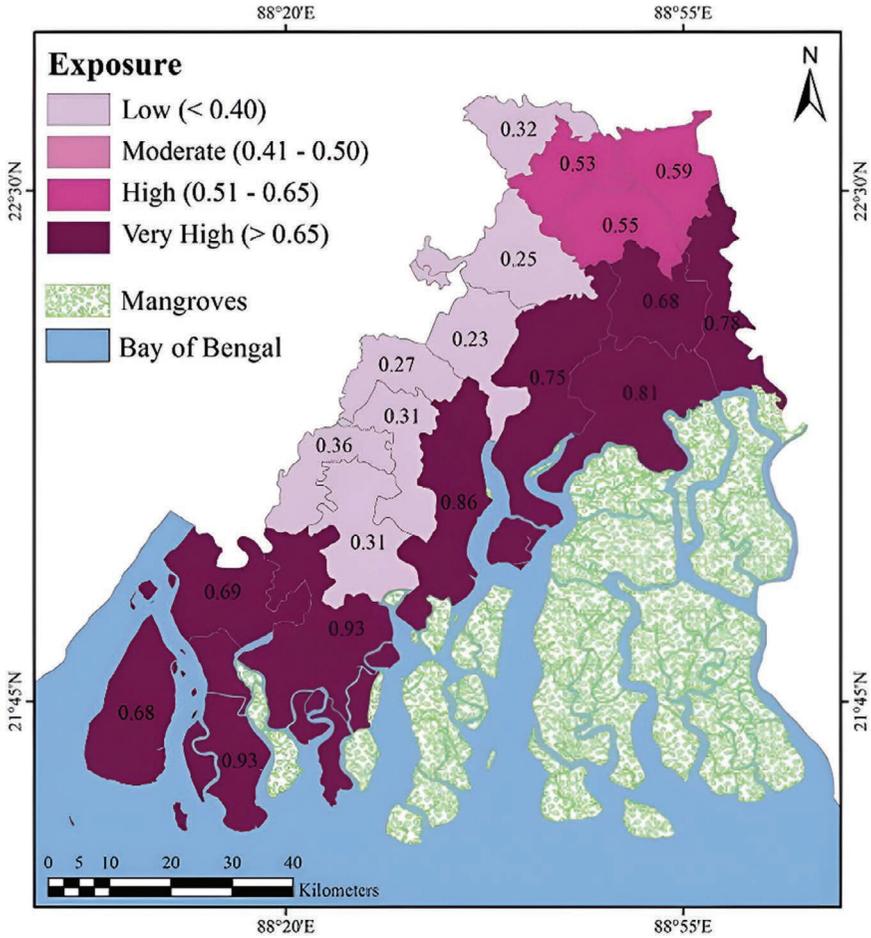


FIGURE 7.5 Degree of household exposure to flood inundation and storm surges in the Indian Sundarbans region.

Source: Figure redrawn based on Sahana et al. (2019).

livelihood, water quality, sanitation, menstrual health management, and healthcare access. Field visits provided personal insights, as did informal discussions with community members about challenges like cyclones and water salinity, and healthcare access as well.

Additionally, we held eight village-level PARG workshops to facilitate awareness creation, knowledge sharing, and capacity building. The focus was on adaptation solutions for menstrual and reproductive health and on links between climate change and women’s hygiene management.

A state-level workshop in Kolkata and two block-level workshops disseminated research findings to stakeholders, encouraging discussions on policy implications. Rigorous analysis of data from the surveys, field visits, and workshops helped identify key findings and challenges. These were compiled into a comprehensive report with detailed insights and recommendations.

## 7.4 Results

Our action research took place from May 2023 to March 2024. Its findings are exploratory in nature, since we were mainly relying on stakeholder observations and experiential insights rather than clinical assessments. Even so, our research is bringing out a need for awareness creation and capacity building among community members to empower them to deal with various challenges.

This section presents selected key findings from the surveys, group discussions, and PARG workshops. Although data collection covered various aspects, we focus here on key insights that underscore the gendered vulnerabilities and multifaceted impacts of climate change, including water quality deterioration and women's menstrual and reproductive health.

### 7.4.1 Multifaceted effects of climate change in the study area

The multifaceted effects of climate change in the study area cover a range of environmental, social, and economic challenges, as validated through household surveys and PARG workshops. Very important is the region's vulnerability to rising sea levels, intensified cyclones, soil and water salinisation, and frequent flooding. These factors disrupt ecosystems, livelihoods, and the well-being of communities in the area.

#### 7.4.1.1 Frequency and intensity of cyclones and floods

The increasing frequency and severity of cyclonic storms – evident from events such as Aila (2009), Phailin (2013), and Amphan (2020) – have had lasting effects on the landscape and livelihoods of the local communities. Additionally, environmental pollution from industrial and agricultural sources exacerbates water quality deterioration, posing significant health risks to residents.

When respondents were asked about their experiences with cyclones, a significant majority reported an increase in cyclone frequency over time. This points to the growing vulnerability of the region to climate-related threats (Table 7.2).

**TABLE 7.2** Perceptions of cyclone and flood frequency among women in the study villages

Village	% report of frequency of cyclones (and associated floods) per year
Chandipur	88% 1–2 times; 11% 2–3 times; 1% more than 4 times
Hetalbari	1% 1–2 times; 32% 2–3 times; 61% 3–4 times; 6% more than 4 times
Durbachati	1% 1–2 times; 87% 2–3 times; 12% 3–4 times
Mahendra Nagar	100% report cyclones 1–2 times

Source: Respondents.

To illustrate, Najma Sardar (50 years) from the Chandipur village in the Gosaba block stated this at a PARG meeting in November 2023:

*‘My family has lost a substantial area of our farmland near the Bidyadhari River due to riverbank intrusions, and our freshwater pond has turned saline from frequent floods and cyclones. Our life in the Sundarbans has changed significantly since Aila hit the village. Every time a cyclone strikes, we rebuild our lives, only to face another disaster waiting on the horizon. We now live in constant threat and stress!’*

Regarding trends, 87% of Chandipur respondents and 86% from Hetalbari perceived an increase in cyclone frequency; all in Durbachati and Mahendra Nagar agreed occurrences have risen over the years.

When queried about the effect of natural disasters, respondents narrated many problems. These included destruction of agricultural crops and collapse of roofs and walls due to *kuchcha* roads, trees, and houses. The aftermath of such a disaster would often extend to temporary bathrooms being invaded by saline water, forcing individuals to open latrine practices.

Additionally, saline water intrusion into ponds would lead to the death of freshwater fish, while livestock would also suffer. The infiltration of saline water into houses would add to health problems, such as skin irritation and rashes, while unhygienic conditions would foster infections.

Moreover, animal carcasses in water sources would contribute to pollution and emit foul odours. In all this, soil quality would suffer, and households were to bear the financial burden of rebuilding infrastructure and homes. Economic consequences would also include disrupted businesses, reduced productivity, and increased unemployment.

Collectively, natural disasters disrupt daily livelihoods by hindering communication, power supply, and transportation services, worsening the challenges households have to face already in the aftermath of such natural calamities. Evidently, the effect of climate change is multifaceted and complex, with many layers, some seen and some unseen.

### 7.4.2 Climate change, water quality deterioration, and effect on community health

Respondents reacted to queries regarding water quality deterioration, the underlying causes, and their perception of environmental changes in the Sundarbans region. We had asked these questions to assess their awareness levels and the implications for community health.

#### 7.4.2.1 Awareness of water quality changes

- In Chandipur, only 47% of respondents were aware of changes in water quality, indicating a significant lack of awareness compared to other villages. This limited awareness may stem from their habitual use of poor-quality water and insufficient environmental education. It may also be attributed to educational disparities.
- In Hetalbari, awareness was universal (100%).
- In Durbachati, 96% were aware, while in Mahendra Nagar, 99% showed awareness.

Heightened salinity is the primary factor contributing to water quality deterioration, often made worse by natural disasters, such as floods and cyclones (Tables 7.3 and 7.4).

**TABLE 7.3** Perceptions of water quality changes

<i>Village</i>	<i>Notable water quality changes</i>
Chandipur	Increased salinity (36%), turbidity (8%), contamination (1%)
Hetalbari	Increased salinity (88%), turbidity (86%), contamination (65%)
Durbachati	Increased salinity (76%), turbidity (38%), contamination (29%)
Mahendra Nagar	Increased salinity (94%), turbidity (87%), contamination (24%)

*Source:* Respondents.

**TABLE 7.4** Perceptions of causes of water quality deterioration

<i>Village</i>	<i>Main causes of water quality deterioration</i>
Chandipur	98% saline intrusion, sewage pollution (1%)
Hetalbari	100% agricultural runoff, saline intrusion (88%), defective tube wells, sewage pollution (4%)
Durbachati	87% saline intrusion, agricultural runoff (45%), defective tube wells (16%), and sewage pollution (13%)
Mahendra Nagar	94% saline intrusion, defective tube wells (22%), agricultural runoff (6%), sewage pollution (6%)

*Source:* Respondents.

### 7.4.2.2 Causes of water quality deterioration

Residents attributed increased salinity primarily to saline water intrusion during cyclones and floods (Table 7.4).

Overall, excessive water salinity emerged as the principal cause of water quality deterioration, with domestic sewage and floating carcasses also recognised as contributing factors. Beyond climate-induced salinity, environmental pollution from industrial discharge and agricultural runoff compound water quality problems. This compounded effect has intensified water insecurity across the Sundarbans, leading many communities to continue using contaminated water due to a lack of alternatives (Tables 7.3 and 7.4).

### 7.4.2.3 Drinking water sources and management

Drinking water management varies among communities (Table 7.5).

### 7.4.2.4 Drinking water purification methods

Purification methods to ensure clean drinking water also differ (Table 7.6). According to the *Jal Jeevan* Mission, West Bengal, the Public Health Engineering Department's WB-JJM dashboard (as of June 2024) gives the following coverage under the government water supply scheme: 0% households in Chandipur, 45% in Hetalbari, 18% in Durbachati, and 63% in Mahendra Nagar have household tap connections.

The groundwater-based water supply to households is only treated with chlorination, which does not adequately address salinity and other pollutants. The unavailability of treated piped water forces communities to rely on hand pumps for drinking and ponds for other essential activities. While groundwater is generally less contaminated than pond water, it faces considerable strain from excessive irrigation needs. This scenario leads to a public health crisis, worsened by the shortage of safe water for drinking, sanitation, and hygiene, ultimately undermining food security and access to healthcare services.

**TABLE 7.5** Responses from women on primary drinking water sources in the villages

<i>Village</i>	<i>Primary drinking water sources</i>
Chandipur	100% community tube wells
Hetalbari	99% community tube wells; 21% purchase RO water
Durbachati	99% community tube wells; 2% have household tap connections
Mahendra Nagar	49% community tube wells; 50% household tap connections

*Source:* Respondents.

**TABLE 7.6** Purification methods for drinking water as reported

<i>Village</i>	<i>Purification methods</i>
Chandipur	97% drink directly from the tube well, no purification; 2% use cloth to filter tube well water; 1% have home RO filters.
Hetalbari	95% drink directly; 5% have home filters.
Durbachati	90% use cloth, 9% drink directly from the tube well, 1% boil water.
Mahendra Nagar	100% use cloth for filtration.

*Source:* Respondents.

A medical officer at Patharpratima Rural Hospital shared:

*‘The majority of patients experience hypertension, hypothyroidism, dermatological issues, diarrhoea, and urinary tract infections. Approximately 60% face skin problems and genital infections linked to polluted water with high salinity, raising infection risks during childbirth.’*

While both men and women experience the consequences of climate change, women have to deal with unique challenges that merit closer examination. This chapter explores the distinct health issues women encounter, particularly regarding menstrual health, which remains stigmatised and under-discussed in the community.

### **7.4.3 Gendered vulnerabilities: climate change’s multifaceted impact on women’s menstrual and reproductive health**

Climate change has diverse impacts on women’s health in the Sundarbans, particularly affecting menstrual and reproductive health due to increased salinity and water contamination. The widespread use of pond water for bathing poses significant health risks for women, leading to various infections from exposure to saline and contaminated water.

#### **7.4.3.1 Water, sanitation, and hygiene (WASH) practices**

Table 7.7 summarises the primary bathing sources and menstrual product usage and acknowledgement of water quality effects on menstrual health as reported across the surveyed villages.

The reliance on pond water for bathing and the lack of access to treated water contribute to health risks, particularly during summer months, when salinity levels rise. Many women primarily use cloth for menstrual hygiene management and turn to sanitary napkins only when traveling due to

**TABLE 7.7** Overview of bathing sources and menstrual product usage reported

<i>Village</i>	<i>Primary bathing source</i>	<i>Menstrual product usage</i>
Chandipur	100% use ponds	55% cloth; 45% sanitary napkins
Hetalbari	92% ponds; 5% bathroom at home; 3% tube well	40% cloth; 62% sanitary napkins
Durbachati	86% ponds; 11% tube well; 3% bathroom	50% cloth; 45% sanitary napkins
Mahendra Nagar	99% ponds; 1% tube well	93% cloth; 21% sanitary napkins

*Source:* Respondents.

*Note:* Percentages may sum to over 100% as multiple responses were allowed.

accessibility and affordability problems. Washing menstrual cloth with contaminated water further heightens the risk of infection.

#### 7.4.3.2 Health issues related to menstrual and reproductive health

Dr Pallab Mondal, the general duty medical officer at Gosaba Rural Hospital, told us:

*‘There are growing cases of white discharge, recurring urinary tract infections (UTIs), irregular bleeding, and cysts among women aged above 30. The lack of advanced diagnostic facilities makes diagnosis and treatment challenging, often necessitating referrals to distant, larger government hospitals. Despite advising against pond bathing, practical constraints make it unavoidable for many women in the region. The number of hand pumps is limited and situated far from most homes for women, and due to limited availability, hand pumps are designated only for drinking water and cooking.’*

A significant proportion of women surveyed (77%) reported menstrual and reproductive health issues, with perceptions of water quality’s effect on health varying widely by village.

Table 7.8 summarises this.

Women in Chandipur appeared to have less awareness regarding the influence of water quality on menstrual health compared to those in other villages. Commonly reported health issues include skin irritation and irregular menstrual cycles in Chandipur, alongside increased instances of white discharge, heavy bleeding, and UTIs in Hetalbari and Mahendra Nagar.

Notably, Mahendra Nagar exhibits higher rates of UTIs and cases of uterine cysts, as shared during the group discussions, compared to other surveyed

**TABLE 7.8** Women's perception of water quality and associated health issues

<i>Village</i>	<i>% of women acknowledging water quality effect on menstrual health</i>	<i>Common health issues</i>
Chandipur	25%	Skin irritation around the genital area (21%); increase in white discharge (3%); painful cramps (5%); light bleeding (2%); vomiting, stomach infections, irregular menstrual cycles (1%)
Hetalbari	100%	Increase in white discharge (54%); irregular menstrual cycles (33%); skin irritation around the genitalia (31%), painful cramps (29%); light bleeding during menstruation (28%); heavy bleeding (21%); uterine cancer (2%); urinary tract infections (UTIs) (1%)
Durbachati	77%	Skin irritations around the genitalia (26%); heavy bleeding (23%); increase in white discharge (16%); irregular menstrual cycles (15%); light bleeding (11%); painful cramps (10%)
Mahendra Nagar	88%	Increase in white discharge (66%); skin irritations around the genitalia (56%); UTIs (31%); irregular menstrual cycles (20%); painful cramps (16%); uterine cancer (1%); heavy bleeding (1%); light bleeding (1%)

*Source:* Respondents.

*Note:* Percentages may sum to over 100% as multiple responses were allowed.

regions. This underscores the need to explore potential correlations between water quality and the incidence of these health issues in the area. Skin irritations around the genitalia and an increase in white discharge are common issues across all regions.

An intriguing observation emerged during the discussions, revealing a trend of 'normalising' skin problems and menstrual and reproductive health issues among women in the Sundarbans. These challenges have become so prevalent they are often considered routine, 'normal', unless they escalate significantly. As a result, when questioned about their health status, a significant number of women responded positively, stating they did not have any health problems.

But on further inquiry regarding specific symptoms, such as white discharge, heavy bleeding, urinary tract infections, and irregular menstrual

periods, they acknowledged experiencing such conditions. This normalisation highlights the pressing need to address and raise awareness about health concerns, ensuring they are not disregarded but recognised instead and managed appropriately.

#### 7.4.3.3 *Waist-deep fishing practices and menstrual and reproductive health risks*

Waist-deep fishing is a common practice in the Sundarbans. Women engage in this labour-intensive activity to gather food for their families. But this practice exposes them to various health risks that can adversely affect their menstrual and reproductive health.

#### 7.4.3.4 *Involvement in fish/prawn/crab capturing*

Data reveal a significant variability in the involvement of respondents in fish, prawn, and crab capturing across the surveyed villages. This could suggest different levels of reliance on aquatic resources. To illustrate, respondents in Gosaba are less involved in fish/prawn/crab capturing than those in Patharpratima.

Most women catch fish or crab in pond water for family consumption and not for commercial purposes. This indicates a subsistence rather than a commercial approach. Women in the study villages frequently carry out such activities in saline waters of rivers and creeks, exposing them to elevated salinity levels and various contaminants (Table 7.9).

Saline water can disrupt the balance of healthy bacteria in the vagina, increasing the risk of infection. Such exposure may lead to chronic health issues, including recurrent urinary tract and genital infections, excessive menstrual bleeding, early menopause, uterine cysts, and a heightened susceptibility to infections like pelvic inflammatory disease.

**TABLE 7.9** Involvement in aquatic resource capture and time spent in deep waters as reported

<i>Village</i>	<i>% of respondents involved in capturing</i>	<i>1–3 hours</i>	<i>4–6 hours</i>	<i>6–8 hours</i>
Chandipur	22	17	5	0
Hetalbari	26	22	4	0
Durbachati	65	47	14	4
Mahendra Nagar	83	83	0	0

*Source:* Respondents.

To compound the situation, according to scientific studies, various pollutants in contaminated water – including heavy metals, pesticides, and industrial chemicals – interfere with hormonal functions and are associated with reproductive disorders, such as endometriosis, infertility, and irregular menstrual cycles.

#### *7.4.3.5 Seeking medical assistance for menstrual and reproductive health problems*

The study villages lack healthcare facilities. Moreover, the absence of advanced diagnostic services at the block-level hospital makes adequate diagnosis and treatment difficult. This often necessitates referrals to distant, larger government hospitals.

Consulting a doctor or seeking medical help for menstruation-related health issues varies among respondents across villages in the Sundarbans region. In Chandipur and Hetalbari, a relatively high percentage of respondents – 82% and 83%, respectively – reported consulting doctors or seeking medical assistance for their menstrual and reproductive health. In contrast, in Durbachati and Mahendra Nagar, only 47% of respondents sought medical help for such concerns.

It is important to note that, in many cases, respondents paid heed to advice from an accredited social health activist (ASHA), a female community health worker. Her work, in a way, blurs the distinction between professional doctors and community health workers. In many cases, women had also been consulting village quacks, which is making their health situation worse.

Financial constraints and limited accessibility to medical centres were cited as significant barriers to seeking medical assistance, particularly in Mahendra Nagar. Additionally, a noteworthy finding from the survey is that a considerable number of respondents across all villages did not consider it necessary to consult a doctor for menstrual health issues. Instead, they adapted to managing these problems without professional medical help. This could point to a lack of awareness or lack of prioritisation of menstrual health concerns within the community.

#### *7.4.3.6 Menstrual hygiene management during natural disasters*

In the Sundarbans region, the aftermath of natural disasters presents significant challenges related to sanitation and menstrual health for the affected communities. The responses from surveyed villages show pressing water and sanitation issues at relief centres and menstruation-related challenges women face during such calamities.

Respondents enumerated several of these challenges, including insufficient sanitation facilities at disaster relief centres. There was, for instance, a lack of clean water to maintain personal hygiene, or to hot water, often needed to alleviate painful menstrual cramps.

**TABLE 7.10** Women's responses regarding sanitation and menstrual hygiene management (MHM) issues in relief centres

<i>Village</i>	<i>Major MHM concerns</i>
Chandipur	Unhygienic washrooms (45%); no provision to dry menstrual cloth (25%); no sanitation facilities inside bathrooms (14%); insufficient number of washrooms (7%); cramped spaces (3%); problems accessing bathrooms due to inundation (2%)
Hetalbari	Absence of soaps or amenities (44%); no provisions for dry menstrual cloth (41%); insufficient number of washrooms (38%); lack of gender separation in toilets (38%); unhygienic washrooms (23%); flooded washrooms (4%); cramped spaces (2%)
Durbachati	Absence of soaps or amenities (44%); unhygienic washrooms (28%); lack of gender separation in toilets (22%); insufficient number of washrooms (17%); no provisions for drying menstrual cloth (17%); flooded washrooms (10%); cramped spaces (2%)
Mahendra Nagar	Insufficient number of washrooms (51%); absence of soaps or amenities (16%); lack of gender separation in toilets (16%); unhygienic washrooms (14%); no provisions for drying clothes (12%); flooded washrooms (3%)

*Source:* Respondents.

Further, women experienced difficulties in drying, changing, and disposing of menstrual cloth. This would be getting worse for them because of adverse weather conditions, inadequate space, and a lack of proper disposal. Additionally, there was limited availability of food and essential resources, including insufficient sanitary pads.

Moreover, cramped conditions in disaster relief camps would not allow for separate spaces for men and women, which made personal hygiene maintenance difficult. Besides, unhygienic environments in relief centres could jeopardise health, which was compounded by difficulties in accessing medical help and nearby markets during critical times (Table 7.10).

#### 7.4.3.7 *Factors aggravating vulnerabilities of women*

Based on the findings from household surveys and PARG workshops, several factors appeared to increase the vulnerabilities of women:

- *Male migration dynamics.* We observed a high prevalence of male migration in the study area. This migration was primarily driven by the loss of livelihood opportunities, exacerbated by climate change effects.

In Chandipur, 47% of respondents have migrant workers in their families. This figure rises to 71% in Hetalbari, 84% in Durbachati, and 65% in Mahendra Nagar.

Many men migrate to cities in search of work, leaving behind women, children, and elderly family members in the Sundarbans. This places additional responsibilities on women, who must now manage household affairs by themselves and provide for their families in the absence of male support. This situation leads to feelings of loneliness, anxiety, and insecurity and, in turn, significantly affects their mental well-being and overall health, especially during disasters.

In the Sundarbans, where fish is a staple food, these women, who are not engaged in commercial fishing, often resort to waist-deep fishing in rivers and ponds to secure food for their families. This complex interconnectedness between climate change, loss of livelihoods, agricultural yields, property loss, and economic burden amplifies the vulnerabilities faced by women in these communities.

- *Economic constraints and period poverty.* *Period poverty* involves the inability to afford and access menstrual products, sanitation and hygiene facilities, as well as education on managing menstrual health. It is a widespread issue among women in the Sundarbans region, increasing their susceptibility to menstrual health challenges.

Due to economic constraints and the limited access to menstrual hygiene products, many women struggle to afford basic sanitary items like pads. Consequently, they often resort to using unhygienic alternatives, such as cloth, which can lead to infections and other health complications. The lack of proper menstrual hygiene management not only poses risks to their physical health but also affects their overall well-being and dignity.

Moreover, stigma surrounding menstruation on account of cultural reasons further marginalises these women, preventing them from seeking support or accessing essential resources.

- *Lack of awareness.* In the study area of the Sundarbans, as in many communities, there is a significant gap in awareness regarding reproductive and menstrual health, perpetuating misconceptions and taboos surrounding these crucial topics. This lack of understanding contributes to women's reluctance to prioritise their health and seek timely treatment, worsening existing problems. Consequently, inadequate healthcare access persists, resulting in poor health outcomes for women in these communities.

In the Sundarbans region, there is a prevailing perception, particularly among elderly women, that menstrual and reproductive health issues are unrelated to water quality. Many elderly women, accustomed to using water from ponds and rivers for decades, attribute health problems to sheer misfortune or the physical exertion associated with their daily

labour. This perception reflects a lack of awareness about the interconnectedness of water quality and reproductive health.

Women's reluctance to prioritise their health and seek timely treatment complicates these issues. Dipali Bhunia (35), from a fishing community in the Mandra Nagar village, remarked:

*'We have 15 patients with uterine tumours in our Purbo Para hamlet, which has 100 households. Women in the village feel shy and don't share early symptoms with anyone. If the symptoms are treated in the early stages, these major complications can be avoided.'*

- *Glaring data gaps in menstrual and reproductive health in the Sundarbans.* A significant finding of this study is the glaring gap in data availability regarding menstrual and reproductive health issues in the Sundarbans region. Despite the high prevalence of these health concerns among women, health centres primarily focus on documenting common vector-borne diseases, such as malaria and dengue, sidelining menstrual health management (MHM) and related risks.

ASHA workers shared during PARG workshops that health centres are currently not mandated to maintain records of menstrual health concerns, including white discharge, irregular periods, early menopause, heavy bleeding, or urinary tract infections. Existing women's health programmes prioritise pregnancy and maternal-child health, marginalising menstrual and reproductive health issues within the healthcare system.

This oversight not only perpetuates the neglect of critical health concerns but also reinforces the vulnerability of women in these communities. Even during disasters such as cyclones and floods, documentation of these health complications remains absent, leading to a lack of timely interventions and resource allocation. The lack of systematic data collection on menstrual and reproductive health issues contributes to the negligence of these large-scale public health challenges, ultimately hindering effective policy development and programme implementation.

## 7.5 Discussion

The Sundarbans region, particularly the South 24 Parganas district, is highly vulnerable to the impacts of climate change, earning the title of 'cyclone capital of India'. Its geographical location, ecological fragility, and socio-economic dynamics render it susceptible to climate-related adverse effects, exacerbating existing vulnerabilities. Here, we witness a clear manifestation of climate injustice, where communities contributing the least to global climate change face the greatest adversity.

Our study delved into the lived experiences of local communities, particularly women, revealing the multifaceted effects of climate change and environmental degradation on their livelihoods, health, and overall well-being. Residents of Chandipur, Hetalbari, Durbachati, and Mahendra Nagar shared narratives illustrating their recurrent struggles to rebuild after cyclones and floods. The loss of crops, infrastructure, and livelihood assets adds to their economic vulnerabilities and perpetuates cycles of poverty and food insecurity, particularly affecting women, who bear the burden of household and caregiving responsibilities.

Typically, climate change discourses regarding the Sundarbans do not adequately address salinity-related issues from the perspective of water as a human right for drinking and sanitation. This oversight is especially evident with regards menstrual health, which remains neglected in climate resilience-building discussions, policies, and actions. Additionally, water pollution issues are often overlooked, further heightening health risks for local communities.

Our study highlights the crucial link between water quality deterioration and women's health in the Sundarbans. The findings indicate that many women struggle to manage menstrual hygiene due to a lack of access to clean water and adequate sanitation facilities. Period poverty exacerbates this challenge, as numerous women cannot afford basic menstrual hygiene products, resulting in adverse health outcomes that perpetuate cycles of poverty and vulnerability. Further, intersecting vulnerabilities arise from socio-economic factors, such as male migration and economic constraints.

A significant finding of our research is the notable gap in data concerning menstrual and reproductive health issues in the Sundarbans. This oversight perpetuates the marginalisation of critical health concerns within the healthcare system. Even during disasters like cyclones and floods, documentation of these health complications is lacking. To address this gap, there is an urgent need to integrate menstrual and reproductive health into the healthcare framework, giving prime attention to these issues alongside infectious diseases.

In response to these challenges, our study emphasises the necessity of context-specific and gender-responsive adaptation strategies that address the needs of vulnerable communities in the Sundarbans. Building collectives to amplify local narratives and engaging women and marginalised groups in decision-making processes ensure that adaptation strategies are holistic, inclusive, and sustainable. It is essential to examine the root causes of these challenges and promote nature-based solutions, such as mangrove restoration, to protect these vital ecosystems, for long-term sustainability and the protection of communities living there.

## 7.6 Recommendations

Addressing the complex challenges of climate change along with menstrual and reproductive health in the Sundarbans requires a multifaceted approach aimed at enhancing resilience among women in the region. It is essential to recognise the critical importance of water quality, since it serves as a fundamental cause of various health problems. There is an urgent need for further scientific research to generate evidence and inform effective, sustainable interventions.

Collaborative actions that integrate health and climate responses must be prioritised. These include mainstreaming menstrual and reproductive health within adaptation strategies, empowering women as active decision-makers, and fostering community-based solutions. Immediate and inclusive policies are vital to drive change and safeguard the well-being of women in the area.

The following specific recommended actions present an inclusive strategy tailored to build resilience among women in the Sundarbans:

- *Mainstreaming menstrual and reproductive health in policies and actions.* Integrate menstrual health management into primary healthcare services and climate change adaptation strategies. This should include promoting awareness, ensuring access to safe water, and providing affordable and sustainable menstrual hygiene products, while employing gender-sensitive approaches in health policies.
- *Conducting in-depth research.* Carry out comprehensive scientific studies and clinical research for a better understanding of women's health challenges related to climate change-induced water quality issues.
- *Developing gender-responsive policies.* Create and enforce policies that specifically target the needs and vulnerabilities of women in the Sundarbans. These policies should promote gender equality, enhance women's access to resources, build their capacity, and strengthen financial services and social protection mechanisms. Involving women's self-help groups in maintaining health records can support evidence-based policy advocacy and targeted interventions.
- *Increasing awareness and education.* Implement community education initiatives to raise awareness about menstrual and reproductive health issues and the crucial role of water quality. Empower women to make informed decisions and seek necessary medical support. Awareness campaigns should address the taboos surrounding menstruation to foster open discussions.
- *Empowerment and capacity building.* Empower women through education, skills training, and leadership opportunities, encouraging their active participation in decision-making processes related to climate adaptation and disaster preparedness. Provide skill-based training and support to help them adopt climate-resilient and risk-free livelihoods.

- *Improving access to resources.* Ensure equitable access to essential resources, such as clean water, healthcare facilities, and livelihood opportunities. Addressing socio-economic disparities is crucial for enhancing resilience among marginalised communities.
- *Building climate-resilient infrastructure, nature-based solutions, and innovative technologies.* Invest in climate-resilient infrastructure and technologies to mitigate the impact of environmental challenges, such as flooding and salinity intrusion. Implement nature-based solutions like mangrove restoration to provide natural coastal protection against disasters. Develop community-based solutions for pond management and innovative, cost-effective technologies for water treatment suited for remote island villages.
- *Fostering partnerships and collaboration.* Build collaborative efforts to encourage multi-stakeholder and community involvement, amplifying the voices of those most affected by climate change, particularly women. Develop partnerships among government agencies, NGOs, academia, and local communities to coordinate efforts and leverage resources effectively, ensuring holistic and sustainable solutions to the complex challenges these communities face.

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# 8

## ENSURING JUSTICE FOR CLIMATE-DISPLACED PEOPLE

*Ranjan K. Panda*

### 8.1 Introduction

Almost all regions of the world are facing an increasing crisis of displacement caused by climate and weather extremes. Small island states are disproportionately affected (IPCC, 2022b), and so are many low-lying local geographical areas of the world. States like several coastal areas of Odisha, on the Bay of Bengal, can be classified as a low-lying, local geographical area. In fact, in such regions, climate change has generated and perpetuated vulnerability through displacement and involuntary migration from extreme weather and climate events.

Such displacements will increase in the mid to long term with more weather extreme effects, such as sea level rise, tropical cyclones, drought, extreme precipitation, and so on (IPCC, 2022a). In fact, many areas of the world have already reached both soft and hard limits of adaptation, forcing people to migrate out of those geographies.

Regions with high exposure and low adaptive capacities would face more involuntary migration in times to come, considering progressive levels of warnings (IPCC, 2022d). As more areas, including coastal zones, experience situations where the limits of adaptation will be reached at heightened levels of global warming, communities will face bigger problems of water scarcity, reduced agricultural production, health crises, and many more.

In geographies that are fast reaching their adaptation limits, things may go worse above the 1.5°C global warming level. Some studies quantify that a 1°C increase in temperature can lead to an 11.9% increase in global migration (Semenza & Ebi, 2019). Under such increased warming levels, adaptation efforts have to transition from incremental to transformational levels.

But unless local governance and finance systems evolve to cover comprehensively all losses and damages occurring from such situations, where soft and hard limits to adaptation are reached, many vulnerable geographies in developing countries will force people to migrate out of their homes. With rising global warming, losses and damages increase and become more and more difficult to avoid, particularly when it is strongly concentrated among the poorest vulnerable populations (IPCC, 2022e).

The Asia and Pacific regions are especially more susceptible to human mobility – both migration and displacement – due to disasters (FAO & IOM, 2023). Facing an all-time high rise in natural hazards that is set to go up further significantly in the coming decades due to climate change, this region has to be especially attentive to adaptation planning to tackle such disasters and the fallout in the form of forced displacement, among others. Over the past 10 years, disasters have caused 225.3 million internal displacements in this region – almost 78% of the global total (IDMC, 2022).

There is growing evidence that climate hazards and variability are directly causing displacement. Also, that climate-induced displacements will increase in the mid-term and long-term from both sudden events and slow-onset effects (IPCC, 2022a). Climate change brings about migration as a risk-reducing or coping strategy for people who want to move out of harm's way.

There is a school of thought that talks about migration as an adaptation strategy. Adaptation in human systems is the process of adjustment to actual or expected climate events, and their effects, in order to mitigate harm or even exploit beneficial opportunities (IPCC, 2012).

In reality, people are forced to move out from areas that have failed, are failing, or will fail in getting them a dignified life and livelihood and in maintaining other societal functions. That is called an adaptation strategy (Lone-sco & Chazalnoel, 2024). Too often, though, migration exposes people to new threats (including new climate hazards) while on the move or at the place of destination.

Extreme weather events directly cause displacements. Climate change is also considered a 'threat multiplier', since it aggravates the effects of other factors that can cause displacement. Poverty, loss of livelihood, problems emanating from dwindling resources, etc. can also create stressors that can lead to conflict and displacement (Siegfried, 2023).

For these reasons, the IPCC report calls for an expansion of local adaptive capacity to minimise the negative impacts of displacement and involuntary migration. Alongside, it advocates for improving migration options so that climate-induced mobility is safer and more orderly and reflects migration by choice, not by force. Progressively, effective responses to slow- and sudden-onset climate hazards will require policies and investments that consider both in-place and mobile responses.

Through our study in the Bay of Bengal, we examined some key issues and challenges people face who are struggling with constant displacement due to climate change, such as sea level rise. In this context, rehabilitation challenges, existing plans, and policy measures to support these climate-displaced people received a closer look. Our study, however, was based on qualitative data collection analysis and, hence, may have some limitations with regard to suggesting measures that require quantitative data. Being a rapid analysis, done with the help of focused group discussions and testimonial evidence, the study has been able to capture broader issues and recommendations based on those that are important, nonetheless. In this chapter, we also touch upon the human rights aspect of climate-induced displacement. We suggest policy measures that can provide climate-displaced people a life with dignity and rights beyond general welfare measures.

Welfare schemes are usually considered the best form of governance, as these vulnerable communities need policy measures to support their right to a dignified life. Existing welfare schemes definitely help them exercise their right to life, but climate-displaced people face special situations because they have to leave their homes and livelihoods with no compensation in sight.

That is why it is important for governance structures to formulate policy measures for welfare schemes that not only provide basic amenities and access to food, shelter, and other needs, but also rights to resources and livelihoods. The right to stay or move, in the context of climate change, needs to be governed by policies and plans for which governments at all levels should work together along with other stakeholders.

We focused on the vulnerabilities of climate-displaced communities along the coasts of the Bay of Bengal. In order to achieve climate justice, we need to consider and close gaps in current policy measures supporting climate-displaced communities. The need for an inclusive strategy to ensure the rights and dignity of internally displaced people is imperative.

## 8.2 Climate displacement and migration – an introduction

There are two kinds of migration: aspirational and distressed. Climate-induced migrants come under the second category. They are forced to migrate out and can be either termed *climate refugees* (taking refuge in another country because of climate events) or *internally displaced people* (IDPs) (people who migrate within their own country for various reasons).

The Guiding Principles on Internal Displacement define IDPs as

persons or groups of persons who have been forced or obliged to flee or to leave their homes or places of habitual residence, in particular as a result of or in order to avoid the effects of armed conflict, situations of generalised

violence, violations of human rights or natural or human-made disasters, and who have not crossed an internationally recognised State border.

(U.N., 1998)

The world is slowly waking up to the crisis of dealing with climate-induced migrants as IDPs. As far as India is concerned, such persons do not feature in any definition of migration or displacement in the current policy regime. The Government of India is said to have started a process of developing plans for them – especially the ones displaced by sea rise. It has had consultations with states about this.<sup>1</sup>

The number of IDPs migrating because of various effects of climate change has been growing exponentially. In fact, at the end of 2023, their number had reached a record high, informed the UN Special Rapporteur on the Human Rights of Internally Displaced Persons (OHCHR, 2024). Compared to a 2022 figure of 71.1 million, 75.9 million people were living in internal displacement at the end of 2023 (IDMC, 2024). Of these, at least, and conservatively, 7.7 million had been displaced on account of disasters.

In that same year (2023), at least 26.4 million people across 148 countries and territories faced internal displacement or movement. This is the third highest figure in a decade (IDMC, 2024). During the year 2024, more than half of all internal displacements would have been caused by weather-related disasters. This is certainly a matter of worry in a world where climate-induced displacement is already affecting all sections of society and economies.

Let us take, for example, the effect on children. Between 2016 and 2021, 43.1 million children across 44 countries had to suffer internal displacements due to weather-related disasters. That is 20,000 child displacements a day (UNICEF, 2023). The problem is going to grow unless climate actions are taken seriously. The Groundswell Report estimates that climate change drivers could force 216 million to migrate inside their own countries by 2050; some climate migration hotspots could emerge even by 2030 (World Bank, 2021). Forty million of these internally displaced people will be from the South Asia region.

Defining climate-displaced people or climate refugees has always been a matter of dispute among different stakeholders. Displacement induced by climate change has been a huge issue for several countries, including India. A common consensus on the definition of these refugees is yet to emerge. Environmental migration is not officially recognised, but the international community is acknowledging more and more that environmental degradation and climate change could result in population displacement on a scale the world is currently ill-equipped to address effectively (Panda, 2011).

For various reasons, the term *climate displacement* was not clearly accepted for long. But in 2009 (Fleming, 2023), António Guterres, then UN High Commissioner for Refugees (UNHCR), predicted in Copenhagen about

climate change becoming the biggest driver of population displacement, both internal and cross-border (UNHCR, 2023). Evidence has emerged that this prediction has come true only too soon.

Currently, the term *internally displaced people* is mostly being used to define people displaced within national boundaries, irrespective of whether this definition also covers people displaced by conflicts or other, non-climate-related reasons. Actually, *climate refugee* is a much better indicative term. It generally refers to cross-country migrants forced to move because of climate crises. The UNHCR gave a landmark ruling in January 2020 (UN, 2020) in one of the most publicised cases of climate refugees from the Republic of Kiribati. It said that governments cannot return people to countries unsafe for their lives due to climate change. Based on this recent ruling, countries should treat people displaced by climate change like refugees, stated current UN High Commissioner for Refugees Filippo Grandi (UNHCR, 2024).

While climate refugees or international migrants due to climate change are getting more attention, climate change-induced internally displaced people are yet to be properly recognised. Policy measures are also not in place for them.

The UN wrote (UN, 2018, 2019) that migration and climate have always had a connection, but things are changing fast in the modern era. Man-made climate crises are having effects that are likely to change human settlement patterns profoundly. More people will have to move as a result of the adverse effects of climate change. The Intergovernmental Panel on Climate Change (IPCC), the leading UN authority on climate science, points out the same problem. It observes that the climate crisis will influence migration patterns.

Knowledge and awareness levels on the environmental factors that affect migration have evolved over time. But how these factors interact with other migration drivers, such as demographic, political, and economic conditions, has also changed. One thing is for sure – with these emerging knowledge and changes in situations, there is more need to act urgently, ‘to be prepared and respond’ (United Nations, 2018, 2019).

Notably, the UN continues to use the term ‘environmental migration’, which is no problem, of course, but defining the term ‘climate migrants’ or ‘climate-displaced migrants’ would definitely make responses much sharper.

We can continue our debate on the definition of the term. Nevertheless, it is surely a positive signal that governments across the globe have been increasingly recognising that there are people displaced by climate change. Political awareness around environmental migration, as the UN says, has spread over the last decade. There is greater acceptance that this is a global challenge. Nation states have signed the Paris Climate Change Agreement (UN, 2015), the Sendai Framework for Disaster Risk Reduction (The United Nations Office for Disaster Risk Reduction, 2015), and

most importantly, in the context of our research, the Global Compact for Migration.

The Global Compact for Migration devotes a whole section on measures to address environmental and climate challenges. For the first time, it lays down a comprehensive vision for states to handle the effects of climate change and environmental degradation on international migration. The primary approach it offers is to find out solutions that allow people to stay in their homes and give them the means to adapt to changing environmental conditions. This way, they can avoid distressed migration and associated woes. But in cases where the effect is too intense, the priority the Compact proposes is to ‘enhance availability and flexibility of pathways for regular migration’. The last resort, the Compact says, is relocation of the affected population.

This means that states are looking at solutions for people to be able to migrate safely, that, too, through regular channels, and at solutions for those already on the move. Relevant data and knowledge are key to guide decision-making in this regard. Importantly, even though there is no such prescription for IDPs yet, the same priority setting can be made for them, and something like a national compact can be prepared.

Climate change-induced migrants need urgent and increased attention from not only global communities but also their national and provincial or state governments. Parties to the 2015 Paris Agreement on climate change had called for developing recommendations to address issues people displaced by climate have to grapple with. To this effect, the Warsaw International Mechanism for Loss and Damage Associated with Climate Change (WIM) was to be set in motion.

The WIM’s Task Force on Displacement (TFD) develops recommendations to address displacement caused by climate change. It was established in 2017 by the WIM’s Executive Committee in response to the United Nations Framework Convention on Climate Change’s (UNFCCC) COP 21 mandate. COP 24 parties in Katowice, Poland, welcomed TFD’s recommendations.

In this chapter, we are considering people who have been displaced or are confronted with the fate of forceful displacement due to climate change, such as sea level rise, coastal erosion, and loss of livelihoods and other socio-economic and cultural support systems that once helped them stay and progress in a particular geography.

These people, already vulnerable to the effects of frequent cyclones, floods, and other related natural hazards, have become (or are on the verge of becoming) more vulnerable to distressed conditions. They need policy support to restore their lives and livelihoods with dignity, where their rights to life and to their local ecological heritage and socio-cultural practices are protected along with other social security measures.

### 8.3 Bay of Bengal, climate change, and involuntary displacement

The Bay of Bengal carries the infamous distinction of being a cyclone hotbed. Around 80% of tropical cyclones have originated from this Bay, and they have been responsible for 80% of the world's cyclone-related deaths (Pinto, 2021). Warmer temperatures, caused by climate change, will cause more damage by holding more moisture. This region, already affected by regular floods, will be exposed to routine flooding. That is dangerous for coastal communities because of rainfall variability and sea level rise (Shidore, 2023). The state of Odisha bears the major brunt of the cyclone and sea level rise because of its geographical location on the Bay of Bengal. Its coasts are specifically vulnerable to vanishing, resulting in displacement and forced migration of people.

Various anthropogenic and natural interventions are causing changes to the coastline. These highly dynamic areas of interaction between terrestrial and marine processes are facing several challenges which are causing the shoreline to modify continuously. Sea level changes, floods, cyclones, and erosion and sedimentation are some of such challenges.

Around 187 km (36.8%) of the 480 km long coastline of the state is exposed to high, medium, and low types of erosion. Out of this, 39.3 km (i.e. 8.2%) were identified as a high-erosion zone (Ramesh et al., 2021). According to a state climate change action plan for Odisha, erosion accounts for 36.9% of coastal events. Another study goes further: It had made a shoreline change analysis for two decades (1990–2019) and found that 227.4 km of the shoreline, that is, 52.47%, would have to manage an erosional trend (Mishra et al., 2023).

A comprehensive vulnerability assessment of coasts that had factored in loss and damage from sea level rise, coastal geomorphology, tidal range, elevation, and other factors, found that specific stretches will have to deal with these challenges and are prone to further disastrous effects. This study, called the coastal vulnerability index (CVI), found that 107 km are highly vulnerable, 297 km moderately vulnerable, and 76 km a little vulnerable (Kumar et al., 2010).

Evidently, then, these vulnerabilities are on a rising trend. In about three decades, large parts of coastal Odisha would be at great risk of deluge and inundation. Further, the entire coastline runs the risk of annual coastal floods, as they would fall below a particular elevation, prone to floods. Some ecologically important systems, such as the Bhitarkanika National Park, Balukhand-Konark Wildlife Sanctuary, Chandrabhaga beach, and areas surrounding the Chilika Lake, may go under the sea permanently. There is chance of a sea level rise. More so, these areas may face submergence or permanent inundation due to the increasing rise of global sea levels up to anywhere between 2 and 7 ft or even more in the coming three decades (Climate Central, 2019).

The Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report had incorporated a sea level projection tool by NASA and found that Paradeep on the Odisha coast was highly vulnerable to sea level rise compared to 12 other Indian cities. Paradeep, the tool predicted, might be submerged by the end of the century. This, again, shows the high vulnerability of the Odisha coast to climate change-induced sea level rise and other disasters. This may also mean more areas in and around Satabhaya could go under the sea by then.

Adverse consequences from human activities on land and in the ocean, sea level rise (SLR), and various other climate-related ocean changes are already affecting coastal ecosystems (IPCC, 2022b, 2022c). The vulnerabilities of coastal communities also grow due to other climate-related and non-climatic drivers. Such drivers, like human-induced habitat degradation on account of infrastructure development and other actions, reduce their capacity to cope with the changes and expose them to more vulnerabilities.

Climate change is causing sea levels to rise at a faster rate than ever before. At the end of the century, according to all scenarios studied by scientists, it is going to get even faster. Even for scenarios compatible with achieving the Paris Agreement long-term goals, the SLR will be faster at that time.

More important to understand is that the sea level will continue to rise even after 2100. Along with this, risks accruing from the SLR will also increase by the end of the century and beyond. Coastal erosion, flooding, and salinisation are some of the biggest such risks the coastal regions will have to deal with. In fact, these risks may continue for centuries to millennia due to a continuing deep-ocean heat uptake and mass loss from ice sheets (WMO, 2024).

A major consequence of these effects, as has already been seen in Odisha, is involuntary displacement by people living on the coasts. A composite risk assessment of coastal vulnerability, for areas closest to the coastlines, was reported in an Odisha state action plan on climate change. It revealed that about 300+ villages in six districts are vulnerable to coastal erosion and other challenges. Almost 55% of these villages were categorised under 'very highly' and 'highly' vulnerable areas. That means 176 villages in Odisha coasts are staring at the risk of being erased from the geographies they have lived in for centuries.

The government of Odisha, in reply to a question in the Legislative Assembly (Barik, 2023), informed that seawater had already submerged 16 villages, while 247 faced displacement because of the rise in sea level.

### **8.3.1 *Haunted by the sea: two regions in study***

We undertook a study in two districts of Odisha where people have been facing an ever-inundating sea. While the Satabhaya region of the Kendrapada district has already gone under the sea, the other area, covering two villages

of the Puri district, is on the verge of being submerged by the water of the Bay of Bengal. We have collected testimonies from affected people and would highlight some of the key challenges people in the study locations have to cope with.

Satabhaya is arguably the first village in Odisha, and perhaps India, to have been officially relocated because of sea ingress. This village in the Kendrapada district means ‘seven brothers’ (*Sata*: seven; *Bhaya*: brothers). Local literature and stories narrated by elderly people point at a once highly flourishing rural area in this region. The villages were dependent on agriculture, livestock, and fishery from the sea, creeks, and rivers. It was a self-sustaining system according to local history.

History changed course in the 1960s. The seven villages – Sanagahirama, Mohanpur, Habeli Chintamanipur, Gobindpur, Kaduanasi, Saheb Nagar, and Paramanandapur – had to move inland as the sea started engulfing the land. The people settled in five new villages they formed further inland. They named them Kanhupur, Satabhaya, Barahipur, Rabindrapalli, and Magarakananda. Satabhaya was the *Gram Panchayat* headquarters. Today, of these five villages, only Satabhaya remains, but without a single person living there. The last village to disappear into the sea was Kanhupur, in 2011.

Relocation of the people took a long time, and the vulnerable communities had to wage a constant battle. They are now settled in Bagapatia, a village 12 km away from their original location.

Bagapatia is Odisha’s first-ever, and perhaps the country’s first, relocation project for sea erosion-affected people. With the relocation to Bagapatia, the people of Satabhaya lost their livelihoods, livestock, and lands. They received only homestead land, not agricultural land. Neither was access to community pastureland made available to them. Now, they are dependent on markets for their food. This, in turn, affects their nutrition security, since the consumption of protein has reduced drastically (milk, curd, fish, prawn, crab) in the family food basket. The government has been working on drinking water supply and other projects, and people are hopeful they will be given all basic amenities, livelihood options, lands, and other support systems in time.

*Tandahar and Udayakani villages.* These villages are located in the Sisuo *Panchayat*. They are among several other villages in the Astarang block of the world-famous Puri district which are undergoing severe water scarcity.

This has been escalating over the years, keeping pace with the advancing sea. There is no piped water supply to these villages. The tube wells and dug wells in the area are getting more and more saline, and waterborne diseases are rampant.

Udayakani villagers have been forced by the sea to move inwards almost thrice, and most of their crop fields have been engulfed by the sea. The villagers of Tandahar are on the verge of being displaced. With more men as

working migrants, there is more workload on the women to take care of farming and livestock, household chores, and childcare.

Many more coastal villages are staring at the same fate. They are living under the threat of accelerated seawater inundation and storm flooding. Coastal erosion is going to engulf more areas, which will result in seawater intrusion into fresh water, including groundwater. The encroachment of tidal waters into river systems is also a big threat they are facing. All such problems could lead to multiple displacements. The poor, who are already living on the margin of subsistence, will be pushed into greater poverty as a result.

While the state of Odisha has already taken measures to rehabilitate the villagers of Satabhaya, it has also been taking up measures to ease the woes of local people at the other study sites. But considering the fact that these villagers, as well as the people, are facing a similar fate in other coastal villages, the state now has to promulgate a rehabilitation policy for such affected communities.

Our study<sup>2</sup> aims to suggest a rehabilitation strategy with which governments and other stakeholders can work to provide climate justice to people displaced by climate change. Before going into the suggested strategy, however, I would like to inform the readers that the study – being a rapid one – could not deal with gender lenses to the climate crisis in depth, even though it covered issues and challenges faced by women. The strategy, therefore, is based on more of a general assessment of the communities without delving deep into any specific aspect, including gender considerations.

#### 8.4 Towards an inclusive rehabilitation strategy

Currently, Odisha does not have a rehabilitation policy for people displaced by climate change. The Odisha Disaster Management Plan 2019 talks about the assessment of different types of vulnerabilities; a ‘coastal vulnerability index’ is one of them. But the Plan does not have the mechanism to support communities displaced because of coastal erosion.

The Odisha climate change action plan (2018–2023) brings in adaptation and mitigation themes in its ‘coast’ and ‘disaster risk management’ chapters. It also includes key priorities where gender concerns can be integrated, focusing on women’s needs and providing shelter-level equipment, especially for pregnant and lactating women.

Overall, none of the current policies singles out rehabilitation and resettlement (R&R) of villages affected by sea ingress. There is a need for an all-inclusive R&R policy for them. Such a policy for climate-induced displacement could be a very good starting point to support displaced people and help them adapt to climate change challenges.

In the field studies for the research on which this chapter is based, communities have participated actively. Based on this data, as well as on discussions

with officials of the Odisha State Disaster Management Authority, district-level government officials, and other experts on this issue, we identified a need for proposing to the state of Odisha to formulate a ‘strategy for the inclusive rehabilitation of climate-displaced communities’.

This daunting challenge has to be tackled at both national and international levels, as the Cancun Adaptation Framework (2010), the Sendai Framework for Disaster Risk Reduction (2015–2030), and other international instruments have emphasised. But serious concerns remain due to the lack of political will to tackle the crisis of internally displaced people (UNSGHLP, 2021).

Many states fail to acknowledge the very fact that climate change is causing more displacement, particularly internal displacements. In fact, there has been a collective failure among both government and international agencies, including the UN, international donors, and others, since they have not demonstrated strong commitments required to tackle this crisis.

Resolving the challenges associated with internal displacements due to climate change lacks serious political will and involvement of all these stakeholders. The communities themselves should be at the centre of interventions, and all these stakeholders should play a supportive and facilitative role in helping them tide through these challenges.

The Odisha government is tackling this issue with some sort of rehabilitation action, but it needs to move forward to a regime that can strengthen this action for a durable solution. This chapter deals with some key components of such a strategy that can benefit not only Odisha but also all the coastal states of India that are facing a similar crisis as follows.

#### ***8.4.1 Identifying and creating decentralised land banks for rehabilitation***

Hundreds of villages are facing the wrath of an invading sea and may be forced to leave their lands and settle further inland in the coming decades. This situation calls for a thorough assessment of all such vulnerable areas along the Odisha coasts. It is then imperative to find suitable lands where the displaced could be relocated as and when the need arises.

Micro-level climate change data should be integrated into such an assessment so that the future vulnerability of proposed lands for ‘land banks’ in various places could also be taken into account. Such land banks should be established in each district. They should not be far off from the original locations, so that the communities concerned can still relate to their socio-cultural systems and histories. These land banks should not only provide housing but also cater to other needs of the communities, such as common places for recreation, farm and grazing lands, and access to local forests.

For fisherfolk families, for whom the sea is the land, the land banks should be created at distances from where they can easily commute to the sea to be

able to maintain their livelihoods and take care of their boat towing zones and fish markets.

This strategy should target the creation of land banks for at least 300 villages that may require relocation in the coming decades. The government has already set 10 decimal (about 40 m<sup>2</sup>) of land per household for housing. It may consider reserving at least 2 ac (about 8,000 m<sup>2</sup>) per household for agriculture and adequate land for other community requirements, including those required for the rehabilitation of cultural practices.

The government could also allocate lands for some ecosystem restoration around these relocation colonies in such ways that their past interactions with these systems can be brought back in as many ways as possible. The Georgetown Climate Centre's report 'Managing the Retreat from Rising Seas', which covers case studies of relocation, points to examples where lands have been purchased by local governments to restore ecosystems such as wetlands and marshes.

In cases like Satabhaya, where people had an intricate relationship with the local deltaic ecosystems and marine resources, providing them access to such local ecosystem services, created with their complete participation, would be very beneficial.

#### **8.4.2 Ensuring housing, land, and property rights**

For development, peace, and climate change action, it is vital to address internal displacement on a priority basis (UN, 2022). For the millions of IDPs of the world, the design and delivery of solutions must recognise that housing, land, and property tenure (HLP) are important (UN, 2022). Experience from across the world confirms this.

In building the IDPs' capacity to respond and recover from disasters that brought about their displacement, the role of HLP is very vital. It goes beyond taking care of 'loss and damage' and accessing restitution and compensation (NRC, 2023).

Long-term solutions come out of tenurial rights and ensuring livelihood security. Climate and disaster resilience initiatives should incorporate HLP, shelter and settlements, livelihoods, and other related interventions. In places like the Odisha coast, where some people have already been displaced due to vanishing lands and some others are on the verge of displacement, ensuring these rights becomes utterly essential.

Rights to land for shelter and livelihoods are linked to the dignity of the affected communities. The current rehabilitation and resettlement policy does not compensate people for lands lost due to climate change. So through this strategy, the government should extend the provisions of land compensation laws to these communities. This can also open a pathway to providing land possession and rights in resettlement colonies/areas.

The HLP approach should also cover all forms of basic amenities that the relocated communities need to live a happy, healthy, and prosperous life. Twenty-four seven water supply, toilets, electricity, schools, *anganwadis*, creches, agriculture support centres, space and support for kitchen/nutrition gardens, recreation centres, and parks are some amenities which relocated climate-vulnerable people have the right and should have access to.

#### 8.4.3 *Ensuring local livelihoods options, skilling*

Displacement, which cannot be prevented, takes a heavy toll on the livelihoods of people. Especially those without any permanent job are affected deeply. But it can also bring new opportunities to people for a better standard of living, if proper relocation is provided.

It should be kept in mind, though, that relocation is not just about moving. It is not that simple. It involves challenges regarding the loss of livelihoods, culture, and identity. There are, of course, potential benefits of relocation when adaptation limits are reached at a particular location. Communities can find new opportunities to devise or re-envision new aspects of community well-being (Fuys, 2023).<sup>3</sup>

But young people and others in vulnerable locations studied by Water Initiatives have raised very prominently concerns over the loss of employment. This is the same with others. This is mostly because their traditional livelihoods depend on local natural resources.

Obviously, livelihood strategies for farmers and fisherfolks, the two most affected communities on the coasts of Odisha, need to be different. They could be tailored to the specific limits of particular geographies. Existing government schemes available at local level should be utilised to help them regenerate a livelihood through all available options. A cash incentive for young people and farmers may also be given for a year or two so that they can reorganise appropriate livelihoods and readjust to local natural resources and other opportunities.

Farm and fisherfolk loan programmes, through cooperatives, SHGs, etc., may be rolled out. Skill development hubs could be created with the involvement of multiple stakeholders. Local marketing facilities should be developed, as well as cold storage facilities, for products, including vegetables and other farm products, as also for fish products.

The new livelihoods should integrate traditional knowledge and skills. They should also have the ability to mitigate disaster risks. Further, a rights-based approach should be followed in livelihood provisioning programmes. People's rights to the land and tenurial security regarding local natural resources are important aspects of providing them with long-term security and building their resilience.

Countries like Fiji have been very proactive in this. It works with the concept of ‘managed retreat’. This involves a gradual relocation of vulnerable coastal communities to safe and inland locations. It is something around which Fiji’s relocation policy revolves. Its government has recognised the need to move people facing a high risk of coastal flooding and erosion to safe places and to protect their livelihoods (Displacement Solutions, 2023).

But in countries like Bangladesh, where there is a shortage of land, as the coasts are densely populated and people are already being displaced in large numbers due to climate change, relocation sites that try to incorporate all land and settlement provisions may not suffice. For people in rural areas and whose major livelihood comes from agriculture and other land-based occupations, finding a solution to their displacement compatible with offering both livelihood opportunities and shelter may not always be possible (Displacement Solutions, 2023).

In Odisha, we might create a very good model that can help other states facing similar situations, that is, if we now carefully craft decentralised land banks and work on both traditional and alternative livelihood options.

#### **8.4.4 Ensuring safe migration routes**

Migrating out for aspirational occupations and in distressed conditions is not new for Odisha. There are established migration routes people follow year after year, season after season. Climate displacement is working as the new trigger, and the number and nature of migration are changing in the studied areas.

Many youths would have otherwise preferred to stay in their own villages and use local livelihood opportunities. But now they are migrating to nearby and distant places in search of daily wage work and contract-based livelihoods. Many adults are also preferring to migrate out. Fisherfolks who do not have any other skills than working in the fishery sector are also forced to migrate out, either to work in the same sector in distant states or in other jobs in nearby places. Increased migration has thrown several other challenges before displaced people. Their vulnerability to fraud in the wages they get and to other problems has increased to a large extent.

A major concern some respondents in our study had raised was the increased migration of girls at a young age. Trafficking of girls and women might also have gone up, as we heard from some respondents. Our study could not confirm this, since our scope did not allow it.

Nevertheless, the strategy, then, should have a robust assessment of existing and changing migration patterns and forms and put in place a system of supporting migrant workers starting from origin to source. Migrants’ rights should be protected while they are provided with safe routes to migrate for better opportunities. Special efforts should be taken to ensure that women

and girls who are migrating out in search of jobs are not subject to trafficking via false promises of marriage and other fraudulent promises.

For this, as also to provide other safeguards and ensure the rights of migrant workers, a special interstate coordination group should be formed with representatives from all the concerned states.

Of course, we cannot rule out migration to other countries, such as Saudi Arabia. Such migrants should also be identified and provided safe pathways, so that their rights as international migrants are respected in the destination countries. Meanwhile, the state should take care of vulnerable members left behind in the families of migrant workers. It could do so with the help of the local Gram Panchayat (local self-government organisation). Efforts should also be made to encourage and enable the migrant workers to remit adequate funds to their families.

#### **8.4.5 Ensuring social protection for the most vulnerable people**

Internally displaced people need social protection. Especially the women, elderly, persons with disabilities (PWDs), children, and other marginalised groups need extra protection. For this, the existing gaps in social and legal protection mechanisms need to be identified.

Due to changing socio-economic, cultural, geographical, and ecological conditions, existing protection mechanisms may not work, at least not during transition times. And the transition from the old situation to a new situation is always painful and tedious. While some people may adjust to this new situation soon, others may take much more time, sometimes several years, to settle down – both psychologically and physically.

The sections of society described earlier are the most vulnerable among all. They need special attention in relocation sites. In any case, all the facilities created for people at relocation sites should be gender-positive and child-friendly. They should also be easily accessible to PWDs and the elderly. Special efforts should be made to provide these categories extra social protection, by making available extra resources, so that their mental and physical growth is not negatively affected.

Counselling, extra food and nutrition facilities, playgrounds, inclusive schools, medical facilities, and cash entitlements for the elderly as well as women (including single women and widowed persons) and PWDs may be some initiatives to reduce gaps and help the vulnerable people experience a smooth transition process.

*Panchayats* and other local social organisations, with the aid of the government, should take extra measures to tackle gender-based violence, as such violence often gets worse in such relocation set-ups. Discrimination against the elderly may also increase in families, since they struggle with a resource crunch.

The right to property, ensured to women, could reduce much of the gap and provide them with better opportunities to participate in the process of a just rehabilitation. There is an evident need to improve women's access to justice in HLP matters.

Further, addressing the barriers that come up due to factors like illiteracy, lack of awareness of their rights, and other socio-economic disadvantages could help women overcome the challenges they face in HLP-related situations. Actions to help women exercise their HLP rights are known to have positive effects on sustainable land use and management, as also household food security (NRC, 2023).

While ensuring social protection and reducing gaps in support to vulnerable communities nationally, it is also important to look at international processes and mechanisms that have been trying to support them. Here are some major normative developments that have taken place in the international arena to deal with protection gaps people who are displaced by climate change and disasters are facing:

- The Sendai Framework for Disaster Risk Reduction 2015–2030
- The United Nations Framework Convention on Climate Change (UNFCCC)
- The Paris Agreement on climate change and other outcomes of subsidiary bodies of the UNFCCC, including the Warsaw International Mechanism for Loss and Damage Associated with Climate Change Impacts (WIM) and its Task Force on Displacement (TFD)
- The New York Declaration for Refugees and Migrants and (following from it) the Global Compact for Safe, Orderly, and Regular Migration
- The Global Compact on Refugees

*(Government of Bangladesh, 2021)*

#### **8.4.6 Common access for climate resilience**

Communities like the Satabhaya villagers had been forced to leave their ecosystem-dependent livelihoods and are now struggling to adjust to new livelihood options. This is going to happen in almost all cases where people will be forced to leave their homelands due to an engulfing sea. While a comprehensive strategy needs to continue supporting them with new livelihood opportunities, including short-term cash benefits and long-term skilling efforts, it should also look into how they can have access to local common property resources, to the extent available, so they can continue with their traditional ways of living and livelihoods.

This will help the rehabilitation process in many ways:

- First, their traditional knowledge of commons-based livelihood continues to help them have (or retain) confidence in their own knowledge and skills.

- Second, the psychological shock of leaving their homelands forever is reduced.
- Third, it contributes to nature conservation during a long-term transition, when a systematic approach is taken to involve the displaced in ecosystem conservation in their new set-up by aligning them with existing communities and policies, as well as by providing land resources in their own ‘rehabilitation package’ for systematic conservation plans that can benefit them in the long run through the availability of various ecosystem services to enrich their lives and livelihoods.

## 8.5 Summary and conclusion

This rapid research and the findings have brought out several issues that need urgent attention. On the one hand, we have communities that had been displaced by climate-induced sea level rise but now have much improved amenities and other facilities provided to them. On the other hand, the ones facing imminent and future displacement need to be provided with an inclusive rehabilitation policy.

In both cases, people’s rights to stay or move with dignity need to be recognised and respected. Also, appropriate climate finance needs to be made available to support their livelihoods and other needs. Existing governance structures should be improved with skills and other support to deal with this ever-growing situation.

This approach to rehabilitation can help not only the vulnerable communities in Odisha but also other coastal regions of the country. Such a strategy also holds significance globally, as researchers, practitioners, and governments strive to look for solutions to the ever-growing problems of people who will be internally displaced by climate change.

Millions of people get displaced every year by disasters, and the future looms large over hundreds of millions who are likely to move internally in the decades ahead (Clement et al., 2021). So many will look more and more at ‘planned relocations’ as the chief solution for those affected by climate change (Bradley & McAdam, 2012). Even IPCC scientists predict that ‘the need for planned relocations will grow’, as the consequences of climate change on displacement and other forms of (im-)mobility accelerate (IPCC, 2022d, Summary for Policy Makers, p. 25).

To sum up, we have suggested solutions, which could be called ‘planned relocation plus’, when we speak about ‘inclusive rehabilitation’. This, then, includes ‘planned relocation’ as well as other support systems.

## Notes

- 1 As per information given by Mr P. K. Jena, IAS, Additional Chief Secretary to Govt. of Odisha, during a conversation with me.

- 2 An unpublished study of 2021–2022 conducted for Water Initiatives, a network of civil societies that works on water, environment, and climate change actions and advocacy.
- 3 Andrew Fuys, SUS 7600C: Environmental policymaking, (2023, May 23). Research chapter: Climate relocation planning in the US. (Unpublished) (Obtained through personal communication)

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# 9

## TRADITIONAL KNOWLEDGE ON ADAPTATION AND RESILIENCE IN HIGHER EDUCATION FOR ENABLING RESEARCH ON CLIMATE JUSTICE

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### 9.1 Introduction

Traditionally, *climate justice* is defined as a human-centred approach to addressing climate change. It emphasises safeguarding the most vulnerable people and sharing the burdens of climate change and the benefits of climate action equitably and fairly (Mary Robinson Foundation, n.d.). The definition of *climate justice* has plural interpretations which vary with contexts and communities, premised on three fundamental principles: distributive justice, procedural justice, and recognition of diversity (IPCC, 2022).

The distributive justice principle examines how the burdens and benefits of climate change and climate action are distributed among individuals, nations, and generations. Procedural justice focuses on decision-making authority and participation, ensuring that all stakeholders, especially the most vulnerable, have a say in climate-related decisions. The recognition of diversity involves respecting and fairly considering diverse cultures, viewpoints, and experiences.

These principles highlight the intersection of gender, ethnicity, and socio-cultural and economic aspects in shaping vulnerability to climate change (Burman & Katyaini, 2022). Women, children, persons with disabilities, older persons, Indigenous people, and migrants are often the most vulnerable groups (UNDRR, 2015). Understanding their participation and representing their concerns are a crucial dimension of climate justice.

In defining *climate justice*, the burdens of climate change include rising temperatures, unprecedented changes in precipitation and water distribution, increased frequency and intensity of floods and droughts, rising sea levels, loss of biodiversity and habitat, and changes in agricultural productivity

(Robinson, 2011). These burdens directly and indirectly affect water and food security, health risks, loss of lives and livelihoods, gender equality, and the social fabric (Mirzabaev et al., 2023).

At the global level, the responsibility to share these burdens and ensure an equitable and fair distribution of benefits from climate action is central to climate justice. This resonates with the United Nations Framework Convention on Climate Change (UNFCCC) emphasis on equity through the principle of common but differentiated responsibilities and respective capabilities (United Nations, 1992). Given the current understanding, there is a pressing need for enabling research on climate justice to bridge the knowledge gap on climate justice and strategise climate action.

The first critical gap in higher education that needs to be addressed is insufficient emphasis on and inclusion of social aspects in the knowledge base on climate change. The historical focus has predominantly centred on the biophysical aspects of climate change. At the same time, the recent introduction of shared socio-economic pathways in the IPCC's sixth assessment report marks a notable shift toward acknowledging and emphasising the social dimensions of climate change (Rogelj et al., n.d.).

The second gap refers to a shortage of knowledge on and from the Global South, even though it experiences disproportionately more significant effects of climate change.

Consequently, reimagining higher education on climate change is needed with an understanding of a socio-ecological perspective on climate change. This encompasses not only vulnerability to climate change but also traditional knowledge, evolved over generations of experiential learning of socio-ecological systems of adaptation to and of resilience from the adverse effects of climate change. Traditional knowledge encompasses understandings, skills, and philosophies developed by societies with a long history of interaction between society and nature (IPCC, 2019 as cited in IPCC, 2022).

The motivation for this research arises from a nascent state of knowledge on climate justice from the Global South despite a disproportionately large burden of climate change being felt in the region (Olabisi, 2022; Baum et al., 2024). It is urgent to capture the unique context of knowledge systems, practices, and roles in governance of communities there before they are lost. They can offer crucial insights into strategising climate action for climate justice. For instance, decentralised governance, to a large extent, has evolved through the critical role of communities in the sustainable management and governance of renewable natural resources, thereby emphasising the significance of local context for building climate resilience (Dietz et al., 2003; Agrawal & Benson, 2011).

Further, there are a few documented cases of transformation 'from below' in vulnerable contexts within the Global South, such as India in South Asia, where high levels of uncertainty are associated with climate change. The

transformations ‘from below’ refer to adaptations initiated and driven by local communities or community-based organisations, where their experiences and traditional knowledge play a crucial role.

With this background, this chapter focuses on how an understanding of climate justice can be imparted through higher education institutions. There is ambiguity, though, on the best way to incorporate issues of climate into the curriculum, for instance, as a module or through inclusion across courses with an interdisciplinary perspective or informal activities which enable learning.

We are referring to higher education in connection with curriculum design, learning with the ability to design and carry out research, and community engagement as a vital component in the process. This understanding is drawn from a curriculum typology approach for climate change in higher education proposed by McCowan (2021). As a consequence, exploration of learning is across three spaces – classroom, campus, and community. In the process of designing a curriculum, imparting learning, and learning by the students, embeddedness, application, disciplinarity, and experientiality are key aspects (McCowan, 2021).

The chapter brings forth crucial challenges and opportunities in reimagining climate change in higher education to enable research capabilities on climate justice. The research approach prioritises experiential knowledge as pivotal to address problems caused by unequal social systems (Rigolot, 2020; Cornish et al., 2023). It also engages with the role of experiential knowledge through a case study of traditional knowledge systems in the context of adaptation to floods in the Global South.

India is considered as a pivotal case from the Global South as it offers valuable insights into enabling climate justice research by incorporating experiential learning into higher education on climate change. The recent National Education Policy (NEP) 2020 of India underscores the significance of higher education in climate change and the need to transcend rigid disciplinary boundaries for specialised learning. It highlights that addressing challenges like climate change, pollution, and resource depletion will necessitate new skilled labour in fields such as biology, chemistry, physics, agriculture, climate science, and social science (Government of India, 2020, p. 3). Moreover, the NEP envisions education as a powerful tool for achieving economic and social mobility, inclusion, and equality, with a particular focus on historically marginalised and underrepresented groups (Government of India, 2020, p. 4), consequently prioritising higher education on climate justice as essential for fostering inclusion and equality in climate action.

Further, India’s National Action Plan on Climate Change (NAPCC) 2008 has two dedicated missions – the National Mission on Strategic Knowledge for Climate Change (NMSKCC) and the National Mission for Sustaining Himalayan Ecosystem (NMSHE) – to support co-production of knowledge

to tackle climate challenges (Singh et al., 2022). The NMSKCC aims to build knowledge networks and enhance climate research (Government of India, 2020), while the NMSHE focuses on traditional knowledge and livelihoods in the Himalayas. These reflect a policy drive for researching scientifically proven aspects of traditional knowledge while expanding the knowledge base on climate change.

Taking a cue from this policy drive, the case of traditional knowledge system, from the Brahmaputra River which flows through the Himalayan region, was explored. The river presents a critical call for climate justice on account of scientific evidence on the increasing frequency and intensity of flooding as a result of climate change (Nepal & Shrestha, 2015; Borah et al., 2022). Frequent floods and climate-related uncertainty, including the inability to predict the scale, intensity, and effect of climate change on human and natural environments, significantly affect riparian communities, whose lives and livelihoods are intricately linked to the river flows (Shrivastava & Heinen, 2005; Mehta et al., 2019).

The relationship between the riverine communities and the Brahmaputra River exemplifies a socio-ecological system. The Brahmaputra, a major river in India, holds cultural significance, with its name translating to ‘son of Brahma’, making it the only river in India with a masculine name. Its trans-boundary river basin spans Tibet (China), India, and Bangladesh. Approximately 33.5% of its drainage area (580,000 km<sup>2</sup>) lies in India, primarily in the north-eastern states of Arunachal Pradesh and Assam. In India, the Brahmaputra forms a network of 21 tributaries categorised into the North Bank (12 tributaries) and the South Bank (9 tributaries) (Roy et al., 2020).

Globally, there is growing recognition of the invaluable long-term understanding of tribal communities, especially women, regarding socio-ecological systems. A better understanding of the knowledge that guides traditional adaptation practices, which considers social equity, can shape an effective and socially just, climate-resilient development for today (UNDRR, 2015; IPCC, 2022; Rasmussen, 2023).

The case study provides critical insights into the participation of women from tribal communities in the Brahmaputra river basin in local decision-making as an essential aspect of climate justice. The research in the Brahmaputra river basin was intended to bridge the knowledge gap in the role of tribal communities in combating climate change (United Nations Environment Programme, n.d.; Robinson, 2011). In 2008, emphasis on the knowledge and stewardship role of tribal communities was laid by the United Nations Permanent Forum on Indigenous Issues through deliberations on ‘[c]limate change, bio-cultural diversity, and livelihoods: the stewardship role of indigenous peoples and new challenges’ (UNDRR, 2015). The chapter is organised into five sections. The first section, on introduction, sets the context. The second section covers the methodology and includes key points

on identifying key respondents, designing the data collection tool, the data collection process, and a thematic analysis for drawing inferences. Section 3 presents the results on three main points: (1) the inclusion of climate justice in pedagogy through experiential learning, (2) a case study of traditional knowledge based on experiential learning on adaptation to floods in the Brahmaputra River, and (3) important learnings from the two studies on climate justice and sustainable development. The chapter concludes with Section 4 and proposes a set of future avenues of research in Section 5.

## 9.2 Methodology

A narrative approach was adopted to collect data in interaction with the respondents. The motivation for a qualitative method was to go beyond numbers to gain rich insights into long-term contextual learning. Narrative research delves into the experiences of individuals on important event(s) and specific action(s) taken to recover. In other words, it recounts the lived and told stories (Czarniawska, 2004; Creswell, 2013). It is a systematic procedure of research where data from different forms of interactions, such as interviews, observations of individuals or small homogeneous groups, documents, pictures, and other sources, are gathered (Reissman, 2008; Creswell, 2013). The advantage is that it brings out multiple voices. The narratives are developed through a strong collaborative effort of researcher and individual (Czarniawska, 2004; Reissman, 2008). The study brings together the key learnings from narratives gathered in two periods: 2021–2023, as a part of the Climate-U (Transforming Universities for a Changing Climate) project supported by the UK Research and Innovation organisation, and 2016–2017, as part of the Vera Thiess Fellowship from the International River Foundation, Australia, on ‘women voices from Brahmaputra to understand adaptation to floods’.

### 9.2.1 Identifying key respondents

The first set of key respondents was identified through purposeful sampling. This is a relevant method to select information-rich cases (Cash et al., 2022). The main idea was to gather a diversified set of people with a medium- to long-term engagement in research, practice, or policy concerning climate change, located in different geographies in India. The group consisted of experts involved in cross-cutting issues of climate change, water security, and disaster risk management, viz.:

- 1 Scientists from natural and social science disciplines relevant to climate action and sustainable development, such as environmental and ecological studies, economics, sociology, geography, biological sciences, and physical sciences

- 2 Practitioners with expertise in grassroots-level project implementation and engagement with communities on themes of climate action and sustainable development
- 3 Officials from departments of environment, climate change, rural and urban development, and higher education who are engaged in climate action and sustainable development at state and national levels
- 4 Young students enrolled in a master's programme in the past three years who have the passion and interest in making a meaningful contribution to climate action and sustainable development
- 5 Journalists covering climate action and sustainable development in print media

The second set of key respondents included tribal communities residing in close proximity to the Dibang and Subansiri Rivers, the North Bank tributaries of the Brahmaputra, and Majuli Island in Brahmaputra Main, locally known as *chars*. These are small river islands, a unique characteristic of rivers in Asia (Lahiri-Dutt & Samanta, 2013).

In *char* lands, the boundaries of water and lands blur. They create ungovernable spaces through a dynamic process of sedimentation and erosion with recurrent floods. These are the tribal communities identified for the interactions:

- 1 The Idu-Mishmi community resides close to the Dibang, which flows through the Lower Dibang Valley district of Arunachal Pradesh. The Idu-Mishmis migrated from Tibet through the Dibang and Lohit Valleys to their present residence.
 

Idus are believers of animism (i.e., all things – animals, plants, rocks, rivers, weather systems, tasks, and even words – have a spirit). They are deeply connected to the river (Katyaini, 2017; Government of Arunachal Pradesh, 2024).
- 2 The Mishing, Deori, Sonowal Kachari, fishing, and Assamese communities living near the Subansiri River. The rivers flow through Lakhimpur, Majuli Island, and the Tinsukia districts of Assam.
  - a The Mishing are the second largest among the 30 tribes of Assam, making up to 17.8% of the state's population (Shrivastava & Heinen, 2005; Konwar, 2022). They identify as a riverine community, regarding the river embodied in the term Mishing ('asi' denotes river). As they traditionally live along the banks of the Brahmaputra, its tributaries, and the *char* lands of Majuli, their lives are shaped by the river flows and its vagaries (Figure 9.1) (Barooah, 1998a, 1998b).
  - b Deoris also have a close association with the river. The sub-groups of the Deori derive their names from tributaries of the Brahmaputra. For

instance, a group settled on the banks of the Dibang River is called *Dibangia*.

- c Sonowal Kacharis have a distinct relationship with the Subansiri River. They traditionally collected gold from the river (Barooah, 1998a, 1998b).
- d There are also other communities, locally known as fishing communities and Assamese communities, which have remained close to the river for decades and are an important group to consider.

### 9.2.2 Designing the data collection tool

In both studies, a semi-structured checklist guided interactions with respondents. The focus of interactions regarding reimagining the curriculum on climate change in higher education was on critical aspects of enabling learning on climate justice. These aspects encompassed the entire span of planning the curriculum, teaching, and evaluating the learning (Figure 9.2). They also dealt with the possible translation of knowledge into a future involvement of students in research, policy, and practice.

Key insights were gathered on (1) essential themes that should be part of a curriculum regarding climate change and (2) pedagogy (educational strategies, teaching and discussion methods, assessment). The discussions culminated in a focused examination of possible avenues for integrating climate justice in the context of the Global South.

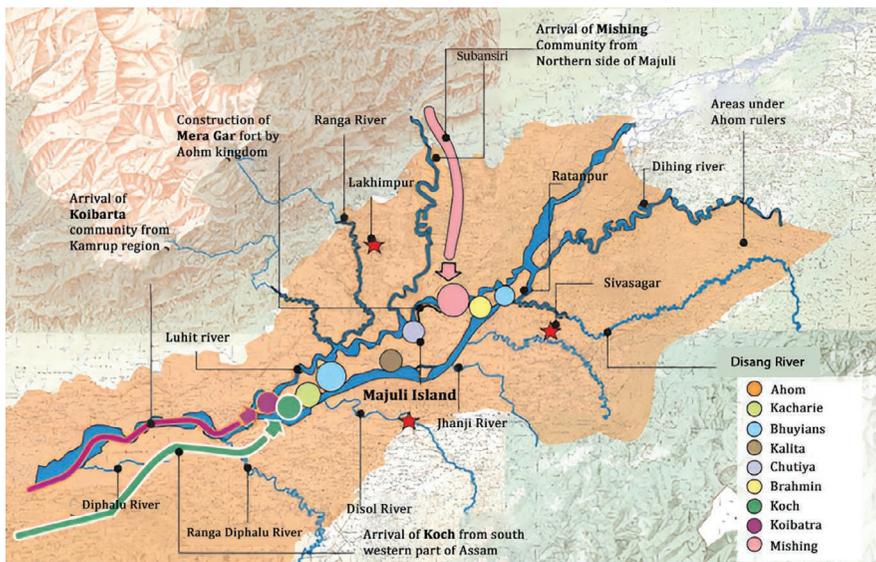


FIGURE 9.1 Key focus of semi-structured checklist and guided discussions.

Source: Authors.

Experiential learning as a pedagogical approach is a common theme in the two studies. It provides an essential avenue for developing the perspective and skills necessary to enable research on climate justice. The participatory research method used to engage with the communities is an integral part of such experiential learning.

In the second project, these methods yielded critical insights into how tribal communities evolved traditional knowledge systems with respect to adaptation to floods. Interactions with the selected communities focused on (1) their critical knowledge systems, that of women in particular, used to adapt to floods over generations, and (2) the level of women's participation in local decision-making, to understand nuances of challenges in the integration of their knowledge in decision-making.

### **9.2.3 Data collection procedure: consultations with respondents**

Key informant interviews (KIIs) and focused group discussions (FGDs) with selected respondents were part of both studies. Multiple interactions were conducted to brief respondents about the study's purpose and the intended use of their responses. Additionally, they were informed about the anonymisation of their responses in conformity with research ethics. Subsequently, their consent to participate in the study was sought. On the whole, the research process followed Bos's step-by-step ethical procedure (Bos, 2020).

For an exchange on reimagining higher education with respect to climate change and the integration of climate justice principles, the research team approached more than 100 potential respondents across India. Around 66 respondents participated (Figure 9.3). Of these, approximately 52% were classified as youth, 24% as practitioners, 17% as scientists, and the remaining 7% as government officials and journalists. Around 2–5 follow-ups were needed to arrange for a KII or FGD with respondents. Interactions typically lasted between 45 minutes and 1 hour and 45 minutes. In 2023, alongside KIIs and FGDs, a multi-stakeholder consultation was convened with 20 participants. These stakeholders represented a diverse range of backgrounds, including international and national development organisation members, researchers, practitioners, and students.

For interactions with the tribal communities, the objective was to explore intergenerational perspectives on flood adaptation, continuity of knowledge and concerns regarding floods, and potential solutions. These methodological choices aimed to ensure inclusivity and gather comprehensive insights into the nuances of flood adaptation strategies, considering gender dynamics, age, and intergenerational knowledge transfer. Around 22 interactions were conducted, covering 55 individuals. Building trust with respondents was an important step in this case, which required establishing initial contact through an insider to the community or a key person who had been



**FIGURE 9.2** Geographical diversity of respondents.

Source: Authors.

connected with the communities for a long period of time. The FGDs were conducted with (1) only women groups and (2) mixed groups comprising both men and women. The rationale behind only-women FGDs was to create a safe space where they could freely express themselves without inhibition. Mixed-gender FGDs were conducted to understand group dynamics and gather joint insights. KIIs were carried out with specific interviewees: (1) elderly women, (2) younger women, and (3) elderly men. More than 80% of the respondents were women, which was purposive. The interactions with respondents lasted between 2 and 3 hours.

#### 9.2.4 Thematic analysis and inferences

Transcripts of the KIIs and FGDs were prepared to ensure the inclusion of all relevant details for analysis. This was followed by developing codes to categorise the data into key themes and sub-themes. This was an essential step in systematically organising the data.

The next step was pattern identification by applying these codes to the transcribed data. This step was crucial for recognising commonalities and differences in the data.

The final step was drawing meaningful inferences based on the identified patterns. This involved interpreting the data to understand underlying messages and implications of responses.

This systematic approach ensures a thorough and structured analysis, providing insights that can be used to inform further research or decision-making.

### 9.3 Results

The results are structured in three subsections. The first focuses on key insights into the inclusion of climate justice in pedagogy through experiential learning. The second deals with a case study of traditional knowledge acquired through experiential learning to adapt to floods in the Brahmaputra River for crucial insights with respect to climate justice. The third combines vital learnings from the two studies on climate justice and sustainable development.

#### 9.3.1 *Inclusion of climate justice in pedagogy through experiential learning*

From deliberations with respondents on ways to include climate justice in the pedagogy, we realised that experiential learning is the crucial method to develop an understanding of the complexities. It enables students to connect theoretical knowledge with practical applications. Engaging students in real-world experiences and reflective practices, such as community-based projects and field exposures, can help them understand various facets of climate justice – social, economic, and institutional.

Further, it is essential to gain insights into the disproportionately more significant burden of this global phenomenon on vulnerable groups residing in remote areas of the Global South. Through interaction with such groups, students can develop critical thinking skills and comprehend complex processes of knowledge building.

There are four key insights:

- 1 *Livelihood as a context-specific priority of climate justice in the Global South.* The study brings into perspective the co-creation of knowledge by looking beyond the boundaries of academic disciplines toward knowledge of the community and priorities of climate justice in geographies where it matters most.

An academician emphasised the learnings of climate change from the Global South because of the lack of representation of the Global South in international frameworks to understand climate change.

Highlighting climate justice issues of the Global South also brings to the fore the effect of climate change on people's nature-based livelihoods within the purview of climate justice. The academician, A1, stated:

*'Students need to thoroughly understand the international architecture around climate change. That's a whole debate and the whole thing students*

*need to know. We, coming from the developing South, have to ensure that our students know what is climate justice, right? . . . So international global frame is one level of it. The other level is [Global South] . . . climate justice . . . especially with sea level rise and with too many effects happening, we can't afford to say that climate justice, we are going to fight it only at the international level . . . because it affects the livelihood of people here.'*

- 2 *Including case studies on local traditional knowledge from the Global South.* Overcoming language barriers to enable learning and deliberating on how experiential learning of people about climate change can be understood and bring forth through the importance of case studies. A student enrolled in a master's level programme, S1, suggested that using case studies on traditional local knowledge is one of the ways to benefit from experiential learning of people adapting to climate change. Further, it also helps students overcome language barriers in enabling learning and knowledge sharing:

*'There should be an incorporation of local knowledge. . . . For example, we can take case studies of local people's [knowledge on] either adaptation or mitigation . . . because certain people who are . . . not that proficient in English . . . or they might be facing challenges in [reading publications] . . . in English [but] have a . . . comprehensive understanding of the practical realities [can develop understanding].'*

- 3 *Incorporation of validated local traditional knowledge into learning.* While including local traditional knowledge is important, it was also important to understand what form should be part of the learning, considering shaping future research, policy, and practice. Therefore, validation of the local traditional knowledge becomes crucial for the communities.

Validation has two aspects here: validation of traditional knowledge in practice by the community to adapt to floods, and scientific validation of the design and functionality of the knowledge system by policymakers on broader applicability and replication at scale with the communities.

In a wider sense, the knowledge of vulnerable communities regarding local ecological and climate systems contributes to their climate resilience. Resonating with this, an academician specialising in climate governance, A2, shared that '[y]ou have to take concrete steps. One way to look at concrete steps is through the state policy on them . . . all these adaptation plan which are brought into place'.

- 4 *Positioning of experiential learning as a part of the pedagogy.* It is important to understand whether experiential learning should precede theoretical learning on climate justice or succeed it. There were plural understandings of the placement of this type of learning.

A majority of respondents suggested that theoretical learning should precede experiential learning to comprehend grassroots-level reality with respect to equity, justice, and community resilience, shaping students' perspectives on climate-induced inequities and varied social responsibilities.

This resonates with a narrative shared by a practitioner from South India engaging at community level and quantifying climate risks (P1):

*'Theoretical orientation and exposure to the field should go in tandem. If students go to the field after reasonable theoretical orientation, then they will be in a better position to gather insights on what's happening in the field.'*

### **9.3.2 Traditional knowledge through experiential learning: living with floods in the Brahmaputra**

This subsection presents a case study of traditional knowledge acquired through experiential learning as a response to floods in the Brahmaputra river basin. It offers important insights with regard to climate justice and sustainable development. To substantiate, traditional knowledge emerges from a long-term understanding of the local ecology, climate, and community's structure.

Women from the tribal communities have a crucial role in certain kinds of traditional knowledge, like cooking practices, housing structure, rituals, and clothing design. This knowledge has been passed from one generation to the next, with women at the core.

Traditional knowledge systems on adaptation to floods may be broadly classified in terms of structural and non-structural measures. The first involve physical constructions and modifications to minimise flood risks and effects. The second refer to practices and policies designed to reduce the vulnerability of communities to floods.

Structural measures include elevated housing in flood-prone areas, also known as stilt housing; flood embankments built by communities along the riverbanks to prevent floodwaters from entering into inhabited areas; terracing to decelerate water flow and reduce soil erosion; and other context-specific structures.

Non-structural measures include food preservation through drying, smoking, and fermenting for consumption in times of flood and when there are shocks and interruptions in the food production systems. They also include early warning systems, such as signs and indicators for predicting floods, like observing changes in animal behaviour; community preparedness, like regular community meetings and education on flood preparedness; crop diversification, to include flood-resistant varieties, to ensure food security during and

after a flood; livelihood diversification, to offset the risk of climate change; traditional methods of water storage during floods; preservation of forests and sacred groves to buffer against floods.

The key findings are:

- 1 *Tribal communities' belief in animism and environmental consciousness.* Animism defines the relationship between the communities and their surroundings. The belief has also shaped the structural and non-structural adaptation measures, because these measures depend on locally available natural resources and also do not aim to modify the surroundings greatly. As a case in point, we understood from interactions with the oldest woman from the Idu-Mishmi tribe in the Kebali village (situated on the bank of a tributary of the Dibang) that community members had rallied to build small wooden bridges over narrow parts of the river to connect their village to the facilities (Katyaini, 2017). The wood had been locally available, and the construction had not led to major modifications in the ecology.
- 2 *Prominent structural adaptation measures recognised in policies.* There are two structural adaptation measures which have found recognition in policies for scaling up. These are in the form of a particular housing design and structure to prevent erosion. First is the stilt house design (locally known as *chang ghor* in Assam). It is a traditional design of tribal communities like the Mishing, who have been living in low-lying areas for generations. The houses are built with locally available bamboo and raised to a height of approximately 1.2 m (Government of Assam, n.d.) on bamboo stilts with mud foundations (Figure 9.3). These stilt houses are recognised in the central government's *Pradhan Mantri Awas Yojana* (PMAY) as a core design to provide 'housing for all' in rural areas by 2024. The PMAY is a flagship initiative by the Ministry of Rural Development, implemented by the Ministry of Housing and Urban Affairs (Government of Assam, n.d.; Bharadwaj, 2023; My Scheme, n.d.). The emphasis is on providing affordable and safe housing (*pucca ghar*) to the economically vulnerable with basic amenities. These include all houseless families and those households living in *kutcha* and dilapidated houses. Construction of the *chang ghor* takes place under the PMAY in convergence with the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS<sup>1</sup>). The basic amenities are provided in convergence with the Pradhan Mantri Ujjwala Yojana<sup>2</sup> and some other government schemes for piped drinking water, an electricity connection, clean and efficient cooking fuel, and treatment of social and liquid waste (Government of Assam, 2024).

The second structural measure is a so-called porcupine structure, to prevent erosion as a disaster risk management intervention. It is also a

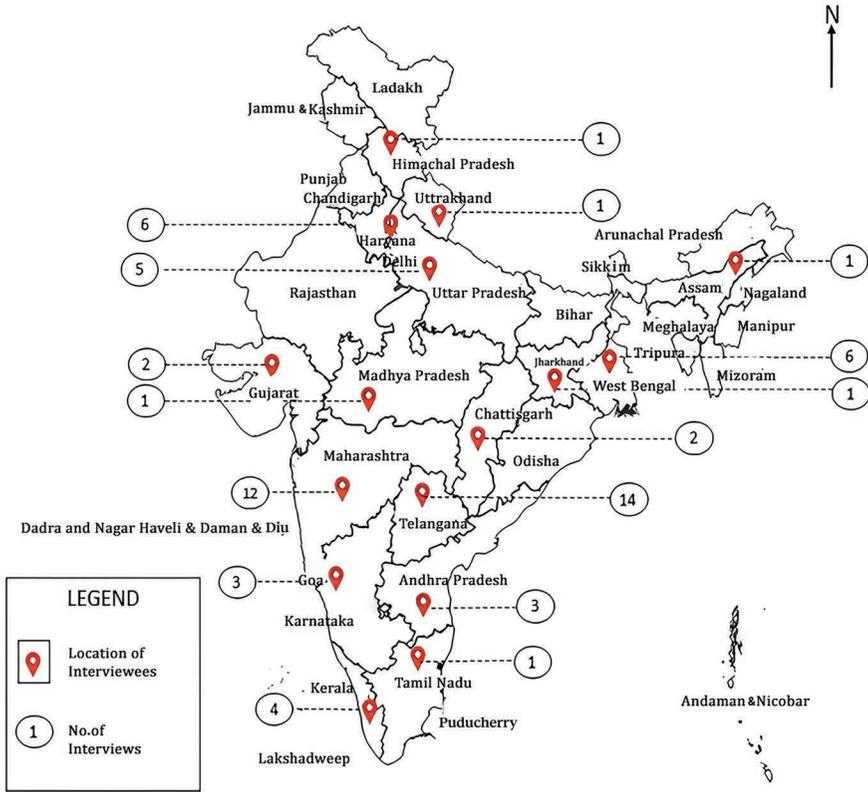


FIGURE 9.3 Geographical diversity of respondents.

Source: Authors.

bamboo structure, arranged in an array of units along and across riverbanks to retard erosion (Aamir & Sharma, 2015). The innovation on the traditional knowledge has been to scientifically establish spacing between the porcupine structures to minimise erosion.

- 3 *Non-structural measures are largely associated with the experiential knowledge of women from the tribal communities, but they have not received the same kind of policy recognition as structural measures.* Women are chiefly involved in the well-being of the family, as primary food producers and providers of fundamental needs like water. Their preparation for floods comes down to food preservation for flood and post-flood periods.

The consultation brought out two key aspects that might be the main contributors to the lack of recognition of women’s experiential knowledge. First is the time crunch women face due to domestic and agriculture responsibilities. Second, due to this time crunch, but also gender-based

norms, women expressed that their level of participation in decision-making at local level was barely consultative, according to a ‘ladder of participation’ proposed by Agarwal (2001). *Consultative participation* refers to the time when women are asked to give an opinion on specific matters. The women respondents were not sure, though, if their opinion, if at all asked for, would be influencing decisions after all (Table 9.1). Such reflections also resonate with the other context of the Global South (United Nations, 2023).

### 9.3.3 *Bringing traditional knowledge and SDGs together on climate justice and sustainable development*

First, traditional knowledge is acquired by experiential learning about ecology and society. It needs to be recognised as a form of nature-based solutions (NbS). They exist as structural and non-structural measures and reflect sustainability because of environmentally conscious choices. These measures rely on natural ecosystem processes to preserve biodiversity and enhance human well-being. Actions involve protecting and restoring natural or modified ecosystems to contribute to a sustainable management of these ecosystems while addressing societal challenges in the adaptation process (Cottrell, 2022; International Union for Conservation of Nature, 2016 as cited in IPCC, 2022). Stilt houses and porcupine structures, understood through participatory action research, should be considered as NbS.

Second, they are significant in advancing several Sustainable Development Goals (SDGs) and support tribal communities which identify themselves as part of the Brahmaputra river basin. The following are the SDGs that are

**TABLE 9.1** Typology of levels of participation and their characteristics

<i>Level of participation</i>	<i>Characteristics</i>
<b>Nominal</b>	Membership in the group
<b>Passive</b>	Informed of decisions, attending meetings, listening in on decision-making without speaking up
<b>Consultative</b>	Being asked an opinion in specific matters without guarantee of influencing decisions
<b>Activity-specific</b>	Being asked to (or volunteering to) undertake specific tasks
<b>Active</b>	Expressing opinion, taking initiatives of other sorts
<b>Interactive (empowering)</b>	Having voice and influence in the groups’ decisions, holding position as office-bearers

*Source:* Authors.

directly linked to resilience to floods and where traditional knowledge systems with respect to resilience and higher education on climate justice are crucial:

- SDG 1.5 refers to building resilience of the poor and those in vulnerable contexts and reducing exposure and vulnerability to climate-related extreme events and disasters. The SDG is relevant considering the recurrent and intense floods in the Brahmaputra river basin and the high exposure of the riverine tribes to these extreme events and disasters.
- SDG 2.4 deals with facilitating the maintenance of ecosystems to strengthen capacity for adaptation to climate change and flooding, with improvement of land and soil quality, since erosion in the Brahmaputra is a prominent challenge.
- SDG 4.7 focuses on ensuring that ‘all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, . . . gender equality . . . appreciation of cultural diversity and of culture’s contribution to sustainable development’ (UN, n.d.). This requires rethinking higher education about climate change and sustainable development through an interdisciplinary lens and, subsequently, through transdisciplinary approaches, where experiential learning on climate justice should be an important inclusion into ‘action-oriented, transformative pedagogy’.<sup>3</sup>
- SDG 6.5 is related to implementing integrated water resources management (IWRM) at all levels, including through transboundary cooperation, as appropriate. The tribal communities in the Brahmaputra river basin have certain important knowledge, as demonstrated in the case study here which internalises this understanding. Cross-learning of adaptation and resilience measures arising from this knowledge can support transboundary cooperation through replication of these measures with communities on either side of the Brahmaputra basin, like those in Bangladesh.
- SDG 13.1 strengthens resilience and adaptive capacity to climate-related hazards and natural disasters (UN, n.d.).

Overall, the case studies presented here are centred on strengthening resilience and adaptive capacity to floods. Science has established that floods in the Brahmaputra river basin are increasing in frequency and intensity with climate change.

Third, while the tribal communities value their traditional knowledge systems to build their resilience to floods, they are concerned about its erosion or loss. They attribute this erosion of traditional knowledge to the increased frequency of floods due to climate change and societal changes. Consequently, as women respondents also voiced, there is a need to supplement

these traditional systems with external and demand-driven interventions to build resilience. This implies a need for policy recognition to develop scientific evidence and preserve these knowledge systems through replication and bring about upscaling through policy provisions.

Fourth, there is the crucial role of civil society organisations and higher education institutions in drawing policymakers' attention to these traditional knowledge systems. Also, these organisations and institutions are bringing in a balance of knowledge on climate change based on physical, natural, and social sciences. This is important knowledge on and from the Global South, and from the grassroots, to improve research on climate justice.

This research is crucial to design demand-driven interventions to build the resilience of communities to climate change through experiential learning. This resonates with the Moore et al. (2010) argument that experiential learning needs to encourage reflective thinking by going beyond the confines of classroom learning in a deep manner and enabling the inculcation of innovative problem-solving skills.

#### 9.4 Conclusions

Three key conclusions emerge from the studies. First, climate justice requires understanding the voices of the most vulnerable, namely, the women from tribal communities. We have taken the case of a complex and dynamic river system like that of the Brahmaputra that plays a crucial role in shaping the lives and livelihoods of riverine communities. This case brought forth knowledge of these communities with meaningful insights into climate justice and climate action.<sup>4</sup>

Moreover, the gender dimension in the institutions governing transboundary rivers is not explicitly recognised, yet it is embedded in the stakeholder participation in international, regional, and basin-level cooperation (Earle & Bazilli, 2013).

Gender blindness in dialogues on transboundary waters could be attributed to the predominance of male-dominated disciplines like engineering and hydrology to understand river flows and large-scale water infrastructure projects (Tétreault, 2008; Zwartveen, 2008; Earle & Neal, 2017). At community level, gender-based norms restrict women from expressing their opinions publicly. Also, economic constraints prevent women from voicing their needs out loud. But narratives of women are crucial for developing nuanced understanding and processes which enable or hinder inclusion of their voices related to the principle of procedural justice.

More so, for an effective management of disaster risk and implementation of gender-sensitive disaster risk reduction policies, plans, and programmes, participation of women is considered crucial (SFDRR, 2015). As regards

effective disaster risk management, ‘experience and traditional knowledge [of indigenous people] provide an important contribution to the development and implementation of plans and mechanisms, including for early warning’ (SFDRR, 2015, p. 23).

Second, it highlights the relevance of qualitative research methods in eliciting the knowledge and perspectives of multiple stakeholders to understand climate justice. The co-creation of knowledge on climate justice requires overcoming disciplinary boundaries.

Participatory action research involving a set of stakeholders for a plural understanding of and a coherent view on imparting learning on climate justice in higher education institutes is important. This relates to principles of distributive justice and a recognition of diversity in climate justice.

This means encouraging students to rely on collective narratives and connections to address climate challenges effectively. By understanding the historical context and structural inequalities constraining people’s access to resources, they can be better equipped to pursue justice and resilience in climate action planning (Mandikonza, 2019). This approach would allow them to tackle climate-related challenges collaboratively, fostering a deeper sense of interconnectedness and shared responsibility for climate justice (Vamvalis, 2023)

Third, there is a need for rethinking higher education on climate justice that catalyses research on this subject as also youth-led climate action for shaping a sustainable future collectively. These findings are in agreement with Mandikonza (2019) and Vamvalis (2023) on the importance of integrating traditional knowledge and practices into the curriculum. This inclusion can enable learning on sustainability, holistic worldviews, interconnectedness, and respect for the environment.

Additionally, incorporating key features from traditional knowledge practices – such as an understanding of local ecosystems and traditional ecological knowledge – can provide valuable insights into living in harmony with nature and inform climate justice efforts.

Higher education can play a crucial role in internalising climate justice principles, helping students understand the significance of equity, fairness, and accountability in addressing climate change (Briscoe et al., 2022; Kinol et al., 2023). By incorporating climate engagement, social justice issues, and sustainability practices into coursework, universities can create a conducive environment for fostering climate justice-centred approaches in higher education (Trott et al., 2023).

This approach enables students to address challenges collaboratively, with a focus on equity, justice, and community resilience, shaping their perspectives to encompass a deep understanding of climate-fuelled inequities and social responsibilities (Briscoe et al., 2022).

By centring principles of diversity, equity, inclusion, accessibility, and justice in their climate action plans, higher education institutions can lead campus–community relationships and cross-sector partnerships, ensuring that climate justice is incorporated into policies, teaching, and impactful research (Briscoe et al., 2022).

By engaging with tangible experiences in the world around them, students develop a deeper understanding of the interconnectedness found in nature, nurturing the cultivation of systems thinking – an essential skill in sustainable development education (Wahl & O’Neil, 2019).

Educators in experiential learning can support the SDGs by integrating a sustainability content into the curriculum and by establishing interactive environments where learners are at the centre of the learning process (Gaffney & O’Neil, 2018). Higher education has the transformative potential to advance knowledge in climate justice (Kinol et al., 2023).

This requires a paradigm shift from technocratic approaches toward integrated and justice-centred initiatives. In this regard, developing a reflective attitude is crucial for understanding climate justice and enabling further research through focused teaching, research, and community involvement as part of higher education (Kinol et al., 2023).

This way, higher education institutions can leverage their position to enable transformation to address inequities in climate vulnerabilities and promote sustainable, equitable futures.

### 9.5 Future scope of research

There are four important avenues of research. First, to advance understanding on the representation of women’s concerns and their participation in decision-making with regard to climate justice, it is important to gauge how women’s leadership takes shape and the priorities for enabling their leadership in the entire range of climate change issues. This needs to be pursued through future research.

Second, loss and damage associated with disasters became a core focus of climate action in the recent Conference of the Parties (COP) 28. India adopted the agreement on a loss and damage fund at this meet (Government of India, 2023). There needs to be further research on the cost of climate change, in terms of damage to infrastructure, livelihoods, and lives as a result of disasters.

Third, as research on NbS is evolving, following our approach of identifying traditional knowledge systems of tribal communities, more of such systems may be identified for policy recognition and upscaling.

Fourth, research is needed to overcome a prominent challenge of influencing university procedures on integrating the outcomes of PAR for advancing higher education on climate justice.

## Notes

- 1 The beneficiary is entitled to employment as a rural mason for constructing the house.
- 2 For liquified petroleum gas (LPG) connection, which is used as a cooking fuel.
- 3 It involves self-directed learning, participation, collaboration, and problem-solving.
- 4 Cabello et al. (2015) and Skáahluwáa Todd et al. (2023) observed how the knowledge of the vulnerable communities is important but is usually not reflected in decision-making.

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# 10

## WOMEN-LED CLIMATE ACTION IN INDIA

Lessons from MGNREGS and DAYNRLM

*Amarjeet Sinha and Ashok Pankaj*

### 10.1 The context of climate change

The call for climate action is global. Developed countries are relatively better equipped to adapt and mitigate climate change impacts as compared to developing countries, while developing countries face challenges in balancing their growth requirements and environmental sustainability. Furthermore, developed and developing countries are placed differently in their development needs, energy consumption, carbon emissions, and others. This is also evident in the unequal per-capital consumption for developed and developing countries, reflected in the per-capita carbon footprints for developed countries being 80 times that for developing countries (World Bank, 2019). However, the disproportionate burden falls on developing countries, wherein they are expected to prioritise environment over development, as opposed to any such constraints for the developed countries that had been the forerunners in the development and exploitation of natural resources (World Bank, 2019; Nath & Behera, 2011; Chinowsky et al., 2011).

These disparities are not only at the international level but also within a country and its different sections of the population. Such complexity necessitates climate strategies to be designed in accordance to challenges faced at different levels and by different sections of the population. Given the geographical and cultural diversity in the country, India can be at the forefront of this shift towards a more inclusive and integrated local-level approach for climate change adaptation and mitigation strategies (Sinha, 2005, 2013). The need to balance the dual challenge of growth and environment sustainability in India could be rooted in Mahatma Gandhi's philosophical thought, that 'nature is endowed with the capacity to meet the needs of human beings,

but not their greed . . . production by masses and not mass production, to be a part of nature and not apart from nature' (Adam, 2014). In practice, this philosophical thought could be operationalised as community-based production system and local governance – a possible way forward as per Prime Minister Mr Narendra Modi pleaded at Glasgow in 2021 for a global movement – 'Lifestyle for Environment' (LiFE), intended for the adoption of community-led climate change adaptation and mitigation strategies (Bhagwati, 2019).

In the above context, two of India's existing initiatives could be possible models for such a way forward. They are the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) and Deendayal Antyodaya Yojana National Rural Livelihood Mission (DAYNRLM), that attempt to achieve environmentally sustainable growth.

These two flagship programmes of community-centric livelihood promotion are women-led initiatives as well. DAYNRLM is a programme of microcredit-led rural livelihood advancement through women, and MGNREGS is an income guarantee scheme that also creates climate-sustainable assets. Over 100 million women are members of over 10 million self-help groups under the National Rural Livelihood Mission. Over 50 million families participate in the MGNREGS as unskilled wage earners. The two programmes affect a very large number of deprived households in rural India.

The chapter elaborates on how the various components of these two programmes promote women-led, community-centric, climate-resilient livelihoods. In particular, how women's agency can contribute towards climate change strategies for rural development and livelihood promotion. Notable outcomes of these programmes are natural farming in Andhra Pradesh, organic farming in Sikkim, and plant nursery in every *Gram Panchayat* of Telangana. Based on the experiences of the DAYNRLM and MGNREGS, we draw a roadmap for the advancement of community-centric, climate-resilient, sustainable agriculture and rural livelihoods – a possible pathway for sustainable local economy development.

We argue that for a vast country like India, with diverse agroclimatic zones, a decentralised community-centric approach to mitigating climate problem would be a suitable strategy. With the nationwide roll-out of various women empowerment programmes and increasingly greater harnessing of women power, including their socio-economic mobilisation, women's agency can be utilised for climate action.

The next part describes a perspective on women and climate change. Part three analyses DAYNRLM and MGNREGS as programme intervention towards promoting sustainable livelihoods through the agency of women. The final part suggests policy and other measures for further promoting community-centric climate action and sustainable livelihoods, with a focus on the role and example of women in India.

## 10.2 Perspective on women and climate change

### 10.2.1 *Climate change and vulnerability of women*

The role of women in climate change is important as much as they are vulnerable to climate change and related shocks. O'Brien et al. (2007) have explained vulnerability as contextual, hence largely local. Kelly and Adger (2000) define *vulnerability* as 'the ability or inability of individuals or social groupings to respond to, in the sense of cope with, recover from or adapt to any external stress placed on their livelihoods and well-being'.

The main reason for the high vulnerability of women is their dependence on the primary sector. Women in rural areas are mostly engaged in agriculture and allied activities, with a great deal of dependence on natural resources. Because of the causal connection between climate change and natural resources, they are vulnerable to climate change shocks. Their vulnerability also emanates from their socio-economic positions and cultural factors. In a gender-unequal society, the burden of household drudgery and care of elders and children is usually on women. Thus, the high vulnerability of women to climate shocks is due to a number of reasons:

- 1 Women constitute a high proportion of the population who are dependent on natural resources, like land, forest, and water. They derive their livelihoods mainly from the primary sector. Rural women in particular, especially in less-developed countries, are heavily dependent on agriculture, horticulture, animal husbandry, and allied activities. These sectors are prone to climate shocks. Poor women collect food, fodder, and water from freely available natural resources, whose depletion creates scarcity and increases the burden on women.
- 2 Women in most societies have limited ownership of land and other immovable assets. They have a limited role in domestic decision-making. Their levels of education and skill are generally lower. Their social deprivation aggravates their economic and other vulnerabilities and reduces their capacity to absorb climate change shocks.
- 3 Socio-cultural norms in many societies privilege men over women in accessing food, clothes, education, health, and shelter. Further, women are unable to migrate in case of crises, calamities, and disasters. They have the primary responsibility of the household, including the care of elders and children, also during calamities like drought and floods.

In sum, compared to men, women have a much greater vulnerability to climate change shocks.

### 10.2.2 Role of women in climate adaptation

Women can play a vital role in climate adaptation. Climate action requires a women-centric approach:

- 1 Women in many societies are the custodians of traditional knowledge. This includes knowledge of water conservation and harvesting, seed and food preservation, and many other things important for climate adaptation.
- 2 Rural women in particular work and seek livelihoods in and around their house and hearth. So stimulating livelihoods locally not only is women-friendly but also strengthens their resilience in times of climate shocks.
- 3 Improving education, skills, and knowledge of women and promoting their economic, social, and political empowerment would greatly help in reducing their vulnerabilities and reinforcing their ability to climate adaptation, including the capacity to absorb climate shocks.

Women should be an important focus in mainstreaming climate adaptation. They should be promoted as an agent of mainstreaming climate adaptation. USAID (2009) has defined *mainstreaming* climate adaptation ‘as integration of climate concerns and adaptation responses into relevant policies, plans, programmes and projects at the national, sub-national and local scales’.

### 10.2.3 Programmes stimulating agency of poor women

For our examination of local-level, women-led climate action, we have concentrated on the DAYNRLM and MGNREGS. Although these programmes are meant for the promotion of livelihood, they are making an important contribution to enhancing the climate-adaptive capacities of rural poor women.

#### 10.2.3.1 Deendayal Antyodaya National Rural Livelihood Mission

The Deendayal Antyodaya National Rural Livelihood Mission (DAYNRLM) was launched in June 2011. It is a national-level programme that aims at reducing poverty by providing institutional and financial mechanisms to the poor to access sustainable and productive self- and wage employment. It works on the principle that there is an ‘agency’ of the poor. By mobilising this ‘agency’, through building their capability, they can come out of poverty on their own.

To this effect, the programme is investing into four areas of capability enhancement:

- 1 Social mobilisation of rural women into self-help groups (SHGs)
- 2 Financial inclusion of all SHG members

- 3 Facilitating access to credit and skills to get gainful and sustainable livelihoods
- 4 Their social empowerment

By March 2024, the DAYNRLM had mobilised about 100 million adult women into 10 million SHGs and 4.63 million village organisations. Cumulatively, SHGs by then had received from the government Rs 197.5 billion as capitalisation support fund and Rs 8.6 trillion as bank credit, with one of the lowest non-performing assets (NPAs) of 1.6% – a remarkable feat in itself.

#### 10.2.3.2 *Mahatma Gandhi National Rural Employment Guarantee Scheme*

The Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) was launched on 2 February 2006 as an act-based public works programme. It aims to provide legally guaranteed 100 days of demand-based wage employment to rural households whose adult members volunteer to seek employment from the local authority. It is an important social security programme for the rural poor, who can fall back on the 100 days of guaranteed employment during a lean season. The provision of guaranteed employment reduces their livelihood vulnerability and strengthens their bargaining position in the labour market.

About 50 million households have been seeking employment under this programme since 2008, when from the MGNREGS was extended to all rural districts. In addition to employment generation, the scheme creates community and individual assets, with a great deal of focus on land, water, forest, and other natural resource management (NRM) works. The ‘multiplier effects’ of these works have created secondary-level employment and income benefits. It has sprouted millions of public and private productive and other assets which have recharged natural resources, apart from reinvigorating the rural economy.

Both these programmes have a strong component of women-led climate action as follows:

- 1 Both aim at reducing livelihood vulnerabilities of the poor. Women are extremely vulnerable to climate change, to which these programmes have ameliorative effects.
- 2 Both programmes contain elements of direct climate action. The MGNREGS helps in recharging natural resources and promoting land, water, and forest development.
- 3 Women are important local actors in both programmes. While the MGNREGS is characterised by a high participation of women, as they earn more than 50% of the person days; the DAYNRLM is a 100% programme of and for rural women.

### 10.3 Women-led sustainable livelihoods and climate action through DAYNRLM and MGNREGS

Women form a sizeable chunk of the workforce in Indian agriculture. About three-fourths of full-time workers on farms are women, because men move to cities for higher wages (MoAFW, 2021). They are the backbone of animal husbandry and take care of other allied activities. In more recent years, the number of women farmers has also gone up significantly. The high share of women in the agricultural workforce and increasing number of women farmers often gets labelled as ‘feminisation of agriculture’, although women still hold only 11.72% of the total operational area (MoAFW, 2021).

Notwithstanding the increasing role of women in Indian agriculture, there has been little attempt to improve the lot and position of women farmers. Realising the increasing significance of women in Indian agriculture, the DAYNRLM initiated a *Mahila Kisan Sashaktikaran Pariyojana* (MKSP) in 2010–2011 ‘to meet the specific needs of women farmers’. There is another initiative under the DAYNRLM, called community managed sustainable agriculture (CMSA). These two programmes of the MKSP and CMSA have made noticeable contributions to improve the lives of women farmers. This chapter captures the findings, as emerged from various impact assessments, conducted on the related programmes to show that these two programmes have enhanced the adaptive capacities of poor women to climate change and led to recharging of natural resources.

#### 10.3.1 MKSP and CMSA under DAYNRLM

Between 2010–2011 and 2020–2021, over 17 million rural women have joined the MKSP and CMSA programmes. The Mission had adopted a diversified livelihoods approach, with a thrust on agroecological practices. It targeted small and marginal farmers, mostly in rain-fed areas, with a view to mitigate their vulnerabilities, augment their income, reduce cost of cultivation, and promote sustainability.

Sikkim’s organic story; Madhya Pradesh’s agricultural improvement works; Jharkhand’s thrust on vegetable, fruit, and animal resources; Odisha’s innovative non-timber forest products (NTFP) and mango plantation initiatives; Rajasthan’s water management works; Andhra Pradesh’s natural farming; and Gujarat’s and Himachal Pradesh’s efforts at *Prakritik Kheti* have all gained from the convergence of social capital and credit under the DAYNRLM.

Under the MKSP, over 60,000 women *Krishi* and *Pashu Sakhis* have been trained as community resource persons (CRPs). These women have not only come out of poverty but also become agents of socio-economic change. They received intensive capacity-building training in partnership with national and state resource persons and institutions like the *Krishi Vigyan Kendras*. Under this programme, a number of farmers’ field schools (*Krishi* and *Pashu*

*Pathshalas*) were set up in partnership with the SHGs. SHG members were trained in the preservation and rotation of seeds (using own farm seeds) and seed treatment by brine solution, cow urine, *beejamrut* (a combination of cow dung, cow urine, and lime), and trichoderma (a bio-fungicide).

Under this scheme, together with the MGNREGS, other activities were carried out, such as improving soil by giving attention to soil moisture and conservation as well as soil nutrient management practices like NADEP, vermicompost, *Jeevamrut*, *Ghanajeevamrut*, and azolla. Also, the use of ridge and furrow, ridge to valley, trenches, corner pits, farm ponds for *in situ* moisture conservation and crop protection through trap crops, yellow sticky trap, border crop, *Brahmastra*, *Agneyastra*, and *Neemastra* was encouraged.

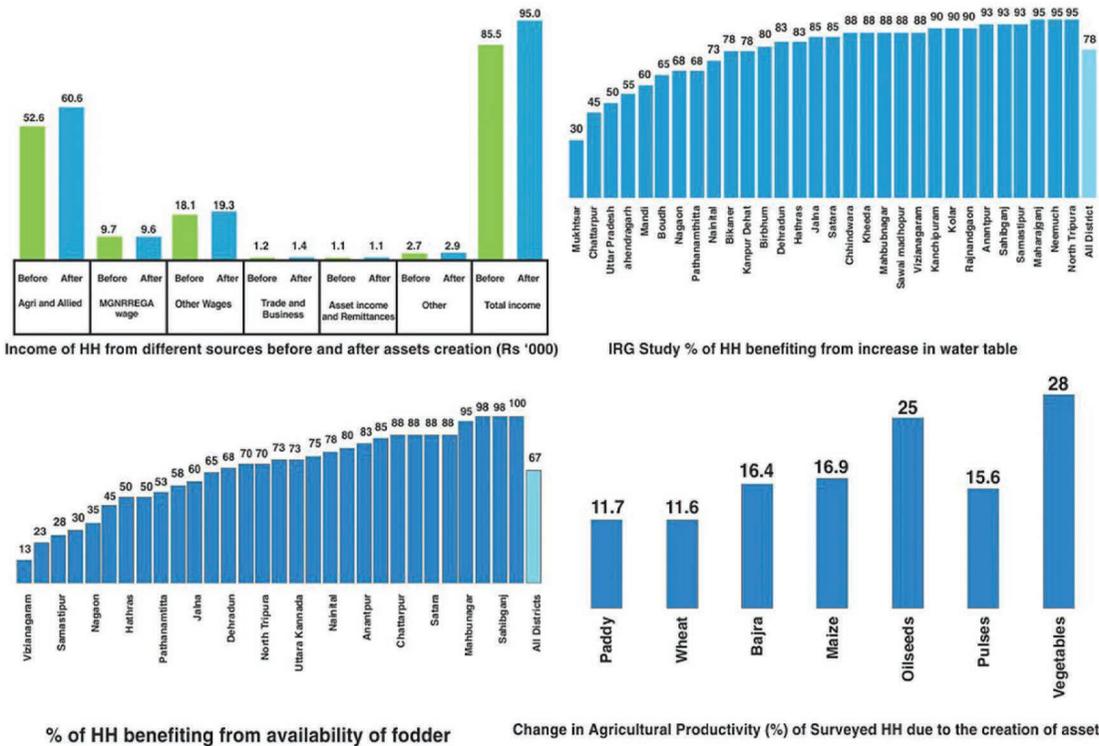
Agri-nutrition gardens with multi-layer cropping were promoted for households. People were advised to plant trees like moringa and papaya but to also go in for creepers, leafy vegetables, along with trellis, poultry, duck rearing, and goat rearing. Household wastewater was to be used for kitchen gardens. In addition, keepers of a kitchen garden could avail kitchen garden kits under the scheme.

Provisions were made to improve the basic amenities of poor households. Beneficiaries of the scheme were also provided with nutrition gardens and animal sheds. Under the *Pradhan Mantri Awaas Yojana – Gramin* (PMAY-G), 90 days of wage work in the plains and 95 days in hilly areas for house construction were allowed under MGNREGS to increase the basic amenities of poor households.

### 10.3.2 MGNREGS for sustainable livelihood

From 2014 to 2015, concerted efforts have been made to combine the MGNREGS scheme with other programmes to create more useful and productive assets. The guidelines were changed to make a provision for 60% of work, in terms of expenditure, on agricultural and allied activities. Individual productive assets received a boost, like farm ponds, animal sheds, dug wells, vermi and NADEP pits, water and soil conservation works, soak pits, solid resource management, and plantations.

As a result of the impetus given to individual assets, the number of individual beneficiary works under the MGNREGA went up significantly. From a fifth of the total works taken up in 2012–2014 to two-thirds<sup>1</sup> (67.71%) in 2019–2020. A huge number of them were productive assets. Between 2014 and July 2022, 35.76 million farm ponds, 307.16 million natural resource management (NRM) works, 21.01 million horticulture works, 67.03 million plantations, 11.38 million check dams, 10.87 million dug wells, 11.90 million cattle sheds, 16.62 million NADEP vermicompost pits, 49.99 million water conservation structures, 24.95 million soak pits to a total of 377.08 million individual beneficiary works had been taken up. This number was only 26.58 million between 2005 and 2014.



**FIGURE 10.1** Impact of water conservation works undertaken in MGNREGS: (a) Improvement in incomes; (b) percentage (%) of households benefiting from increase in water table; (c) percentage (%) of households benefiting from availability of water; (d) change in agricultural productivity in surveyed households.

Source: Sinha (2024).

Given the significance of a huge number of productive individual works, Pankaj and Bhattacharya (2018, 2020) had suggested how the MGNREGS could be re-engineered to double farmers' incomes. Another comprehensive study at the Institute of Economic Growth (IEG), under Manoj K. Panda, confirmed the efficacy of water conservation works undertaken in the MGNREGS. Other micro studies also underscored the substantive improvement in water conservation and harvesting, which had made rain-fed areas better prepared to face the vagary of the monsoon. The river rejuvenation work in the Banda district of Uttar Pradesh and the revival of tanks in Udham Singh Nagar of Uttarakhand are important examples.

An IIT Delhi study (2019–2020) showed that the MGNREGS had contributed to gainful growth in rain-fed agriculture (Suraj et al., 2023). Panda et al. (2018) had quantified the gains of NRM works in terms of productivity, income, fodder availability, and improvement in the water table. Down to Earth (2019–2020) tracked water conservation works across districts in the first 15 years of the MGNREGS. They show significant benefits to the villages with water conservation works.

#### 10.4 Diversified livelihood under women's collectives

Women's collectives under the DAYNRLM have diversified their economic activities. This has resulted in 24,520 women-managed, custom-hiring centres for agricultural operations, 1,30,000 banking correspondent sakhis (BCS) as community resource persons, 2.08 million start-up village enterprises, 1,811 women-managed public transport companies, and so on. They received 8.6 trillion credit from banks, with barely 1.6% NPA, one of the lowest of all types of lending. Nonetheless, challenges remain in terms of mapping of SHG accounts to individual accounts, formalisation of SHGs for financial support, and creating a credit history, to become eligible for higher-order loans, especially with regards to working capital for SHGs.

Various studies (Panda et al., 2018; Misra et al., 2017; Nielsen, 2019) clearly establish income gains for SHG women members, thanks to their diversified livelihoods. A case study by the TISS Mumbai (2019) on MKSP farmers in Chota Udepur in Gujarat with the Shroff Foundation; PRADAN's work in village Bhadubeda in Keonjhar in Odisha; work of *Krishi Sakhi* like Champa Singh in Anuppur in MP, Urmila Linda in the Namkum block of Ranchi in Jharkhand, Ranjana Tai in the Koli village of Yavatmal in Maharashtra, and thousands of similar other cases in thousands of villages confirm that hand-holding by the CRPs has resulted in substantive income gains to women members of the SHGs (Bhanumurthy et al., 2018).

These cases highlight how consistent hand-holding by CRPs led to significant income gains and empowered women in SHGs. This is confirmed by another study of 6,595 households, 173 SHGs, 162 community resource

persons, and 306 villages across eight states (Rajasthan, Chhattisgarh, Madhya Pradesh, West Bengal, Jharkhand, Karnataka, Assam). It shows raised income levels and diversified livelihoods of SHG women members (Nielsen, 2019). It further showed that households (HHs) with SHG women members with training had a higher average annual income from agriculture (1.3 times higher), animal husbandry, and NTFP than those without any training. There was a better dietary diversity in the treatment villages and a wider use of agroecological practices like land preparation, soil and plant nutrition management, and plant protection. Also, in these villages, households, income from livestock was 2.5 times higher than that of the control group (no training). *Pashu Sakhi* supplied three major veterinary services to the livestock – medicines, vaccination, and deworming. All this had led to higher returns from cattle rearing. It may be noted here that livestock is a secondary activity in most households, also multiple sources of livelihood.

To sum up, the promotion of women farmers through the DAYNRLM has shown clear advantages. Also, there are some lessons from the promotion of natural farming and climate resilience practices, according to various studies including Misra et al., 2017. The most important are given here:

- 1 Women's collectives can promote sustainable agricultural practices, as is happening in many places, especially under the DAYNRLM.
- 2 Women's collectives take time to mature. But once they do, it is much easier to promote livelihood diversification through them.
- 3 One way to promote a higher-order income for the landless and poor, marginal, and small farmers is to encourage them to take up multiple sources of livelihoods, consisting of farm and non-farm activities.
- 4 Animal husbandry, if tapped effectively, can result in major income gains to poor rural households.
- 5 Bio-fertilisers and bio-pesticides not only reduce dependence on chemical ones but also reduce the cost of cultivation, although productivity gains remain modest, at least initially. Yet one cannot be a purist on natural farming practice, as there are alternative and effective sustainable agricultural practices that hold a key to improving soil health. Therefore, we should let a thousand flowers bloom rather than try to pursue only one set of purist practice. Improved soil health and climate resilience require a multisectoral, diversified livelihoods approach.
- 6 The decision to adopt natural farming needs to be an informed one. It should be based on evidence to be acceptable. Besides, there should be efforts to promote a community connect, the use of technology, CRP hand-holding of women SHG members, and assessment of last-mile challenges.
- 7 Credit availability to and linkage of the women's collectives with initiatives of other concerned departments, such as Agriculture, Horticulture,

Animal Husbandry, Forests, MSMEs, Fisheries, Food Processing, and Rural Development, facilitate the effective use of public resources and boost returns from them.

It is clear from facts and studies that women's collectives under the DAYN-RLM have mobilised millions of rural women who have emerged as an important agent of change across the states. But the SHG movement needs a higher-order access to credit, based on a detailed microcredit plan, to transform rural households. Low levels of human capital and skills make many nano-enterprises low on the value chain as also income and profit. They still remain at subsistence level in many cases.

The success of the Start-Up Village Enterprise Programme indicates that community resource persons for enterprise development, along with access to credit, can play an important role in poverty reduction (World Bank, 2019). Similarly, Mudra loans need to support the last-mile<sup>2</sup> hand-holding (not just digital money transfer!) and a culture of making a microcredit plan before any lending. Improved access to credit can surely break the 'fortresses of poverty', using women's collectives as the medium of transformation.

## 10.5 MGNREGS for sustainable livelihoods and climate action

MGNREGS 2005 was, in a way, a culmination of India's experiments with public works-based employment generation programmes. The Scheme has multiple objectives around its principal objective, which is to provide livelihood security through 100 days of guaranteed wage employment to every rural household. It has been variously described as a poverty alleviation, social security, infrastructure building, and participatory development programme. Its scale of operation commands applause as the world's largest public works programme and the biggest state-sponsored employment generation programme in a non-communist country.

In over one and a half decades of its implementation, the MGNREGS has achieved many objectives, partly or substantially. Some of them were explicitly intended, and some not so explicitly. For example, the creation of community assets, especially related to land, water, and forest, has rejuvenated natural resources, positively affecting climate resilience. The restored natural resources have generated locally sustainable livelihoods for the rural population, especially the poor, while it has improved natural resources to cope with climate events, such as droughts and floods – to some extent (Figure 10.1).

### 10.5.1 Poverty reduction and sustainable livelihoods

A United Nations Development Programme report (UNDP, 2022) on multidimensional poverty in India shows that 415 million persons have come

out of poverty since 2005–2006, the year of enactment of the MGNREGS. Although this decline in poverty is attributed to a number of factors, guaranteed employment through the MGNREGS has played an important role in reducing rural poverty (Pankaj, 2023).

This is corroborated by some other studies. The State of Employment in Rural Areas 2022 (Dalberg, 2022) finds that ‘MGNREGS is critical to the livelihood security of vulnerable households in rural India and several aspects of the scheme are working well’. The Azim Premji University conducted a study during Covid-19 on the role of the MGNREGS in the year after the 2020 lockdown. The outcome emphasised the utility and importance of the programme during the lockdown.

Although the MGNREGS has played an important role in rural poverty reduction, rural households have been lifted out of poverty thanks to various other programmes as well. Important among them are the PMAY-G; financial inclusion; opening of bank accounts through the *Jan Dhan Yojana*; provision of toilets, roads, and electricity, as also improved school and health facilities, like universal free primary education, universal immunisation of infants and pregnant women, insurance coverage, and cooking gas provision (*Ujjawala*).

Concerted efforts through pro-poor public welfare programmes, adopted more rigorously since 2014, have made a difference to the assets base of deprived households. Sudipto Mundle (Mint., 2022) re-visited some villages in the Palamu district of Jharkhand and found that chronic poverty had declined, although some households were still in poverty. The 78th Round National Sample Survey (NSSO, 2019) and the National Family Health Survey-5 (2019–2021) capture and confirm these gains (MoHFW, 2021).

### 10.5.2 For the poor in poor regions

A large number of the MGNREGS assets are related to water conservation, solid and liquid resource management, animal sheds, vermicompost and NADEP pits, afforestation, and natural resource management. These works have visible consequences for the recharge of natural resources. Rajasthan’s *Mukhyamantri Jal Swavalamban Yojana*, Maharashtra’s *Jalyukta Shivar*, Bihar’s *Hariyali* Mission, Telengana’s plant nursery in every *Gram Panchayat*, and other works like segregation sheds, soak pits, percolation tanks, as also Chhatisgarh’s thrust on developing land for beneficiaries under the Forest Rights Act, are some state-specific contributions of the MGNREGS. Sikkim used this programme for springshed development to provide drinking water and animal sheds for dairy as well as promote organic farming and cardamom plantations. Meghalaya’s village employment committees used the MGNREGS for all-round village development and income improvement for its rural population.

### 10.5.3 *Climate-sustainable livelihood and climate action*

Tiwari et al. (2011) made a systematic assessment of the environmental effects of certain MGNREGS assets in 20 selected villages of the rain-fed Chitradurga district in Karnataka. They found significant positive impacts of the MGNREGS on environment and livelihood: (a) through the improvement of environmental services like recharging of land, water, and forest, and (b) by reducing the vulnerability of agricultural production and the subsequent enhancement of livelihood resources.

They argued that the degradation of natural resources – land, water, and forests – exacerbates the vulnerability of the rural poor because of its adverse effects on crop production and yields. The poor are also badly affected by the scarcity of fuel, fodder, and water. The MGNREGS works are recharging natural resources and thereby reducing the vulnerability of the rural poor.

#### 10.5.3.1 *Promoting environmental services*

An important contribution of the MGNREGA works is the improvement of environmental services, which include recharging of groundwater, increasing rainwater percolation, conserving water, expanding the irrigated area, reducing soil erosion, boosting soil fertility, conserving biodiversity, reclaiming degraded crop and grazing lands, and enhancing the supply of leaf manure, fuelwood, and non-wood forest produce, and carbon sequestration.

The study of Tiwari et al. (2011) focused on the renovation of traditional water bodies that had been taken up in large numbers in the Chitradurga district. In this district, 62% of the total cultivable land was dry; only 9% cropland was being irrigated. So water conservation was given priority. The work pertained to desilting of ponds and other traditional water bodies. Between 2007 and 2008, a number of small and large tanks, out of a total of 291, were desilted. About 9,26,890 mt<sup>3</sup> of silt were removed from the renovated tanks. Out of six villages where desiltation was done, the groundwater level came up significantly, thanks to percolation and better storage of water. It rose by 113 m (77% rise) in the Koverahatti village, by 82 m (53%) in Khandikore, and by 46 m (30%) in Talavatti.

Because of the recharging of borewells, there was a substantive increase in irrigated area in the six villages. That is, 90% in Dodderi and Khandikerri, 100% (doubling of irrigated area from 400 to 800 ha) and 20% increase in the Parashurampura, Rangavanahalli, and Talavatti villages. The silt removed from the pond was applied to a cropped area, which resulted in a two- to three-fold growth in organic carbon content of the soil. Organic carbon indicates nitrogen in the soil that, in turn, improves soil fertility.

Tiwari et al.'s 2011 study further showed that check dams and percolation tanks had resulted in improved water levels in the surveyed villages, for example, by 24% in the Koverahatti village. Tree plantation and afforestation

had contributed to biomass production and green leaf manure. One hectare of pongamia trees (that is, about 300) can provide leaf manure for about 40 ha of land. This, in turn, can also give about 1 ton of biodiesel after 10 years of plantation. Land development like land levelling, terracing, and building of bunds was found to raise income levels from rupees zero to 1 million per acre per annum.

#### 10.5.3.2 *Reducing vulnerabilities*

The study also reported a reduction in three types of vulnerability, with respect to water, agriculture, and livelihood, which varied from village to village (Tiwari et al., 2011). Agriculture and livelihoods improve primarily when water is accessible, making a reduced vulnerability to water scarcity; a key factor to reinforce resilience.

The construction of check dams and the desilting of tanks reduced the water vulnerability in the Khandikere and Koverahatti villages. Because of water-related actions, these two villages also showed improved agriculture. There was more irrigated area, and nutrients were added to the cropland. Water conservation and harvesting works resulted in reduction in water and agriculture vulnerability in villages. Because of employment and additional income in the surveyed villages, there was also a reduction in livelihood vulnerability.

Evidently, the MGNREGS water conservation and harvesting initiatives had contributed to better environmental services and reduced vulnerabilities with respect to livelihood, water, and agriculture. Interestingly, pongamia plantation, which had been taken up as a drought-proofing activity, not only produced leaf manure, fuel, wood, and oilseeds, but also sequestered carbon within them and in the soil.

The Indian Institute of Science, Bengaluru, in its 2013 study of four districts and four states, had collected evidence on the environmental benefits of natural resource-promoting MGNREGS actions and their effects on livelihood improvement, including reduced vulnerabilities of the beneficiaries. It found that water conservation and harvesting work undertaken in the sample villages had resulted in either improved groundwater level or had remained the same, notwithstanding a higher number of borewells, and more use of groundwater during the study period, 2006–2012.

The finding is striking because groundwater levels had sunk elsewhere in the villages without such activities (the control group). Improved groundwater levels had led to an increase in irrigated areas and greater availability of drinking water to human and livestock. In 30 out of 40 sample villages, there was an increase in irrigated area that varied from 7% in the Bhilwara district of Rajasthan to 100% in the Dhar district of Madhya Pradesh. The result, of course, varied depending on the number of such works undertaken.

Further, there was an increase in the average number of days of water availability: from 13–88 days in the Medak district of then Andhra Pradesh (now Telangana), 5–15 days in the Chitradurga district of Karnataka, 30–90 days in the Bhilwara district of Rajasthan, and 190–365 days in the Dhar district of MP. In this last district, a scheme called *Kapil Dhara* (a local initiative under the MGNREGS) was implemented, with a focus on dug wells, percolation tanks, ponds, and bunds, using MGNREGS funds.

There was also higher availability of drinking water for humans and livestock. In all four surveyed districts with water conservation and harvesting works, the amount of drinking water consumed by households had increased. It was most visible in the Dhar district, where a special focus had been given on promoting water bodies under the *Kapil Dhara* scheme. In Dhar, there was an improvement in the availability of drinking water in all the surveyed villages. As a result, 25–39% of the sample beneficiary households reported an increase in the quantity of water used for domestic purposes. Further, the drudgery of rural women to collect drinking water had become less, since the distance travelled and the time taken to collect water had come down. The distance had come down by 44.2%–63.2%, and the time required for water collection on an average by 20%.

Desilting and the application of silt on cropland improves soil quality. It enhances the water storage capacity of the land and improves the soil structure and organic carbon component, which increase the productivity of land.

Check dams resulted in heightened soil organic carbon (SOC) by 62% in the Bhilwara district, and 85% in the Chitradurga district. About 72% of the beneficiary sample households reported an increase in SOC on their treated land. Land terracing, contour and field bunding, apart from afforestation and tree plantation, reduce soil erosion and prevent loss of soil fertility. Beneficiaries of soil erosion-preventing works reported an overall reduction in soil erosion in the range of 0.07 to 4.3 ton per hectare per year in the Medak district and 0.01 to 7.9 ton per hectare per year in the Bhilwara, Chitradurga, and Dhar districts. Between 62 and 100% of the sample beneficiaries had reported reduced soil erosion on their land.

Water conservation and land development works increased cultivated area and crop yield and promoted crop diversification. About 7% of the beneficiaries of land and irrigation works reported crop acreage increase in the surveyed districts, 10% in Bhilwara, 22% in Chitradurga, and 98% in Dhar. Overall, 25% of the beneficiaries reported an increase in crop intensity, while this was so for about 100% of the beneficiaries in Dhar.

In some villages, beneficiaries had diversified their cropping. In Bhilwara, they had started growing soyabean, black *gram*, and barley during rabi, cotton during *khariif*, and groundnut during *zaid* cropping seasons. Beneficiaries of land and irrigation works informed about higher crop yields on their farmland. Overall, 46–100% of the beneficiary farmers of different crops

reported an increase in productivity. This varied crop-wise and district-wise, though.

A similar study of six districts, two each from Tamil Nadu, UP, and Rajasthan, by Pankaj and Bhattacharya (2018), shows various effects of land and irrigation works. While land development works had resulted in crop acreage increase, irrigation works had also led to greater crop yield and crop diversification.

In a number of villages, afforestation, tree plantation, and fruit orchards had been promoted. Apart from direct income benefits to the beneficiaries, it had improved environmental services. For example, drought-proofing, afforestation, tree plantation, and land development works had increased soil organic carbon (SOC) in 72% of the total sample beneficiary plots.

The IISc's study (2013) demonstrated that water and irrigation works had reduced agricultural vulnerabilities. These, in turn, had brought down livelihood vulnerabilities, buttressed by additional income and employment benefits through the MGNREGS. Agricultural vulnerability had decreased between 13 and 52% in the surveyed villages of Medak (AP), between 4 and 49% in Chitradurga (Karnataka), between 28 and 56% in Dhar (MP), and 9 to 30% in Bhilwara (Rajasthan). Similarly, livelihood vulnerability had declined by 11 to 62% in Medak, 8 to 52% in Chitradurga, 34 to 81% in Dhar, and 4 to 46% in Bhilwara.

Another study (Panda et al., 2018) covered 158 villages, selected from 18 agroclimatic zones of the country. It found that in 2017–2018, plantation and soil quality improvement works of the MGNREGS had captured 102 MT carbon dioxide (MTCO<sub>2</sub>). This amount could rise to 249 by 2030.

Dalberg, (2022) noted that the MGNREGS forest and tree plantation works could help India achieve the creation of an additional carbon sink, equivalent to 2.5–3 Gt of carbon dioxide.<sup>3</sup> It found that drought-proofing, including tree plantation, forest restoration, and grassland development works, contributed to 40% of the total carbon sequestration under the MGNREGS. Carbon capturing from drought-proofing was in the range of 0.29–4.50 ton per hectare per year, land development activities captured 0.1–1.97 ton per hectare per year, and minor irrigation 0.08–1.93 ton per hectare per year.

These projected benefits can be sustained only if communities actively maintain them. As a consequence, mechanisms must be established to ensure ongoing community engagement and upkeep. Panda et al. (2018) assessed the effects of natural resource management (NRM) works on income and livelihoods of 1,200 sample beneficiaries of individual and community assets. They had been selected from 30 districts, spread over 14 agroclimatic zones and 21 states.

The major gains of NRM assets pertained to an increase in land productivity, enhanced irrigation and groundwater level, greater availability of

drinking water for human and livestock, and overall increase in income level. They had also resulted in diversification of livelihood of the local population.

Of the total sample beneficiaries of individual assets, 38% reported an improvement in the quality of land, 29% mentioned diversified livelihood opportunities, 28% an increase in irrigation potential, 21% conservation of soil and water, 21% recharging of groundwater level, 12% availability of water for livestock, 9% an expansion of cropping area, 7% an increase in cropping intensity, and 4% availability of fodder. Similar benefits were reported from community assets as well.

A major impact of NRM assets for the sample beneficiary households was a higher income. Between 2015–2016 and 2016–2017, the average income of such households had gone up by 11.1%. This did vary from district to district, though. It had increased by 23.3% in Mahendragarh (Haryana), 17.6% in Jalna (Maharashtra), 16.4% in Pathanamthitta (Kerala), and 16.3% in Nagaon (Assam), among others.

Most of the beneficiary households that were dependent on agriculture and allied activities informed about the highest increase in income from agriculture. It had grown by 15% (average of the 30 districts). This high increase in agricultural income was mainly caused by an improved productivity of various crops. For example, productivity had gone up by 11.7% in paddy, 11.6% in wheat, 16.4% in bajra, 16.9% in maize, 16% in pulses, 15.5% in oilseeds, and 28% in vegetables.

### 10.5.3.3 *Enhanced income reduced vulnerabilities*

There was a decline in migration and household indebtedness, two vital indicators of the vulnerability of rural poor. Although the overall migration in the surveyed districts became less by a mere 1%, there was a decline of 10% in Jalna (Maharashtra), 7.5% in Chindwara (MP), 5.0% in Satara (Maharashtra), and 2.5% each in Mahaboobnagar (AP), Sahibganj (Jharkhand), and Samastipur (Bihar). There was also a reduction in borrowing from various sources, except that from SHGs. Households borrowing from relatives went down from 25.27% to 21.93%, from village moneylenders 12.68% to 6.69%, and from traders 12.39% to 8.19%.

Further, 10 out of 30 surveyed districts reported an increase in new livelihood activities after the creation of NRM assets. Horticulture, fishery, and the cultivation of cash crops like vegetables, pulses, oilseeds, and spices were new activities that beneficiaries of land development and irrigation works had taken up.

Apart from these economic benefits, environmental benefits had also come to a large number of beneficiaries: about 85% of them reported better access to drinking water, 93% confirmed improvement in land quality, and 78.4% reported an increase in groundwater level.

Pankaj and Bhattacharya (2018) examined productive individual assets, mainly land and irrigation activities, tree plantation, horticulture, animal sheds, and fishponds in six districts, two each from Rajasthan, Tamil Nadu, and UP. They found substantive economic gains in terms of enhanced income, reduced vulnerabilities of livelihoods, and an increase in the intensity of agricultural activities.

While land development works resulted in increased acreage, water conservation and irrigation works enhanced agricultural productivity and diversified crops. For example, there was an increase in crop acreage by 0.53 acre on an average per land development work. Similarly, sample beneficiaries of irrigation works reported higher yields of 19 out of 29 cultivated crops. Again, this varied crop-wise and region-wise (Pankaj & Bhattacharya, 2018). For example, the yield of potato increased by 140.38%, lentil 135.65%, sugarcane 133.90%, cotton 116.88%, bottle gourd 100%, cauliflower 100%, *paddy* 92.63%, wheat 78.06%, maize 73.50%, and *gram* 73.05% (Pankaj & Bhattacharya, 2018, p. 127).

There was also crop diversification as a result of these irrigation assets. Beneficiaries of irrigation works grew new crops, like coriander, green fodder, and methi in Rajasthan; mustard, peppermint, and eggplant in UP; and maize and capsicum in TN (Pankaj & Bhattacharya, 2018, p. 128).

Horticulture, livestock rearing, and fishery improved the income levels of the beneficiary households. The return on different types of assets varied, but that on the fishpond was relatively the highest.

As a result of improved incomes through horticulture, livestock, fishery, and agriculture, there was a reduction not only in the livelihood vulnerability of the beneficiary households but also in their dependence on casual wage employment (Box 10.1). About 25% of them had stopped seeking wage employment post-MGNREGS assets. About one-fourth of the total sample of beneficiaries (33.75% in Rajasthan, 27.5% in UP, and 11.25% in TN) had stopped migrating in search of jobs.

**BOX 10.1 ECOLOGICALLY SUSTAINABLE LOCAL ECONOMY – THE SAGA OF A FISHPOND BENEFICIARY OF MGNREGS’S INDIVIDUAL WORK IN THE CUDDALORE DISTRICT OF TAMIL NADU**

There was a poor couple who was mainly dependent on wage labour. The husband used to work as a carpenter and would earn about Rs 300–350 per day for not more than 20 days in a month. His educated wife was working as a private school teacher with a meagre salary of Rs 4,000 per month. This couple was eligible for MGNREGA’s individual work, so they became a beneficiary of a small fishpond. This transformed the character of their livelihood from that of

a wage-seeker to a self-employed person and made theirs a livelihood-secured household. The couple was initially enabled to get a small fishpond through the MGNREGA. This pond gave them a return of Rs 50,000–60,000 income per annum. Encouraged by the rise in income, the carpenter expanded the size of the pond to 200 × 200 meter by investing his earnings from the fishpond.

Then he heard that rearing poultry on the bank of a water body was a profitable proposition. Not only would it give a high yield of the poultry, but the cold breeze from the pond would also keep the chickens free from diseases. He started a poultry unit on both sides of the bank of the pond. The cool breeze of the water body kept the birds healthy and free from diseases, as he had been told. He used poultry excreta as feed for the fish.

Once his earnings increased, he expanded his activities and bought two cows. After deducting for his own consumption needs, he sold the surplus milk in the market. He spread the cow dung in the pond for the fish.

His overall earnings from the fishpond, poultry units, and cows gave them a decent income, about Rs 4–5 million per annum – so much so that he stopped working as a carpenter. Prior to this, he used to get about Rs 350 per day in a month on an average of 20 days of wage work. His wife also left her school-teacher job, in which she was getting about 4,000 rupees per month.

The average monthly income of the couple had been Rs 10,000–11,000 but has now gone up to Rs 50,000 per month. Now the (ex-)carpenter couple works full-time on their own farm – in fishery, poultry, and animal husbandry. The household had transformed itself from a wage-employment seeker to a self-employed household. Also, this was a fantastic case of environmentally sustainable and mutually complementing economic activities. There was zero wastage generation.

There are many such examples of beneficiaries who have transformed their lives making use of MGNREGA assets for their individual lands or homesteads.

*Source:* Pankaj (2023, pp. 133–134).

## 10.6 Conclusion

The pursuit of climate-insensitive development policies is an important reason for triggering climate change. Similarly, over-exploitation of natural resources is a cause of environmental degradation. But climate change is not irreversible. Climate-friendly development policies and locally sustainable livelihood can help both prevent climate change and stop environmental degradation. A climate-resilient policy and the promotion of sustainable livelihoods hold a key to preventing environmental loss. In this context, women are an important agent for climate action, both as a production agent and as

a manager of economic resources. As such, their role in preventing climate change is vital.

While climate change is a global phenomenon, climate adaptation is, essentially, a local action. Although climate change affects all, it affects the poor and women more than anybody else. Even so, the poor and vulnerable people can play an important role in climate adaptation. Women are one such group that is not only the most vulnerable to climate change but can also be equally the most important agent to bring about climate adaptation.

Women in many societies are heavily dependent on nature-based occupations, say, agriculture and allied activities. They seek their livelihoods from the primary sector, by collecting (free) fodder, fuel, and water from common resources. Climate change affects their livelihood adversely. It also affects them by increasing their drudgery in collecting fuel, fodder, and water. Climate change depletes these resources so that the task of women gets increased. They have to walk longer and spend more time to collect fuel, fodder, and water from common resources.

The role of women in promoting climate action requires promoting sustainable livelihood locally. Women in general, because of socio-cultural and other factors, including a greater responsibility in the care economy, prefer work near their houses, so that they can meet both responsibilities. Here comes the role of India's two major flagship programmes aimed at promoting sustainable livelihood locally.

The DAYNRLM and MGNREGS are poverty-alleviation and rural development programmes. They have made noticeable contributions in reducing rural poverty and promoting sustainable livelihood locally. The former programme targets mainly women; the latter, by default, has benefitted mostly women. Women constitute more than 50% of the MGNREGA workers in some states and have earned about 50% of the total person days at all-India level. This has a direct effect on bringing down their livelihood vulnerability.

In the process of job creation, the MGNREGS has also created useful and productive assets, including a huge number of natural resources promoting land, water, and forest works, which bear directly on climate change action. In the places where these works are operative, the water level has gone up, land quality has improved, and green coverage has widened. These and other works have also created secondary-level income and employment benefits. Overall, they have promoted a sustainable livelihood for the poor and for women. They have also brought down their vulnerabilities.

DAYNRLM is actually a great social capital, accumulated through the nurturing of women's collectives. They are making significant contributions to livelihood improvement; their social capital can be tapped to enhance various environmental services.

Women are also custodians of traditional knowledge and practices, of which many are environment-friendly and climate-sustainable. Their social

capital can be used to promote environment services and prevent further climate change – say, by taking a collective decision not to use biomass for cooking and by their direct, local, livelihood-sustainable actions.

Both programmes have created a noticeable and significant influence on the promotion of environmental services, reducing water and livelihood vulnerability of the rural poor, more so of women. But a closer partnership of local *Gram Panchayats* with women's collectives can further the case for deliberative, decentralised community action for sustainable economic progress. There is evidence to suggest devolution leads to improved human development indicators, and improved human development indicators lead to higher incomes. These two programmes can strengthen local action for climate resilience by diversification of livelihoods on scale. Multiple and diversified livelihoods are the best way forward for climate action and justice.

## Notes

- 1 This includes providing 90 MGNREGA workdays for plains and 95 for hilly areas in the completion of the Prime Minister *Awas Yojna – Gramin* (PMAY-G) scheme.
- 2 See Sinha (2024), *The Last Mile*, a valuable resource on public policy choice in India.
- 3 The Government of India, in its biennial update report to the United Nations Framework on Climate Convention, underlined the role of the MGNREGS as a contributor to carbon sequestration.

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## **PART 3**

# Innovations in sustainable practices



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# 11

## MEETING ASPIRATIONS

### The Lakhpati Kisan pathway

*Ganesh Neelam and Sujit Kumar Gopinathan*

#### 11.1 Introduction

The majority of the wealthiest districts in the country, in terms of natural resources, are also the poorest and most underdeveloped. Of the 50 top mineral-producing districts, 34 fall under the 150 most backward. They are almost contiguous districts and form a tribal belt in the Central Indian heartland. It houses 73% of India's tribal population (GoI, 2013).

The connection between tribal communities, rain-fed areas, and poverty has been clearly acknowledged in the 12th five-year plan (GoI, 2012, p. 313) as follows:<sup>2</sup>

*Of 2445 blocks having a poverty headcount ratio exceeding 50%, 897 blocks can be classified as tribal blocks, that is, having a tribal population exceeding 20%. Of these 897 tribal blocks, 649 blocks (72%) have poverty (HCR) exceeding 50% and 577 tribal blocks (64%) are rainfed. It appears, therefore, that there is a high correlation between tribals, rainfed areas and incidence of high poverty. The fact that the blocks inhabited by a greater percentage of tribals tend to be the poorest blocks is a matter of serious concern.*

The small and marginal tribal and other rural families in the Central Indian tribal belt are dependent on agriculture and allied livelihoods for their food security and income. Land, livestock, and in certain clusters, non-timber forest products (NTFP) form their livelihood dependence in a layered manner, such as agriculture plus livestock, agriculture plus non-timber forest products, agriculture plus livestock plus non-timber forest products. Unfortunately,

land fragmentation, undulating land terrain, rain-fed agriculture, poor agricultural practices with poor infrastructure, livestock mortality, reducing forest cover, etc. have been creating challenges for the families in meeting their food security needs; they are thus pushed to migrate to urban centres as labourers.

Annual incomes according to baseline surveys conducted in some states vary from Rs 19,000 to Rs 30,000 per annum from agriculture and allied livelihoods (Ministry of Agriculture & Farmers Welfare, 2023). As land parcels of these families are fragmented and located on undulating land, with a bare 9% irrigation availability in the post-monsoon season, yields are minimal, also because only staple crops are cultivated. Forest resources such as NTFPs have been depleting over the years, with the forest cover itself reducing (Nandurbar forest cover reduced from 46.44 km<sup>2</sup> in 2001 to 19.99 km<sup>2</sup> in 2008) (GoI, 2020).<sup>3</sup>

The Indigenous and rural communities in the Central Indian tribal belt are among the most vulnerable communities being hit by climate variability and extreme events. Heat stress along with droughts, floods, and long dry spells in the monsoon are seen frequently in that area. Regions that are rich in mineral resources, especially coal, are facing the critical issue of transition according to the climate commitments India had made internationally.

With increasing climate exposures, the communities migrate in distress, looking for alternative livelihood opportunities in the form of (daily wage) labour. This is mainly because they depend on agriculture and allied livelihoods and are mostly illiterate or semi-literate. Day labour, then, is the only option when climate vagaries, such as droughts or floods, hit them.

Climate variability and extremes and the impact on the livelihoods of tribal and rural communities need a focused approach and engagement that look at building their capabilities to improve their livelihoods. Resources available within the community need to be strengthened, along with building a relevant support system in the form of infrastructure, schemes, and markets, to secure their livelihoods from a long-term perspective (Sharma & Soni, 2006; Enhancing rainfed farming livelihoods: Need of policy changes, 2007).

Various stakeholders are looking at improving farm livelihoods while adapting to climate vagaries.

For instance, the Government of India is promoting the 'doubling farmers' income' scheme, with a focus on agriculture and allied livelihood value chains, and building on the same through the vast self-help groups network as part of its National Rural Livelihood Mission.

The Lakhpati Kisan programme aims to meet the aspirations of small and marginal families through focused efforts on strengthening the agriculture and allied livelihoods value chain, along with building resilience through water and soil management, crop and livelihood diversity, and technology

integration. Women's collectives and community institutions are leading all activities.

This chapter takes us through the journey of communities and their institutions in the Lakhpati Kisan programme, the steps taken towards meeting their aspirations and the accompanying discussions to bring in relevant opportunities and solutions to address the challenges linked to water, soil, crop yield, etc., while addressing the larger climate connections as well.

It articulates the field experiences with communities and the systems thinking exercises, as they learn to connect value chains with relevant services and technologies, keeping in view the goals of acquiring 'Lakhpati' incomes and achieving long-term sustainability.

## 11.2 The Lakhpati Kisan programme

The programme is implemented in four states: Jharkhand, Odisha, Gujarat, and Maharashtra, in 17 blocks of 12 districts, with a total of 425 villages (Figures 11.4 and 11.5). This geographical selection had been based on past engagements in blocks with more than 50% tribal population.

### 11.2.1 Institutions – their formation and role

The Lakhpati Kisan programme builds on the key principle of communitisation. The base-level institution consists of women-led self-help groups (SHGs) that are engaged in a basic saving and credit process that supports their immediate financial needs. These SHGs are brought together at the village level as village producer groups. The producer groups are focused and organised around agriculture, livestock, and NTFP. They are engaged in field action along with sharing and learning among themselves.

Producer groups are federated into a farmer producer company (FPC). The FPC steers the services and products overall as part of the programme for community members. The FPC is the key organisation that will be taking over responsibility to lead community growth.

All institutions on the ground are women-led, apart from lift irrigation cooperatives in Gujarat clusters, where it is a combination of men and women members. Since women are in charge of these institutions, women leaders form the board of directors, including a president, secretary, and treasurer. Efforts through the *URJA* event focus on the creation of energy among the women members to enable building the leadership capability of the women.

The next level of scale as part of phase 2 is secured through these women-led institutions as they focus on strengthening their base through the expansion of members at the village level.

The women leaders, especially the board of directors of the FPCs, are now well-known and accepted at village, cluster, block, and district levels, as also by government authorities. Members from these institutions are represented in *Gram Panchayats*; a few are also elected as *sarpanch*. This facilitates links with the local governance system.

Overall, the Lakhpati Kisan programme builds on these institutions right from the base-level institution of SHGs to the apex institution of FPCs (Figure 11.1). Each institution has clear roles within the livelihood value chain. For example, the SHGs are mostly occupied with basic credit needs at individual level, while the FPCs step in at production and market stages.

FPCs enable members to get a better price for their produce. The entrepreneurs, identified along with the FPCs, play a role in providing quality services to members. These entrepreneurs are from the community. They address gaps in the value chain, as polyhouse–nursery entrepreneur, livestock entrepreneur or brood lac entrepreneur, and so on.

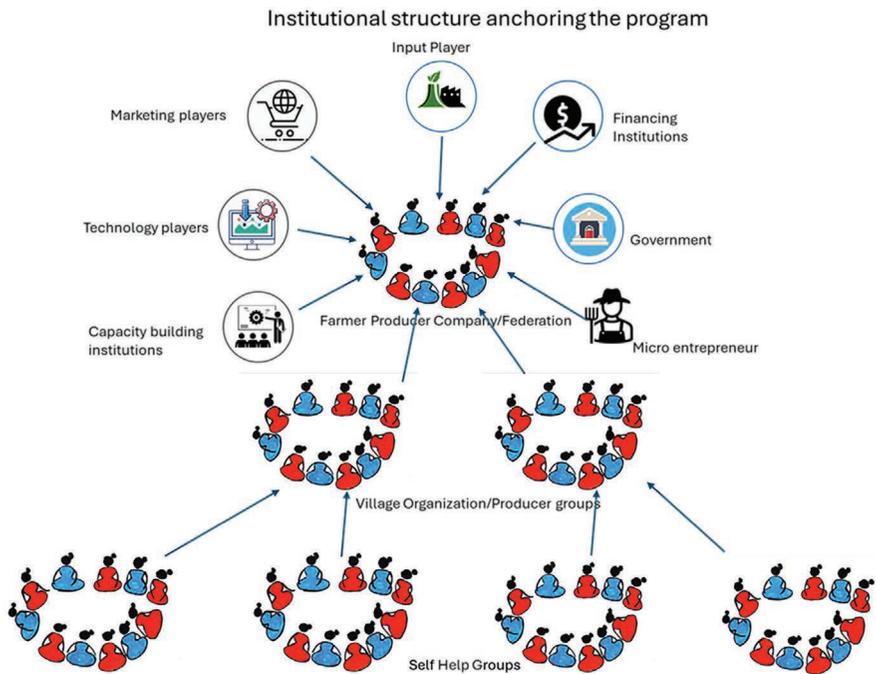


FIGURE 11.1 Institutional structure.

Source: Authors.

### 11.2.2 *The Lakhpati Kisan process*

*Preparatory phase (6 months prior to April 2015).* Prior to the kick-start of the Lakhpati Kisan programme in April 2015, the Collectives for Integrated Livelihood Initiatives (CInI) organisation spent around 6 months in close engagement with small and marginal farmers, especially women from those communities, across the four states to focus on key ‘aspirations’ of the women – for themselves, their families, and the villages they live in.

The *Lakhpati Kisan*, a term coined by the women themselves, emerged from these in-depth interactions at the community level. CInI staff worked with the women to establish an understanding of their status, challenges, and aspirations. Emphasis was put on voicing their aspirations, since the programme design was to move away from incremental outputs and outcomes. They also discussed their past situations. These discussions provided baseline findings, which were mainly related to agriculture and allied livelihoods. It became clear that the annual income of families was a meagre average of Rs 30,000. The women felt that critical issues like erratic rainfall, poor water conservation, irrigation, high-value agriculture, markets, and technology were reasons for their poor livelihood status, which had been so for years.

They stated they were looking at a future in which their children could get a better education, have a *pucca* house and assets at household level, and get a vehicle for transport. Besides such family-level aspirations, their overall village perspective encompassed a vibrant economy with the development of education, health services, a market, and other forms of progress.

The Lakhpati Kisan programme aimed at balancing two pillars – economic security and climate resilience – from a long-term sustainability perspective. It also aimed at enabling women to lead their own growth trajectory, build bonds with relevant stakeholders to meet their needs, and manage a balance between economic and environmental concerns from a long-term perspective. In short, empowering them to lead the Lakhpati pathway.

Since women in a tribal and rural setting spend most of their energy and efforts on improving the livelihoods of their families, the programme kept them at the centre, with all the principles and actions revolving around them.

This did not mean that the men were kept away in the process. In the efforts to look at the family through the women, they became engaged as well, in relevant activities such as land preparation and irrigation development. Women leaders were getting the responsibility of bringing them on board in joint trainings with women, which gave them the same exposure. This was taken up so that family-level strengthening and decision-making could be looked up for desired outcomes.

*The goal, expected outcomes, and theory of change.* The goal of the programme was ‘[s]mall and marginal farming families becom[ing] Lakhpatis in

a sustainable manner'. Implementation was kept flexible depending on the geography, community, resources, etc.; the outcomes of the programme were structured accordingly (Table 11.1).

The outcomes envisaged were:

- 1 Nearly 60% of the families (of a total of 100,000 families) move to the Lakhpati pathway.
- 2 Each household will have at least two livelihood layers.
- 3 Women-led collectives drive the linkages with key stakeholders, along with the adoption of relevant technologies.
- 4 Replication of the approach is possible across similar geographies.

### 11.2.3 Theory of change (phase 1) – theory of change for the Lakhpati pathway

**TABLE 11.1** Theory of change for the Lakhpati pathway

<i>Past status</i>	<i>Means</i>	<i>Change sought</i>
<ul style="list-style-type: none"> <li>• Annual income from agriculture and allied livelihoods: Rs 35,000</li> <li>• Poor livelihood practices with limited infrastructure, irrigation, market support for the community</li> <li>• Limited institutional structures focusing on services and market aggregation</li> <li>• Limited integration of technology</li> </ul>	<p>The key principles defined together with the community at the start of the programme:</p> <ol style="list-style-type: none"> <li>1 Livelihood layering at the family level with agriculture plus livestock, agriculture plus NTFP, agriculture plus livestock plus NTFP to move to the Lakhpati pathway</li> <li>2 Water conservation and management, irrigation, asset creation, market linkages for inputs and outputs</li> <li>3 Communitisation with women-led collectives and micro-entrepreneurship</li> <li>4 Promotion of relevant technologies for agriculture, energy, livestock</li> <li>5 Climate resilience focus on soil health, water management, drip promotion, mulching</li> <li>6 Support for leveraging finance from financial institutions</li> </ol>	<p>Expected outcomes of the Lakhpati programme:</p> <ol style="list-style-type: none"> <li>1 The 100,000 families moving to the Lakhpati pathway in a systematic manner</li> <li>2 Active women collectives, ensuring quality services and products to their members</li> <li>3 Technology adoption and demand within the community</li> <li>4 Understanding the role of soil health, water management, energy development, and mechanisation</li> <li>5 Micro-entrepreneurs promotion within the livelihood value chains providing paid services to members</li> <li>6 Ensuring that households, through women leaders, move towards investing the increased income in education for children, drinking water, sanitation, creation of livelihood assets, etc.</li> </ol>

Source: Authors.

### 11.2.3.1 Phase 1 (2015 to 2021): Implementation, immediate outcomes, and lessons learnt

Implementation of the programme based on the aspirations of the community focused on the economic security at family level along with the promotion of vibrant local clusters.

The implementation process with the overall goal of the Lakhpati Kisan programme was a dynamic one, year by year, wherein learnings from actions with the community were assessed and improved upon appropriately.

In year 1 of the programme, the crop basket was vast with multiple crops promoted through families who had been ready to take up the risks. As low-hanging fruits were much sought-after, they adopted new practices and crop varieties as also technologies such as drip, mulch, and polyhouse, which enabled others to see the impact on farmland. This, in turn, generated acceptance and demand.

Based on learnings from across the states in year 1, plans for the following year were revised. The focus turned to select crops which families desired (such as tomato, chilli, eggplant, and bitter gourd) and layering of livestock, along with the promotion of polyhouse nursery and drip irrigation. Families selected these crops with an eye on market demand and yield. This was bolstered by quality seedlings from the polyhouse nurseries.

The process of learning and improving the plans helped the programme innovate and experiment with various new activities, keeping the overall goal intact. While women executed the plans in their self-help groups and village organisations, the process of institutionalising them in apex structures was initiated in 2018. It brought to life the women-led farmer producer companies (FPCs).

The aim was to offer various services to their members in agriculture, livestock, and non-timber forest products. Villagers were taken on exposure visits to centres of excellence (such as the Indo-Israel Centre of Excellence) to understand polyhouse nursery technology and the ways to promote it as an enterprise providing quality services to members.

The dynamic action on the ground through regular iterations helped streamline the method of livelihood layering (agriculture, livestock, non-timber forest products), depending on resources available at family level, bringing in overall a focus on water, new crop varieties, quality inputs, and market linkages.

FPCs play a key role in ensuring their members get quality services and products to improve their livelihoods and move to the Lakhpati pathways. In terms of assets, most are group-based, and members use them according to their group understanding. Assets such as an irrigation infrastructure with renewable energy lifting systems are managed at group level using processes to operate and manage them. All these assets are aggregated at FPC level, in an overall management perspective.

Outcomes envisaged in the first few years of the phase 1 programme were mainly related to adoption and ownership of the Lakhpati Kisan approach at the community level. They also expected nearly 50% of families with at least two livelihood layering, integration of technologies such as polyhouse

nursery (at entrepreneur level), drip and mulching taken up by small and marginal farmers, development of irrigation assets in the form of seepage wells, and check dams to take up a second crop (all group-level assets).

These outcomes were outlined in annual work plans and visualised by families with respect to yield increase, market linkages, and technology adoption.

Overall, there has been enthusiasm across clusters about the Lakhpati Kisan programme as it had been enabling early adopters (around 10,000 families across the four states) to move up the Lakhpati pathway. This encouraged other families to follow this process of adoption.

In the early years of phase 1, the agriculture-focused interventions showed positive results. High-value agriculture, such as vegetable cultivation at family level, started with around 10 decimal. As the years passed, this increased to around 30 to 40 decimal land parcels.

Food security was addressed in kharif actions that considered improvement of practices regarding staple crops like systems for rice intensification. In addition to cultivating staples, crop diversification enabled farmers to strengthen food security and market linkages. With crop area increasing, FPCs could also promote market linkages through aggregation. In the Gujarat cluster, federations were promoted from year 3 onwards, since by then high-value agriculture had been scaled.

With the advancement of value chains within the community, critical challenges linked to financing market linkages for output marketing and crop yields surfaced. The fluctuating price for produce in the market created a negative impact on farmers, which had a hit in the coming seasons on the crop area and productivity.

### 11.2.3.2 *Challenges of climate change*

The Lakhpati Kisan programme has been underway since 2015. Through the years, communities and the CInI team encountered variations in weather patterns in terms of rainfall and temperature, which affected the agriculture cycle.

The trend over the year shows that the onset of the monsoon has been deferred by a month. The normal rainfall cycle runs from June 20 to September 30 but has moved to mid- or end of July in recent years. With the first rains, farmers take up nursery planning for the main crops, hoping rains continue to be good. They prepare their lands accordingly. But each year long dry spells are noted, which impact paddy nursery as well as yields.

With the monsoon season stretching and the transplanting of paddy delayed, the overall cycle is affected, for harvesting gets done in late November or early December only. So the crop cycle of 120 to 150 days is getting stretched. This delay is restricting planning and action for the rabi season, there are labour constraints because people have migrated meanwhile to cities, and land remains unused for the season.

With these changing patterns, there are broadly only two seasons coming up, of kharif and late rabi/early summer. Rainfall is also erratic, with rains increasing in the harvest season, affecting harvesting itself and drying of the produce before it is stored or sold in the market.

Apart from a rainfall pattern change, significant temperature variations have also been observed in the last 2 to 3 years. Winter temperatures are dropping severely, which impacts the germination and growth of crops, especially trellis crops. On the other hand, a temperature rise in February/March has also been seen across clusters. Since this happens near harvest time, it hits crop production. Farmers are witnessing these changes on their farms, so they are taking measures to protect their cultivation, which include options of water conservation and management and crop diversification.

While promoting economic security for households, along with addressing some climate factors, village members, along with the CInI team, have been trying to leverage government programmes as well.

Schemes such as drip irrigation, MGNREGS for asset creation, and solar energy were taken up for households to adopt and adapt to. Climate-related disasters are due to sudden rainfalls or long gaps in rainfall mainly. An insurance programme both from government side and from some start-ups, such as IBISA Network, was introduced in 2020, toward the end of phase 1. IBISA had been designed as a parametric insurance for vegetable crops that face temperature shocks and unseasonal rains.

Positively in the Odisha and Gujarat clusters, women-led FPCs received claims for summer season vegetable crops that had been affected by high temperature in Odisha and unseasonal rainfall in Gujarat. Parametric crop insurance is seen as an important risk management tool, and FPCs are managing the premium on behalf of the farmers and giving it as a service to them.

This approach as a service from the FPC to a large member base can promote the adoption of insurance at scale. It removes the need for farmers to apply for insurance individually, which is very difficult for them.

Besides feedback on climate challenges, women reported that crop yields have stagnated. They had noted wilting diseases proliferating in crops. Discussions with them led to an understanding that the same land parcel was being used for vegetable cultivation year on year because families have limited landholding. This would create problems for soil health and result in yield stagnation or reduction, along with an emergence of specific diseases.

During the implementation of phase 1, some activities were also taken up that contributed to building climate resilience, such as water management, soil health improvement, and decentralised renewable energy. Women leaders of the FPCs executed these in their respective villages.

As various issues were surfacing from time to time, a need was felt to ensure that women leaders and the larger member base would understand the

linkages between climate implications on their livelihood resources and the activities being implemented.

Activities initially may appear positive and beneficial, but they could have negative impacts in the mid- and long term. Such negative impacts need to be considered during project implementation. At the end of phase 1 (2020–2021), the information on yield stagnation, high temperature, and water availability was taken into account while preparing for phase 2.

CInI felt the need to have a better understanding, by its team members and the community, of how climate change impacts their lives and livelihoods and the importance of good choices of different coping mechanisms to enhance people's adaptive capacities. In this process, the method of systems thinking was considered. A DESTA Research team was brought in, primarily to identify climate adjacency for enhancing local climatic actions through using participatory systems thinking and modelling approach.

#### 11.2.3.3 *Systems thinking exercise*

Phase 1 of the Lakhpati Kisan programme focused on economic prosperity. Aspects of soil health (deficiencies in micronutrients, soil carbon, moisture) and water management, mostly linked to climate resilience principles, had not intensively been dealt with. In this context, CInI, together with DESTA Research introduced a 'systems thinking' approach.

The purpose was to get a better understanding of the interconnections between the various components of the Lakhpati Kisan programme with the positive and negative loops of each, and the time lag between a particular intervention with immediate positive benefits and a later negative impact if the activity continued for long.

This approach meant to enable the women to understand the positive and negative implications of climate on their livelihoods, specifically on agriculture, livestock, NTFP, and water. It also sought to introduce appropriate measures as a mid-course correction within the larger programme. The exercises initiated with the CInI team, and later with the community, are explained in the next section.

#### 11.2.3.4 *Exercise with CInI team*

The systems thinking exercise was initiated within the CInI team in 2020 to understand the links between various interventions of the Lakhpati Kisan programme. Looking at each of the thematic areas of agriculture, livestock, water, and NTFP, the team was able to articulate the loops connecting them positively and negatively.

Loops connecting each other that show a short-term positive gain may show long-term negative concerns too. So the team was able to make the links and also formulate actions to be taken to remove negative loops in the long run (Figure 11.2).



### 11.2.3.5 *Overall model of systems theory of change of the Lakhpati Kisan programme according to the CInI team*

The aforementioned model is an attempt at simplifying a detailed model with all thematic areas. Reinforcing loop R1 is aimed at enhancing livelihoods, such that it leads to a higher income, which further improves by taking up appropriate interventions. This enables the development of a rural entrepreneurship ecosystem. It supports the development of livelihood interventions and livelihood enhancement (reinforcing loop R4).

The FPCs are the central force in enabling this entrepreneurship ecosystem by providing the means for a successful uptake and sustainability of these interventions by the community (reinforcing loop R7). Now, loop B1 on the right shows how natural resource-based constraints can limit the growth of high-value livelihoods (like cash crops). This is managed through resource intensity reduction (efficiency improvement) measures, as shown in loop R2, such as efficient irrigation management. At the same time, resource conservation and creation measures, like fodder cultivation, also help ease resource constraints.

On the forward linkage side, an increase in output may result in a problem of oversupply and fall in prices (balancing loop B2), which needs to be dealt with to maintain profitable market prices. This is done through programme interventions like collective marketing and optimising agriculture produce marketing (reinforcing loop R3).

The FPCs play a critical role in this stage as well (reinforcing loop R5). There is also the point of a reduction in diversity that could occur as a result of intensification and focus on high-value livelihoods. This could increase the vulnerability of farmers, reducing their resilience to market and climate shocks. This may affect their income negatively in the long run as well (loop B3). But thought is put into designing measures that could increase or maintain diversity to reduce this risk. All these loops show how project interventions are trying to overcome the loops of constraints and limits toward the overarching goal of improving farmers' incomes.

The systems thinking exercise helped the team understand the interlinks of the Lakhpati programme against climate-related events and plan relevant actions accordingly. This causal loop diagram that the CInI team had developed had been based on their work in the past few years. Now, it was being introduced in community institutions to get their inputs on the loops. At the same time, to make them understand how to develop relevant action plans with a focus on climate resilience, such as improved agriculture and allied livelihoods to obtain good incomes, to that effect, the programme concentrated on enhancing the resilience of agriculture and livestock systems to deal with climatic variability, by developing and applying improved production and risk management technologies.

#### 11.2.4 *Engagement with the communities (start of phase 2: up to 2023)*

To ensure the women take relevant decisions and actions, based on an understanding of climate challenges and impact on their livelihoods and aspirations of being Lakhpatis (from a long-term perspective), a systems thinking exercise was conducted with them in the field, at Dahod in Gujarat and Dumka in Jharkhand. The idea was to help women-led institutions (federations/farmer producer companies) drive their economic growth while understanding the climate challenges and take appropriate actions, through a systems thinking approach. By developing causal loop diagrams during the exercise, the women came to understand how to balance their economic security with actions to manage climate-induced challenges related to soil health, water management, etc.

In these exercises with members of women's collectives in the Jama cluster in Jharkhand and the Dahod cluster in Gujarat (around 15 villages each), open discussions were held to understand the changes they had visualised with respect to water, rainfall, crops, and soil in the last few years. The engaging discussions and articulate observations of the women highlighted various connections, both positive and negative, from the climate adjacency.

In agriculture, dependency on groundwater is fairly high as compared to surface water. With the focus on cultivation of vegetable crops for at least over two seasons in a year, groundwater extraction for irrigation is highlighted. In discussions with the community on groundwater use for agriculture and whether it was depleting or remaining constant, various qualitative insights emerged.

They emphasised that if groundwater is an irrigation source, it also has a recharge system, along with the promotion of water management technologies, then the strain on the resource is not as much as compared to when it is done under flood irrigation. While taking care of groundwater management, farmers had also made efforts on water conservation along with local adaptations of groundwater extraction through low-line seepage wells.

With the application of a participatory, systems thinking strategy, the programme is being designed in coordination with community leaders to make appropriate decisions to initiate multiple climate-related actions to address the problems of small landholders. These farmers have poor coping mechanisms and do not readily accept risk management products available in their villages. This has increased peoples' vulnerabilities and affected the resources they value for their life and livelihoods.

Now the programme goals were:

- 1 Better understanding of community perspectives on interventions and their impact on the Lakhpati Kisan
- 2 Identification of priority areas and new areas of intervention based on community interactions for the Lakhpati Kisan programme

#### 11.2.4.1 *Communities specify their understanding of interconnections*

Meetings with FPCs were conducted with the aim of understanding women's mental models and the interventions they think will make a difference in sustaining their livelihoods while also conserving natural resources within the larger Lakhpatri Kisan approach.

An integrated causal loop diagram emerged in the meeting with community institutions where approximately 35 women participated, representing two FPCs (Figure 11.3).

#### 11.2.4.2 *Systems thinking experience with the women's collective in Dahod, Gujarat: Description of the loops*

The availability of lift irrigation through wells and borewells allows an increase of areas under cash crops and of agricultural production. This results in a boost of farmers' incomes over time. This, in turn, allows them to invest in more lift irrigation, creating a cycle of growth (reinforcing loops R1, R2). It means, though, that water demand also escalates over time, which steps up the requirement of lift irrigation as well (reinforcing loop R3).

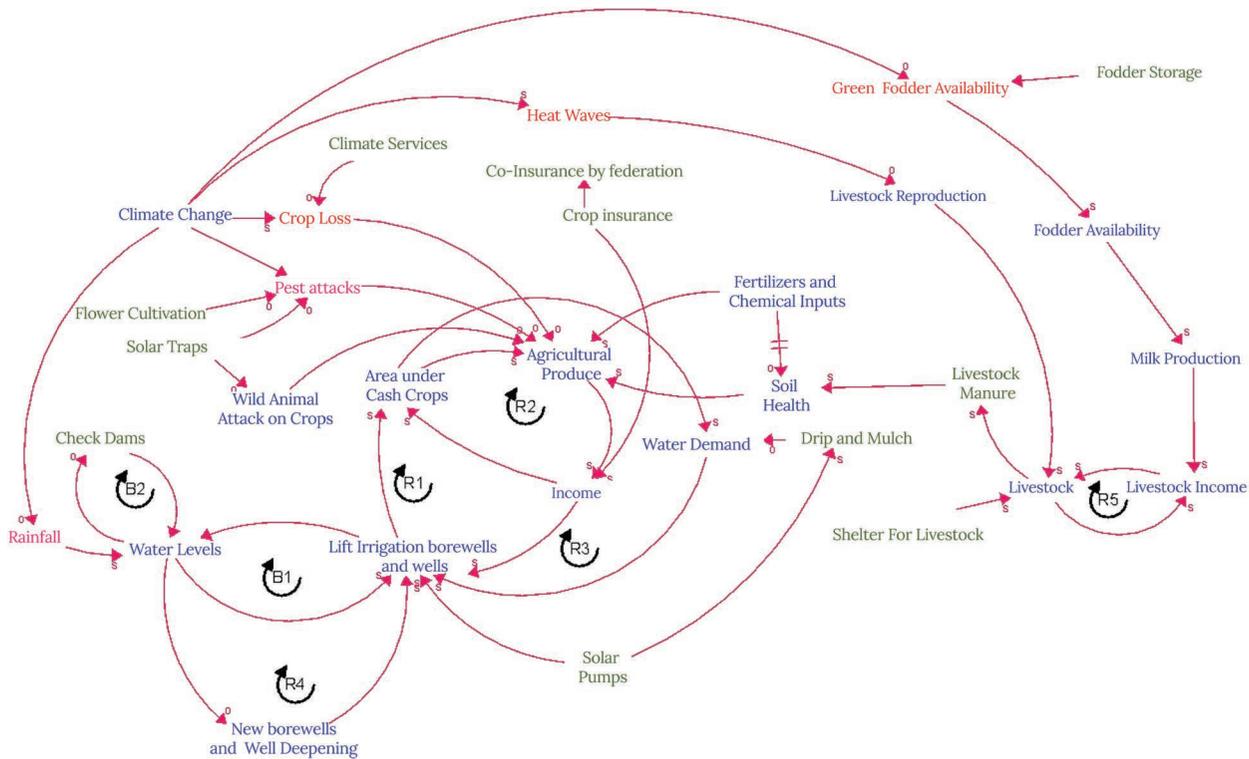
Lifting of water from the ground beyond its recharge capability over time means that water levels will start to fall. This puts a constraint on lift irrigation for agriculture (balancing loop B1). One of the ways in which communities cope with the shortage of water is through both deepening existing wells and constructing new wells. While this allows lift irrigation to continue, it also exacerbates water shortage in the long run by reducing water availability further (R4). To increase this availability, a key intervention suggested by the community was to augment the number of check dams (B2).

On the soil side, farmers said that fertilisers and chemical inputs are important to maintain agricultural production. They also communicated that, in the long run, overuse would result in loss of soil fertility and health. Livestock rearing would give them manure, which is very useful in improving soil health. Besides, they would get some income from livestock produce (R5).

Farmers had already been confronted with various climate challenges. These are detailed in what follows, followed by a discussion on solutions they are either using already or not yet but feel would help them cope with the effects of climate change:

- 1 *Reduction in rainfall and changes in rainfall patterns.* This is lessening water availability on the one hand and increasing runoff on the other, thereby reducing groundwater recharge. This causes problems in crop sowing, especially of staple crops, during the monsoon.

Solution: People suggested that check dams be constructed to harvest water and then use them for agriculture and other needs. But in more in-depth discussions, it emerged that with additional water, farmers were



**FIGURE 11.3** Women's perception of climate change impacts on farm-based livelihoods, and measures to counter them.

Source: Authors.

Note: Variables in red show the impacts of climate change felt. Variables in green show interventions suggested by the FPC representatives and their understanding of the interconnections between the Lakhpati programme and climate change.

more likely to keep more land for cultivation and shift to cash crops in the form of vegetables in all three seasons. This, in turn, would increase the water footprint and, once again, result in water scarcity. (Going through the loops mentioned earlier.) Farmers agreed and added that along with check dams, drip irrigation with mulch would be necessary to bring about a sustainable solution. Solar pumps, if introduced with a view that drip and mulch should be applied alongside, could also provide a sustainable, clean method of lift irrigation while curtailing demand.

- 2 *Pest attacks.* Farmers were seeing a surge in pest attacks on their crops over time and ascribed it to climatic variations. This is taking a toll on their agricultural production.

Solution: Pesticides or innovative solutions, like solar insect traps that capture pests, and flower and crop cultivation, which distract them.

Farmers preferred the second type of solution because pesticide usage in the long run results in mutated pests and also increases toxicity of soil and crops.

- 3 *Physical crop loss.* Untimely and harsh rains as well as hail have resulted in the loss of standing crops ready to be cut or just cut.

Solution: Although farmers were not very aware of it, climate change-related services emerged as a possible solution. These could provide a warning to farmers to take timely steps to cover harvested crops or safeguard standing crops. Also, these services (such as weather information, water level) could give some guidance on what to sow, given expected rainfall patterns in the coming seasons.

Crop insurance that could compensate farmers for their losses came up as another possible solution. A co-insurance mechanism where the FPC becomes an intermediary in the insurance settlement process is something farmers would be willing to adopt, since normal insurance paperwork gives too many hassles. Besides, returns were usually nil, in their experience. Interestingly, they were already familiar with and currently availed of livestock insurance, but not (yet) crop insurance.

- 4 *Heat waves.* Farmers have been facing heat waves; they noticed that these resulted in a reduction in livestock reproduction. This takes a toll on income from livestock.

Solution: Shelter for livestock in which they can be kept in times of heat stress so that they do not feel its negative effect.

- 5 *Loss of green fodder.* Because of climate change, farmers were faced with a shortage of green fodder. This is taking a toll on milk production.

Solution: *Fodder storage.* Farmers felt that having quality fodder storage could help tide over times of climate stress.

During this systems thinking process, people could specifically indicate connections between high-value agriculture, income gain, irrigation sources,

fertiliser–pesticide usage from short-term positive loops. Since they were involved in understanding the long-term use of groundwater sources and pesticides for high-value agriculture, community members were able to explain there would be issues of water availability, yield stagnation or reduction, and soil health reduction. This has resulted in unsustainable incomes.

Despite being able to articulate connections between livelihoods and climate, there were certain aspects people could not place properly. Since their exposure is limited, they were unable to come up with relevant, climate-smart technologies. This is where the CInI team could form a bridge in the discussions and suggest missing aspects. For instance, the use of plastic mulch is presently giving a good income from vegetable cultivation. But plastic use in soil will have long-term challenges. So in the discussions, the CInI team introduced biodegradable mulching, to be piloted first, then taken to the next level.

Other key elements which could be integrated into the overall systems thinking approach would be the interconnections between ‘agriculture–livestock’ and ‘agriculture–non-timber forest products’. Action on improving livestock could result in positive outcomes for agriculture.

These connections are important to be built on, along with enabling women leaders to be empowered to take it up with their larger member base. The loops of linkages between different interventions open up the need to connect directly with various government schemes and programmes that can strengthen grassroots-level action and mobilise government resources.

The programme has started documenting climate adjacencies as systems stories, using tools from systems thinking – behaviour over time graphs and causal loop diagrams. The CInI believes that applying tools and processes of systems thinking and system dynamics modelling at local scale can stimulate people’s learning, enhance their awareness about their own adjacencies with climate change, and trigger behavioural change among community members.

### 11.3 Learnings

The community approach, especially of the women, towards meeting their aspirations is sustainable and shows they are on the right path. The focus on understanding their aspirations for their family and themselves helped define action plans. Attention to strengthening the livelihood layering of existing resources at household level (agriculture, livestock, top) ensures a sustained income along with managing risks by layering interventions rather than depending on only one livelihood prototype. With the growth of improved agriculture through vegetable cultivation, problems of soil health, water, and pests come in. It is important to take action on these problems early on rather than wait for them to turn severe. This is where the programme, along with the communities, worked on water conservation, bio-applications in soil, crop diversification, drip promotion, technology integration, and so on.

Since programme engagement was a dynamic and continuously evolving process, it helped to learn of concerns linked to climate as well. Experiences of the community with climate change on the one hand and building their understanding of its impact on their livelihoods on the other may form a problem for their aspirations.

These factors are important to address long-term climate challenges while enabling the community to anchor and lead the actions from a scale perspective. It also ensures a balance between economic and environmental security. Ownership at community level and their articulation of the process are critical for actions with a long-term sustainability.

The systems thinking approach is seen as a process in which a community and the team would be engaged together to get perspectives and find possible solutions jointly. The community is validating the causal loops by implementing water management and soil health improvement interventions along with the adoption of various climate-smart products and services by the federation and farmer producer companies.

Community institutions address forthcoming challenges, as shown in the causal loops, through services and products. This means considerable efforts for those anchoring the process and other stakeholders who are contributing to their specific roles. CInI is facilitating connections of community institutions with relevant stakeholders.

The programme has started documenting the climate adjacencies as systems stories using the tools of systems thinking – behaviour over time graphs and causal loop diagrams. CInI believes that applying tools and processes of systems thinking and system dynamics modelling at a local scale can expedite the learning of people, enhance their awareness about their own adjacencies with climate change, and trigger behavioural change among the community members.

#### 11.4 Conclusions and the way forward

The lead role taken by community leaders in conducting participatory, systems thinking exercises with their collectives promoted programme improvement. The model consists of key feedback loops from each thematic model, and those that cut across themes improved awareness about climate linkages wherein the community has provided inputs on actions to tackle climate change issues around the Lakhpati Kisan programme through the right interventions and building resilience around the programme. They broadly suggested improvement in both segments of the programme – agriculture and livestock and their relationship with climate.

Continued promotion of mixed crops – main crops like maize with other nitrogen-fixing crops, like pigeon pea – is good to enhance the availability of nutrients, resulting in increased production and decomposition of plant biomass. Increased use of organic fertilisers like cow dung manure and vermicompost, all

to increase water-soluble nutrients contained in the soil. Cultivating leguminous crops for 30 to 45 days before the monsoon will help increase soil moisture in the plot, scaling up and intensifying ongoing interventions like health services, improved breeding, shelter management, and insurance to increase livestock numbers and quality. As a way forward, community institutions (federations/FPCs) will undertake this exercise of systems thinking across clusters and states. Understanding the close interlinks between the Lakhpati Kisan programme and climate adjacencies at community level is most critical, for this will only enable them to relate, own, and design their actions accordingly.

In the annual work plan exercises of the institutions, the actions are defined by the interconnectedness between livelihoods and climate (water, soil, cropping). Accordingly, the plan will have outlined actions related to bio-applications in the soil to improve micronutrients and soil carbon (application of bioslurry-based products, etc.), water and soil conservation, drip irrigation with mulching, crop rotation with legumes, decentralised renewable energy-based production hubs, etc. This detailing as part of the annual work plan will specify the actions for the coming year. After that, it goes on to build a close synergy between the Lakhpati programme and the climate to see sustainable outcomes for the small and marginal families.

## Notes

- 1 [pib.gov.in/PressReleaseIframePage.aspx?PRID=1910357](http://pib.gov.in/PressReleaseIframePage.aspx?PRID=1910357)
- 2 12th Five-year plan (2012–17), p.313
- 3 [nandurbar\\_at\\_a\\_glance.pdf](http://nandurbar_at_a_glance.pdf) (maharashtra.gov.in)

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## Annexure – exercise taken with the community institutions in Dahod and Dumka

### Dahod LK 2.0 Suggestions emerging from engagements with FPCs

The community was well aware of climate change and its impacts on their livelihoods and the agriculture–water–soil system they depend on. Side effects of conventional agriculture practices, such as depleting groundwater and loss of soil fertility, were also well understood by them. Through a systems thinking exercise, they opened up about already-implemented interventions or possible ways to mitigate some of these negative effects (Table 11.2).

**TABLE 11.2** Challenges encountered and proposed sustainable interventions in Gujarat

<i>Climate challenge</i>	<i>Suggested intervention</i>	<i>Implementation status</i>	<i>Challenge</i>	<i>Way forward</i>
Declining water availability	Check dam	Some check dams are in place, but more are possible.	Increase in water availability could imply introduction of more water-intensive crops; may shave off gains.	Check dams to be implemented only with strict water demand management measures, such as crop water planning and effective drip and mulch implementation.
	Drip and mulch	Now, less than 10% does so actively, but the community sees the advantage and importance of drip and mulch.	Maintenance.	Community says this could go up to 30% by 2035, or even up to 75% if implemented where maintenance is easy.

*(Continued)*

**TABLE 11.2** (Continued)

<i>Climate challenge</i>	<i>Suggested intervention</i>	<i>Implementation status</i>	<i>Challenge</i>	<i>Way forward</i>
	Solar pump	Few have come up. The community finds these effective and thinks they will replace all pumps in the next 10 years.	This could lead to groundwater over-exploitation.	To be implemented only along with strict water demand management measures, such as crop water planning and effective drip and mulch implementation.
	New borewells and deepening of existing ones	This is a prevalent coping mechanism communities follow in times of water stress. The community expects borewells to increase in the future, overtaking open wells.	Maladaptation leads to further reduction of already-depleted groundwater reserves during periods of water stress.	Measures that use surface water, such as check dams, and reduce demand, such as drip and mulch, must be promoted.
	Crop water planning (This is from DESTA's side, since it responds to a requirement emerging from some of the preceding points.)	Some crop planning is underway. Still, it could be strengthened from a water budget perspective, especially in line with water availability.	Community accepting this practice.	The work done with the Advanced Centre for Water Resources Development and Management (ACWADAM) on developing groundwater protocols with the community could be a good starting point to develop a tool to help them in planning their crops sustainably while ensuring economic returns.
Crop loss	Crop insurance	It has not been effectively applied yet.	The claims settlement process with the government is very tedious and usually ineffective.	Co-insurance by federation could be attempted, with FPC as an intermediary. This would increase uptake and effectiveness.

(Continued)

TABLE 11.2 (Continued)

<i>Climate challenge</i>	<i>Suggested intervention</i>	<i>Implementation status</i>	<i>Challenge</i>	<i>Way forward</i>
	Climate services on mobiles as a service	People were more or less unaware of this service but keen to have it.	NA.	To be explored and promoted.
Pest attacks	Flower cultivation	In use and proving effective. The community sees this as a better alternative to pesticide use, which damages the soil.	None as of now.	To be promoted.
	Solar insect traps	In use and proving effective. The community sees this as a better alternative to pesticide use, which damages the soil.	Scaling up could be expensive.	Business models to be explored.
Reduction in livestock productivity due to heat stress	Livestock shelter	Some are implemented; more can be brought in.		To be promoted.
Reduction in green fodder availability	Fodder storage			To be promoted.
Reduction in soil health	Replacing chemical inputs with cow dung manure	Not implemented.	Shifting away from chemicals to manure would mean a short-term loss of productivity and income, followed by longer-term benefits. Also, livestock numbers have dwindled due to less availability of labour, changes in occupation preferences of youth, etc.	Incentives and guarantees to help tide over short-term challenges. Farmers are keen to have a larger livestock, which may be promoted. But this would also increase the water footprint, that must be factored in during planning.

*Source:* Author's own composition.

Overall, the programme could focus here on developing community governance and protocols to conserve natural resources and reduce vulnerability to risks from climate change (Table 11.3). The awareness and interest of people in the community are high. So, the preceding interventions are a good starting point.

Further, the activity of developing groundwater protocols in collaboration with ACWADAM at Dahod (Dhabhada) is a good example of how Lakhpati Kisan could help farmers earn money from agriculture while sustaining resources.

**TABLE 11.3** Challenges encountered and proposed sustainable interventions

<i>Climate challenge</i>	<i>Intervention</i>	<i>Possible challenges</i>	<i>Way forward</i>
Fall in soil fertility and many pest attacks	Reducing pesticide and fertiliser input requirement through (1) better alignment of crops with the agroecological system and (2) increase in livestock manure application	For (1): Finding the right balance between high-value crops and those fit for the local agroecological system. For (2): Low livestock population due to lack of interest from the younger generation. Also, fall in grazing land due to year-round cash crop cultivation.	1 Participatory consultations of experts and fine-tuning of crop choices. 2 Bio-resource unit for providing manure if livestock-keeping is not feasible for most people. 3 Use alternatives to pesticides, such as solar insect traps, flower cultivation, and natural pesticides.
Delay in monsoon	Crop insurance Increase in water availability through check dams and stopping runoff Demand management – drip irrigation, crop management	Same as Dahod. Water demand budgeting is key to ensure gains are not shaved off. Maintenance problems with drip irrigation.	Same as Dahod. Interventions to reduce runoff to be promoted along with demand-side management measures. To be promoted along with effective training and easy-to-maintain techniques.
Livestock disease	Livestock insurance, medical interventions for livestock	—	—

*Source:* Authors.

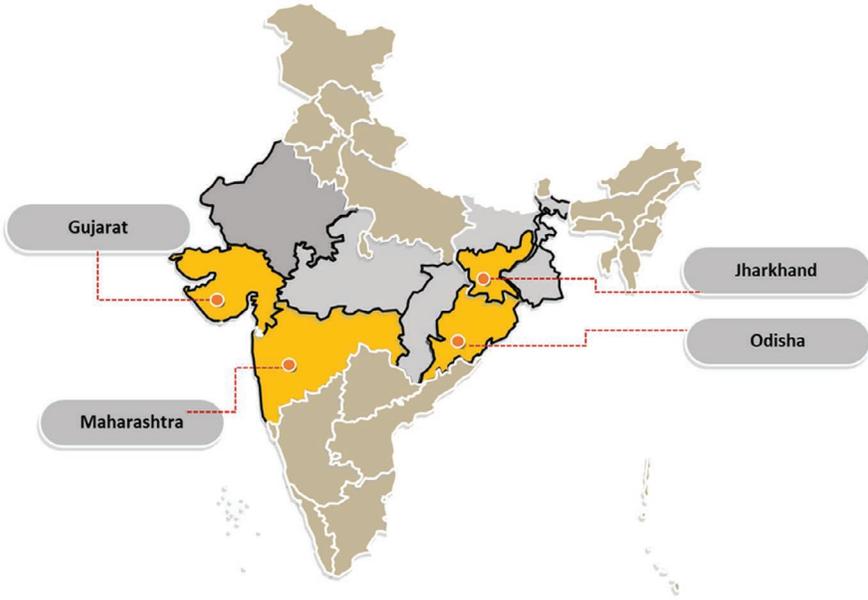


FIGURE 11.4 Four states as study areas under the programme.

Source: Authors.

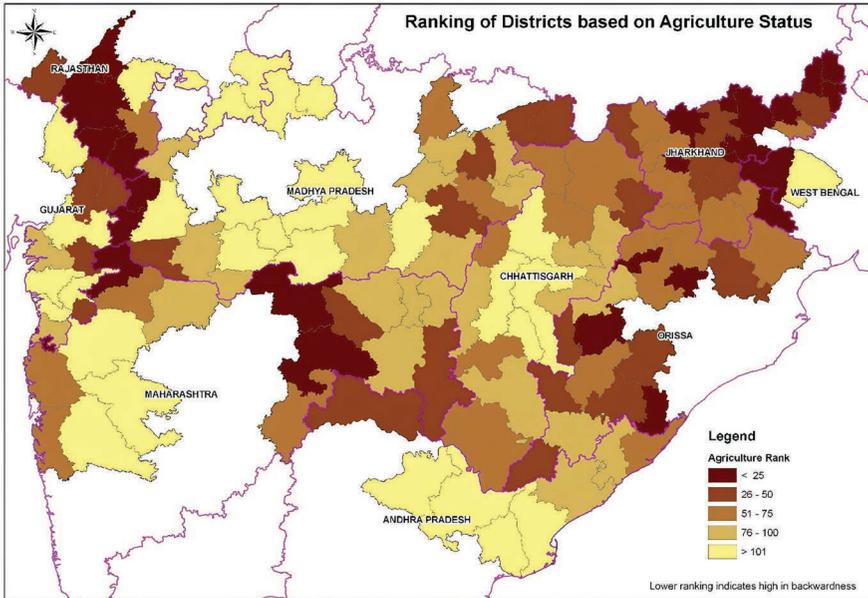


FIGURE 11.5 Districts' ranking based on agriculture status.

Source: Figure redrawn based on Foundation for Ecological Security (FES, 2008–09).

# 12

## LAND RESTORATION AND MANAGEMENT IN RAINFED INDIA

Lessons from NABARD's 30+ years' experience

*C. S. R. Murthy, R. Ravi Babu, Chetna Nahata,  
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### 12.1 Introduction

Serving as a livelihood source for approximately 50% of its workforce (Pathak et al., 2022), the agriculture sector is the backbone of the Indian economy and critical for its sustainable and inclusive growth. Nearly three-quarters of Indian households depend on rural incomes derived from agriculture and allied activities (World Bank, 2012).

Despite its significance, the sector grapples with various challenges, such as fragmented landholdings, declining productivity, limited access to credit and technology, degradation of natural resources, plummeting water resources, declining farmers' income stemming from small-size farm holdings and scale issues, poor infrastructure, rising cost inefficiencies, intra- and inter-regional disparities, the dubious distinction of being the biggest exporter of embedded water, and high vulnerability to climate change.

Rainfed areas, accounting for 51% of the net cultivated sown area, contribute significantly (40–45%) to the total food production. Among the several field crops, 39% of rice, 83% of nutri-cereals, 81% of pulses, 72% of oilseeds, and 66% of cotton are rainfed (MoA&FW, 2022). However, most development efforts and investments in agriculture have been directed towards irrigated regions, while rainfed areas have received limited attention. During the Green Revolution, rainfed crops were significantly affected as farmers shifted from traditional millet, pulses, and oilseed crops to more water-intensive crops, like wheat and paddy, relying on water, fertilisers, and pesticide-intensive strategies lured by promised markets. But it all led to ecological degradation and malnutrition (NRAA, 2022). With a continuously increasing population, there is a growing demand for food grain production

in the country, with an imminent need to develop and enhance the productivity of rainfed areas (MoA&FW, 2022). As rainfed agriculture is frequently exposed to various abiotic and biotic stresses, particularly climate extremes, sustaining production systems remains a major challenge.

Rainfed areas are also home to small and marginal farmers. The socio-economic factors in rainfed agriculture have a greater bearing on the livelihoods of small and marginal farmers. Therefore, the future challenge is sustaining the livelihoods of these farmers, who will still depend on agriculture despite increased climate variability and shrinking landholdings (Singh & Prabhakar, 2025).

According to the 'Prioritization of Districts for Development Planning in India – A Composite Index Approach' report, 168 districts had been identified as high-priority, vulnerable rainfed districts (NRAA, 2020). Notably, rainfed areas are ecologically fragile and bear the brunt of land degradation due to increased external input use and mono-cropping (mimicking the practices of the Green Revolution prevalent in irrigated areas). This, coupled with severe soil erosion, is threatening the sustainability of the food production system. Climate change exacerbates the existing problems of rainfed areas.

Sustainable agriculture has been a constant endeavour of NABARD. Equal focus was laid on irrigation development and holistic development of rainfed areas in its projects. To create a balance in the complex rainfed areas between natural resources and the demands of humans and animals, it is imperative to adopt a holistic approach rather than ad hoc solutions or tackle problems in isolation. Watershed development is one such comprehensive solution that promises to keep in check the degradation of natural resources and aid in their conservation and regeneration. It is predominantly relevant for upland areas and has been tested and demonstrated in many countries in Africa, Asia, and Latin America with various degrees of scope, size, duration, technology, and budget envelope (FAO, 2017). Watersheds with vegetation cover and intact soil resources can sequester carbon, thereby offsetting greenhouse gas emissions (Hanson et al., 2010) and enhancing the resilience of the vulnerable sections of society and livestock to the adverse effects of climate change.

To address the issues in rainfed farming comprehensively, the National Bank for Agriculture and Rural Development (NABARD) entered the watershed development space in collaboration with the WOTR in 1992–1993 through a KfW-<sup>1</sup> and GTZ- (now GIZ<sup>2</sup>) assisted Indo-German Watershed Development Programme (IGWDP) in Maharashtra. In this project, under the guidance of NGOs, community-led watershed development was adopted on a large scale for the first time.

NABARD's watershed development efforts align with India's Sustainable Development Goals (SDGs) 2030 and revised nationally determined

commitments (NDCs), focusing on climate change adaptation through investments in vulnerable rainfed areas and sectors like agriculture, soil, water resources, livelihoods, etc. It also targets mobilising funds to bridge resource gaps for adaptation actions while contributing to land degradation neutrality to restore 26 Mha of degraded land.

For the first decade since its formation, that is, from 1982 to 1992, the journey of NABARD in natural resource management (NRM) was exclusively for extending refinance for land development/soil conservation, wasteland development/forestry, and water resource development, particularly minor irrigation. NABARD's entry into natural resource management in 1992–1993, supported by KfW, GIZ, and the Government of India, and driven by collaborations with civil society organisations, has played a pivotal role in advancing community-led participatory watershed development in India. This chapter traces the evolution of a watershed development programme (WDP) of NABARD into robust, community-driven climate adaptation programme for rainfed areas, highlighting valuable experiences and future directions.

## 12.2 Methodology and implementation

NABARD's watershed programmes are participatory in nature. With NGOs playing a capacity-building role, local communities, especially women, actively participate in all stages of planning, implementation, monitoring, and fund management through people/community-based institutions. Participatory net planning (PNP)<sup>3</sup> is the basis of implementation of all watershed projects, with a preference for resource-poor small and marginal farmers, including women farmers. Landless and vulnerable social groups are also involved in watershed management with due representation in decision-making watershed committees. Everybody's inclusion here emphasises climate justice. This community-centred approach ensures projects are tailored to local needs and are sustainable and effective in enhancing agricultural productivity and natural resource management, thereby increasing resilience to climate change in rural areas.

The evolution of NABARD WDPs is shown in Figure 12.1. It started with the launch of the IGWDP in 1992–1993, followed by the Watershed Development Fund (WDF), climate change adaptation (CCA) project, KfW soil programme, WDF Climate Proofing Programme, Springshed Development Programme, IWDP Climate Proofing Project (i.e. Integrated Watershed Development Programme with Climate Proofing), recently launched JIVA Agroecology Programme in 2023, and Landscape-Based Regenerative, Resilient, and Rainfed Ecosystem Development Programme (LREDP). Each programme is described in greater detail in the following sections.

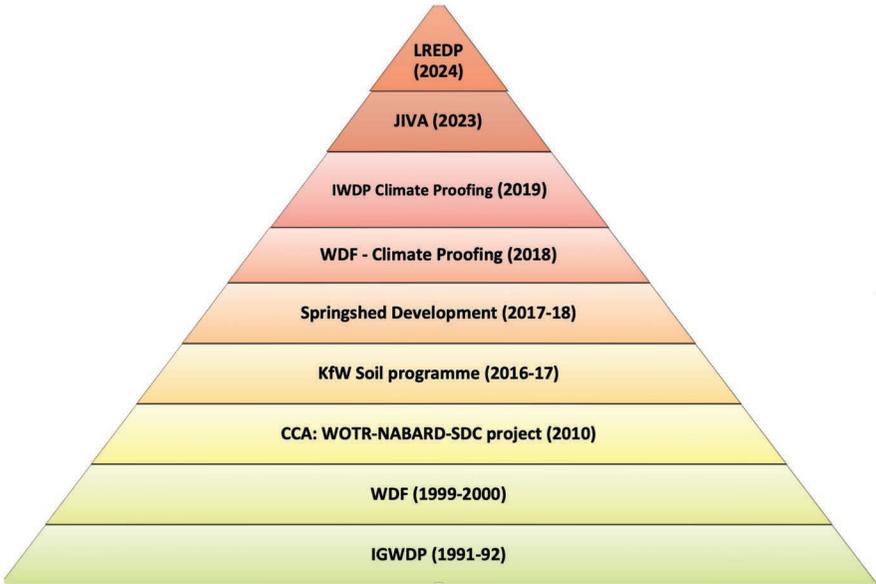


FIGURE 12.1 Evolution of the NABARD watershed development programme.

Source: Authors.

### 12.2.1 Indo-German Watershed Development Programme (IGWDP) (1991–1992 to 2016–2017)

The IGWDP, implemented by NABARD and the Watershed Organisation Trust (WOTR), supported by the Federal Ministry for Cooperation and Development, Government of Germany, through the KfW (with NABARD) and the GIZ (with WOTR), began on a small scale in 1992 in Maharashtra. The programme was expanded to Andhra Pradesh, Gujarat, and Rajasthan.

The IGWDP Maharashtra covered over 300,000 ha of drylands through about 300 projects, with an investment of over €70 million. It involved over 100 NGOs for capacitating watershed communities towards participatory implementation of projects. The WDP was meant to restore degraded lands, harvest rainwater, build a better economy, and promote equity in the rainfed regions of the country. The programme has a proven strategy to address rainfed farming issues and poverty. It holds potential for ensuring climate change adaptation while contributing to food security.

The IGWDP adopted a participatory approach. With capacity-building support from NGOs, it involved the community from the planning to the implementation stage, with a village watershed committee (VWC) as the focal point. The VWC had a due representation of women and the landless in the decision-making process.

The concept of *shramdan* (voluntary labour) for land management activities was introduced to create a sense of ownership among the local people, gender sensitivity (with dedicated women and a livelihood component for supporting economic activities), ridge-to-valley approach, and participatory net planning as against gross planning.

Each project under the IGWDP went through three distinct phases – pre-capacity building, capacity building (CBP), and full implementation (FIP). The WOTR, along with partner NGOs, laid the foundation with a successful methodology for grounding participatory watershed development projects in India.

*Pre-capacity building phase.* During this phase, massive community awareness building about the need for conservation and regeneration of natural resources in the watershed was taken up through hamlet-wise meetings and cultural shows. Also, exposure visits for representatives of the community, including women, were conducted to nearby successful watersheds, where the visitors interacted with the local people.

To inculcate a sense of ownership, the community was mobilised to perform four days' mandatory '*shramdan*' on common lands, by carrying out soil and water conservation work. The village had to give a written consent to accept the project and its norms. The document had over 70% signatories of the total watershed community. This demonstrated their willingness to participate in the watershed development programme.

On completion, a VWC with representatives from small and marginal farmers, as well as women and the landless, was formed with proper representation from different villages and hamlets falling in the watershed.

*Capacity-building phase (CBP).* This phase is also known as the 'proofing stage' of the watershed development programme. In a micro-watershed with a geographical area of about 1,000 ha, a catchment of about 60 to 100 ha starting from the ridge was delineated. Soil and water conservation work was planned through PNP.

Under this PNP, each survey/gat number-wise planning was done by interacting with each farmer family who owned land and with the community as such in case of common land. In this process, the basic topography, including soil slope, depth, and texture, as well as erosion status, inter alia, were assessed, and the land capability class was determined. On that basis, conservation measures and alternate land use practices were finalised in consultation with the farmer family who owned the land.

There were two kinds of treatments: area and drainage line treatments. The first included soil conservation, rainwater harvesting structures, and appropriate tree plantation measures, based on the topography and land use. Treatments such as continuous contour trenches, water absorption trenches, farm ponds, farm bunds, together with afforestation and grass seeding, were implemented on the overall area of the watersheds. Drainage line treatments

included gully plugs and gabion structures, and finally, at the outlet, small check dams were constructed, starting from the rills and first-order stream of each watershed. The implementation period of a CBP varied from 6 months to 1 year. This was meant to test people's interest and their willingness to come together for the common purpose of conservation and regeneration of the natural resources, which affected their livelihoods.

*Gram Sabhas* played an active role since the VWCs reported the work there. Funds were given to a VWC to be managed under the guidance of an NGO. A ban on tree cutting and free grazing was in force. *Shramdan* at 16% of the cost of watershed measures by 70% of households, excluding the landless poor and single-headed women households, was proof of their acceptance of the programme.

*Full implementation phase (FIP)*. In this phase, the work initiated during the CBP was replicated and upscaled with active community involvement. NGOs continued to be the backbone of the project. Women's empowerment for their engagement was given attention with the allocation of a substantial fund (5% of project measures) to design, implement, and manage activities of their need.

The implementation period of this phase lasted for about four years. Upon its successful completion, the coordinating NGO submitted a project completion report to NABARD. Then the project, along with any created assets, was handed over to the local people formally.

Assets created as a part of the watershed development programme were to be maintained by the respective landowners in the case of private lands and the community in the case of common lands. The local people set up and maintained a required maintenance fund, which is managed by VWC as part of the watershed development programme. Further, an amount equivalent to 8% of total labour cost (i.e. 50% of *shramdan*/voluntary labour) is also contributed from the project maintenance fund.

This made clear that the IGWDP not only helped combat poverty by improving soil conditions and agricultural productivity but also prepared communities to reduce the effects of drought. Major effects of the IGWDP at the micro-level of villages and households included a substantial increase in groundwater level, crop production, cropping intensity, and people's income. It also improved their resource base and enhanced community confidence and resilience to climate events.

Based on a study of the IGWDP, the 'World Resources 2005' report concluded that 'restoration can revitalise watersheds and communities' (WRI et al., 2005).

#### 12.2.1.1 Features of the IGWDP

The unique features of the IGWDP include the following:

- 1 A ridge-to-valley concept.

- 2 Mandatory four days' *shramdan* (voluntary labour) before sanctioning the project and regular *shramdan* (at 16% of the labour cost) to ensure a sense of ownership.
- 3 Implementation through the VWC, a community-based institution, with facilitation mainly through NGOs.
- 4 A ban on free grazing on the treated areas and a ban on tree felling.
- 5 Implementation works executed in phases, namely, pre- and actual capacity-building phases and the full implementation phase.
- 6 Participatory approach: planning, implementation, monitoring, and fund management were done through community-based institutions. Participatory net planning was the basis of the implementation of watershed measures.
- 7 Close monitoring (physical and web-based).
- 8 Regular impact evaluation studies through external agencies. Lately, impact evaluation was conducted using remote sensing and geospatial technologies.

### 12.2.2 Watershed development programme (1999–2000 till date, ongoing)

Based on the successful implementation of the participatory watershed development under the IGWDP, the importance was evident of bringing the multiplicity of the WDPs within the framework of a single national initiative that fostered implementation ability at the local level and the creation of community infrastructure for micro-watershed projects.

WDF was set up at NABARD in 1999–2000 by the Government of India (GoI) with an initial corpus of ₹2 billion. Later, the fund was augmented annually with the interest accrued from unspent amounts under the WDF and the interest differential under the Rural Infrastructure Development Fund as allocated by the Reserve Bank of India.

Since 1999–2000, cumulatively, a total of 3,747 projects (including 157 springshed projects) were sanctioned, covering an area of 2.709 Mha, benefiting 1.2 million households in 30 states and union territories. Of these, 2,942 projects have been completed. The cumulative sanction and disbursement of financial assistance by NABARD stood at ₹28.11 billion and ₹22.45 billion, respectively, as of 31 March 2024.

The main objectives of the WDF were the conservation, regeneration, and judicious use of natural resources and the promotion of sustainable farming practices to enhance agriculture production and productivity and simultaneously support off-farm activities for income and livelihood security of rural communities in rainfed/dryland areas. In particular, the WDF helped in scaling up the IGWDP experience across the different states of India (Table 12.1).

**TABLE 12.1** Area covered and total budget allocation to IGWDP and WDF

<i>Programme</i>	<i>Area treated</i>	<i>Total budget</i>
IGWDP	300,000 ha	€70 million
WDF	2.687 Mha	An initial corpus of ₹2 billion contributed equally by the GoI and NABARD

*Source:* Authors.

During its implementation, the operational guidelines were revised to include agriculture productivity enhancement measures and support for livelihood activities of women and the landless. NABARD promotes self-help groups (SHGs) in watershed projects to enhance financial inclusion, empower women, and support sustainable livelihoods through credit access and capacity building. Additionally, 287 farmer producer organisations (FPOs) have been promoted in watershed projects to strengthen collective action, enhance market access, and improve livelihoods by enabling small and marginal farmers to aggregate produce, access inputs and services, and engage in value-added activities more effectively.

### **12.2.3 Climate change adaptation WOTR-NABARD-SDC project (2010 to 2015)**

Following the implementation of the watershed development programme, WOTR observed weather variability, which reduced the expected effects in treated watersheds. Consequently, it coordinated with the Swiss Agency for Development and Cooperation (SDC) and NABARD to support the implementation of a climate change adaptation (CCA) project.

A tripartite agreement was made for the implementation in 25 villages across the Akole and Sangamner talukas in the Ahmednagar district of Maharashtra. The district lies in a rain shadow region of the Western Ghats, with an average annual rainfall of 578.8 mm, and grapples with frequent droughts.

The new concept aimed at enhancing the adaptive capacities of rural communities in the face of climate variability with special reference to rainfed watersheds. Building on watershed development, the project worked to empower local communities to manage their water resources, promote local biodiversity, and advance climate-resilient agriculture practices using organic material as much as possible.

It also set up automated weather stations in villages. With the help of the Indian Meteorological Department and agricultural universities, the WOTR incorporated agro-meteorology to track weather patterns and provide agro-meteorological advisories to farmers.

Further, the project focused on water budgeting, crop planning, sustainable agronomic practices, and irrigation management. Additionally, biodiversity concerns were integrated into all activities. The initiative promoted alternative energy sources, such as solar and biogas, while prioritising sustainable livelihood opportunities with market linkages for rural communities. The project also aimed to strengthen effective local governance and increase awareness of climate change among farmers, children, the public, and policy-makers. The outcomes are intended to improve environmental resilience and the quality of life for marginalised communities.

#### **12.2.4 KfW soil programme (2016–2017 to 2025)**

While implementing and upscaling watershed development projects, it was observed that the adverse effects of climate change, such as changes in rainfall runoff, onset and withdrawal of the monsoon, dry spells/drought, sediment load, and soil degradation, had started undoing the conservation and regeneration work done till then. NABARD, in collaboration with the KfW, initiated an '[i]ntegration of watershed development strategies with climate change adaptation for rehabilitation of degraded soils' project in 2016–2017. The programme was supported under the German government (BMZ) initiative called 'One World, No Hunger'.

The KfW soil programme was implemented in three phases covering ten states in the country, with grant assistance from KfW. Under the programme, a layer of interventions based on a sector-wise climate risk assessment and vulnerability analysis was superimposed in the completed watersheds. These were identified and prioritised based on a rainfed area priority index developed by the Central Research Institute for Dryland Agriculture under the Indian Council of Agricultural Research (ICAR-CRIDA). The interventions were classified under five major heads: additional soil and water conservation measures, soil health restoration measures, climate change adaptation measures, climate risk mitigation, capacity building, and knowledge management.

Phase 1 of the soil programme was implemented successfully in 123 completed watersheds in 32 districts of five states, viz., Karnataka, Telangana, Andhra Pradesh, Odisha, and Chhattisgarh. Phase 2 was completed in 55 watershed projects in Kerala and Jharkhand. Phase 3 was extended to 48 projects in Bihar, Maharashtra, and Tamil Nadu.

The KfW soil programme applied a climate change lens to watershed development projects that led NABARD to initiate its own WDF Climate Proofing (WDF-CP). Notably, to address the adverse effects of climate change, and as part of the KfW soil programme (SEWOH), for the first time in India, a climate lens was applied to watershed projects through project-level climate risk mapping and a vulnerability assessment through an analysis of climate change and its effects.

The analysis combined a top–down and a bottom–up approach. It utilised data from previous, current, and future climatic patterns collected by experts, and it applied a local perception through a participatory rural appraisal with stakeholders. This approach enabled the identification of the most vulnerable areas, sectors, and social groups, thereby assisting in identifying context-specific measures to deal with climate change effects. A success story from the programme is presented in Box Item 12.1.

### **BOX ITEM 12.1 HARVESTING PROSPERITY: FROM WATER SCARCITY TO ENTREPRENEURIAL SUCCESS IN KERALA**

In Anchammile watershed, situated in Kozhinjampara Gram Panchayat, Palakkad district, Kerala, the transformative story of Jayapriya began thanks to initiatives undertaken by NABARD and KfW through the KfW soil project. Jayapriya, tending to her 2.5 ac of land with coconut as the main crop and engaging in cattle rearing, faced a dire situation due to water scarcity. The declining prices of coconuts exacerbated their financial struggles.

As part of the KfW soil project, desilting of well has been identified as a critical intervention for enabling intercropping by village watershed committee and project facilitating agency Integrated Rural Technology Centre (IRTC), and the same was approved by NABARD. With the assistance of local labourers, including women from the neighbourhood, Jayapriya successfully desilted her well after a decade of neglect. This intervention not only increased water availability but also paved the way for intercropping.

With improved water access, Jayapriya cultivated 800 fruit (banana) plants and turmeric on 1.5 ac of her land. As Jayapriya was faced with a surplus of turmeric after harvest due to market conditions, her entrepreneurial spirit, and that of her brother Hari, led to the establishment of ‘Sree Siva Sakthi (SSS) Turmeric’. They seized the opportunity to start a turmeric powder unit, ensuring that the process preserved the nutraceuticals vital for health.

The farm yielded 800 banana bunches and 2,800 kg of raw turmeric in a single year. Their branded turmeric became known for retaining nutraceuticals through a cold stone powdering machine identified by Hari. Selling through online platforms, in local shops, and for medicinal purposes, they invested ₹74,000 in cultivation and the powdering unit, reaping a net profit of ₹1,08,800 from 1.5 ac of land.

The critical intervention of supporting desilting of a well under the KfW soil project led to igniting the entrepreneurship of farmers, leading to their economic prosperity. They expressed their gratefulness to NABARD and KfW for supporting the initiative that transformed their lives.

### **12.2.5 Watershed development programme with climate proofing (2018 to 2024)**

Based on lessons from the KfW soil programme, climate proofing interventions were first integrated into selected completed watershed development projects under NABARD's WDF climate proofing (WDF-CP) programme.

The WDF-CP explicitly focused on protection against land degradation, erosion control, conservation of biodiversity, and improving water use efficiency, with the ultimate objective of enhancing environmental and social resilience to adapt to the changing climate. So far, NABARD has supported 207 WDF-CP projects. It helped in the application of climate risk assessment and integration of climate change adaptation measures in completed watershed projects.

### **12.2.6 Springshed development programme (2017–2018 to the present, ongoing)**

The springs are the lifeline for rural communities in hill regions of the country. Over the decades, springsheds have suffered ecological degradation, leading to drying up of almost 50% of the estimated 5 million springs in India (MoRD, 2021). More than 15% of the Indian population (approx. 200 million people) in the Himalayan regions, encompassing the north-eastern states, Himachal Pradesh, Sikkim, Uttarakhand, Jammu and Kashmir, and Ladakh, as well as the Western and Eastern Ghats, and in hill areas of other states depend on springs for drinking and crop irrigation. Although these regions receive relatively high rainfall, springs have dried up because of the destruction and degradation of natural resources and climate change. This has led to water scarcity, affecting agriculture and the livelihoods of rural communities.

In 2018, with a view to revive the dying and drying springs through participatory conservation measures, NABARD initiated a springshed development programme for the north-eastern and other hill states of India. The programme began with core soil and water conservation works with a participatory ridge to valley concept for conservation and regeneration of natural resources. It evolved as a holistic programme with the changing ecosystems and requirements.

A total of 157 springshed development projects were sanctioned, covering approximately 45,700 ha and benefiting over 5,650 families across 16 states, including the north-eastern and other hill regions.

The springshed development programme not only addressed water scarcity and enhanced water security but also increased farmers' incomes, expanded livelihood opportunities for the landless, and promoted community ownership through ecologically sustainable management. The programme has enhanced the economy, ecology, and equity at grassroots level in hill regions

of the country. It has facilitated climate change adaptation along with other benefits in these fragile mountainous areas. Additionally, the initiative is expected to contribute to India's commitments toward the SDGs, specifically clean water and sanitation, climate action, life on land, and gender equality. Also, it could help advance the nationally determined contributions (NDCs), such as Mission LiFE and climate justice. A success story from the programme is presented in Box Item 12.2.

**BOX ITEM 12.2 TRANSFORMING AGRICULTURE THROUGH IMPROVED ACCESS TO SPRING WATER IN BAGESHWAR, UTTARAKHAND**

Shri Dan Singh Koranga and other farmers in the Farsali Walli village, Bageshwar district, Uttarakhand state, faced significant irrigation challenges, restricting vegetable cultivation to just 0.04 ha. A limited water availability not only reduced the variety and quantity of crops but also hampered his ability to meet household and market demand, significantly affecting productivity and income.

To address these challenges, several water conservation measures were implemented under the Khirganga springshed project supported by NABARD. Staggered contour trenches were constructed to capture rainwater, enhance groundwater recharge, and prevent soil erosion. Additionally, an irrigation tank was built and linked to a traditional water channel (guhl), allowing the efficient storage and distribution of excess spring water. This ensured a consistent water supply even during dry periods, optimising agricultural productivity.

With improved water availability, Shri Koranga expanded cultivation to 0.1 ha, significantly increasing vegetable production. His annual income rose from ₹8,000–10,000 to ₹28,000, demonstrating the transformative impact of reliable irrigation. The intervention not only improved productivity and profitability but also enhanced resilience against seasonal water fluctuations, making his farm a model for sustainable agricultural practices in the region.

**12.2.7 *Integrated watershed development programme with climate proofing (2019 to present, ongoing)***

Based on the successful experiences of the KfW soil programme and the WDF-CP, climate risk assessment and vulnerability analysis became central to the watershed development projects supported under WDF. Subsequently, the NABARD WDP was named Integrated Watershed Development Programme – Climate Proofing (IWDP-CP), with the inclusion of climate change adaptation measures.

The programme ensures inclusive growth, promotes climate-resilient farming in vulnerable rainfed areas, and bridges the gap between productivity levels of rainfed and irrigated areas by integrating WDP with climate-proofing interventions.

### **12.2.8 JIVA – agroecology (2023 to present, ongoing)**

*JIVA* means ‘a living being or entity imbued with a life force’ in Sanskrit. This programme was designed to transform agricultural ecosystems in India’s vulnerable rainfed and dryland regions by pioneering and scaling up agroecology. By promoting natural farming practices with climate-resilient and diversified cropping integrated with trees and livestock and extensively engaging with farmers, *JIVA* aims to enhance productivity, improve livelihoods, and foster sustainable economic growth while nurturing the essential ecological processes that sustain agricultural systems. The *JIVA* programme was grounded on pilot basis covering five diverse agroecological zones and 11 states in the year 2023. With innovative farmer-led extension and agroecology-based value chain approaches, the *JIVA* programme has showcased regenerative agricultural practices in the pilot projects, demonstrating huge potential for scaling up across the country in its highly vulnerable rainfed and tribal regions and by integrating agroecology principles in the WDP.

### **12.2.9 Landscape-based regenerative, resilient, and rainfed ecosystem development programme (2024 to present, ongoing)**

LREDP was launched by NABARD in the year 2024 based on the learnings from regular watershed development projects, climate proofing of watersheds, encouraging results from *JIVA* agroecology, and technology advancements, viz., use of geospatial technology in the planning and monitoring of watershed development projects, water budgeting-based crop diversification, post-project sustainability plan (with FPOs and SHGs taking up business enterprises and banking plan), green taxonomy and carbon credit framework, etc.

The landscape approach under the LREDP focuses on developing a cluster of micro-watersheds with a total geographical area of approximately 5,000 ha, in a phased manner, in highly degraded catchments within the sub-basin of a river. The programme is currently in its pilot stage.

The LREDP aligns with India’s commitments towards the Sustainable Development Goals (SDGs), nationally determined commitments (NDCs), and land degradation neutrality (LDN).

Though the aforementioned programmes are supported by grant assistance in the highly vulnerable rainfed areas, NABARD also supports the state

governments in availing financial assistance under the Rural Infrastructure Development Fund (RIDF) to take up soil and water conservation and watershed development initiatives. Further, NABARD partners with corporate social responsibility (CSR) foundations of major corporates through co-financing, to channel resources for watershed development.

### 12.3 Results and discussion

Watershed development plays a crucial role in enhancing agricultural productivity, ensuring water security, and fostering sustainable livelihoods in rural India. NABARD's interventions on micro-watershed scale, implemented through collaborative efforts with various stakeholders, have led to significant ecological, social, and economic transformation, reshaping rural landscapes, strengthening livelihoods, and enhancing climate resilience. Through participatory approaches, soil and water conservation measures, climate adaptation measures, technological innovations, and strategic partnerships, these interventions have addressed the critical challenges of water scarcity, land degradation, and low productivity, paving the way for agricultural sustainability.

The following sections present a detailed analysis of the impact of these initiatives, highlighting improvements in groundwater recharge, crop productivity, livelihood diversification, community resilience, etc. The discussion is based on impact evaluation studies, geospatial technology-based assessments, and case studies that provide a comprehensive understanding of the effectiveness of watershed projects.

#### 12.3.1 *Impact of NABARD's watershed development initiatives*

The effort of NABARD has been to reach out to people, even in the most remote or inaccessible parts of the country. From the beginning, the role of local people in NABARD's watershed management programmes has been key to their success. Their involvement ensures that projects are contextually relevant, are sustainable, and contribute to the long-term well-being of rural communities and their environments. Through this participatory approach, NABARD, with the support of WOTR and the NGOs, has trained more than 300,000 community members in watershed management practices and sustainable agriculture techniques.

NABARD's watershed development programme has not only improved water security and agricultural productivity but also promoted sustainable livelihoods, environmental conservation, and community resilience in rain-fed areas across India. These shared effects underscore the programme's role in fostering inclusive rural development and addressing challenges posed by climate change and resource scarcity. Over the years, NABARD's watershed

development programme has evolved significantly to address diverse challenges and opportunities in rural India. Beginning with the IGWDP, the programme expanded in the 2000s to emphasise community participation and integrated watershed management. This phase introduced sustainable agricultural practices and livelihood diversification strategies, aiming to enhance rural incomes and reduce dependency on agriculture alone.

As climate change became a pressing issue, climate change vulnerability assessment and climate-smart agriculture techniques were included, promoting resilience against environmental stresses. The programme also embraced technological advancements, such as GIS mapping and remote sensing, for effective planning and monitoring.

Through partnerships with international agencies and collaborations with diverse stakeholders, particularly NGOs, NABARD has advocated for policy integration and enhanced knowledge sharing, ensuring the programme's relevance and efficacy in fostering sustainable rural development and improving livelihoods in rainfed areas across India. To sum up, NABARD's efforts have resulted in the restoration and conservation of over 2.7 Mha of degraded lands across India.

The evaluation of NABARD's watershed projects employs a robust methodology combining quantitative and qualitative methods. Beginning with baseline data collection to establish pre-project conditions, the evaluations monitor changes in water availability, land use and land cover changes, crop yields, adoption of sustainable practices, and livelihood improvements throughout implementation.

Quantitative analysis compares pre- and post-intervention data to measure outcomes, such as increased productivity and income levels, while qualitative assessments capture community perceptions and socio-cultural impacts. Stakeholder engagement ensures diverse perspectives are considered, enhancing the credibility and relevance of evaluation findings. Ultimately, these evaluations provide evidence-based insights to guide future interventions and policy decisions for sustainable agricultural development and environmental conservation in rainfed areas.

To assess the impact of interventions in watershed development projects on agricultural production, productivity, and income level of the watershed community, assessment studies have been conducted in project areas. Examples are the evaluation of IGWDP projects in Telangana, Rajasthan, and Gujarat by the National Remote Sensing Centre (NRSC) and Central Research Institute for Dryland Agriculture (CRIDA), the KfW soil (phase 2) projects in Jharkhand and Kerala by CRIDA, and regular watershed projects in Andhra Pradesh, Madhya Pradesh, Odisha, Karnataka, Telangana, and West Bengal. These evaluation studies have also formed the basis for several research studies (Osman et al., 2013). One such study is presented in Box Item 12.3.

### **BOX ITEM 12.3 IMPACT OF WATERSHED DEVELOPMENT PROJECTS IN TELANGANA, INDIA**

CRIDA conducted a study to assess the pre- and post-effects of four watersheds (Laxmipur, S. Venkatapur, Kakatiya, and Shettihadapnur) in the Adilabad district of the state of Andhra Pradesh (now the Telangana state) in India using a timescale disparity index.

#### **Overall key effects**

- 1 Significant improvement in **groundwater recharge** in all four watersheds. The average depth of groundwater availability improved, decreasing from 72.9 m before WDP to 54.1 m.
- 2 **Cropping intensity** improved by 11%, reflecting a growth of 9.9% in the four-year period. Farmers were able to cultivate more than one crop per year, leading to higher agricultural output.
- 3 Overall improvement in **crop productivity** was observed across the watersheds.
- 4 **Biomass and fodder availability** improved to the extent of 25% that led to increased production and productivity of milk per milch animal.
- 5 **Milk productivity** saw an upward trend with yield (absolute difference) of 84 L per year per milch animal, attributing to better fodder and water resources.
- 6 The absorption level of the **institutional credit** increased up to 64.1% after WDP from 42.9% earlier.
- 7 The **migration** status of households has significantly come down from 48% (before WDP) to 12%.
- 8 **Watershed impact index:** The total impact (composite disparity index, or simply, watershed impact index) of WDP activities was found to be the highest in Kakatiya watershed and the least in S. Venkatapur watershed, as indicated by the calculated values of composite indices of timescale disparity, 0.77 and 0.21, respectively.

Impact assessment studies conducted by the WOTR Centre for Resilience Studies (W-CReS) in the Akole and Sangamner blocks of Maharashtra (2009–2018) demonstrated significant agricultural productivity gains and improved water availability. Project villages in hill, plateau, and rivulet regions reported substantial yield increases, particularly in paddy, chickpea, soybean, wheat, and pearl millet. Water availability also improved, with some villages eliminating their reliance on water tankers post-intervention. The detailed findings are given in Appendix I.

Another set of impact evaluation studies conducted through reputed institutions and agencies (such as the Institute of Rural Management, the Central

Research Institute for Dryland Agriculture, the Indian Institute of Soil and Water Conservation, and the Tamil Nadu Agricultural University) for a different set of watershed development projects confirmed benefits, such as:

- Groundwater recharge improved by 20%, increasing irrigation access.
- Crop productivity increased by 29%, leading to higher incomes.
- Cultivated land expanded by 26–35%, bringing more land under agriculture.
- Plantation area increased by 77%, contributing to carbon sequestration and economic benefits.
- Household income grew by 35%, with women-led SHGs playing a key role in micro-enterprises.

In addition, the implementation of watershed development supported livelihood diversification among rural communities. For instance, in Karnataka's Tumkur district, over 70% of households engaged in NABARD-supported programmes diversified into horticulture and livestock rearing, significantly boosting their income levels.

NABARD employs geospatial technology to monitor and evaluate land use and land cover (LULC) changes within its watershed development projects. In view of the increasing number of projects and the emerging need for effective end-use monitoring, a NABARD BHUVAN portal and mobile app were developed in collaboration with the NRSC to supplement physical monitoring. The assets created (soil and water conservation structures) in the watershed projects are being geotagged using the mobile app. The portal hosts physical and financial data and approximately 2 lakh geotagged assets on its server pertaining to over 1,100 projects. A change detection analysis for the Banar–Barbati watershed in Madhya Pradesh, a state of India, is given in Appendix II as a sample. The summary of the findings is presented in what follows for ready reference.

The impact evaluation of the Banar–Barbati watershed development project in Madhya Pradesh assessed changes over 2,063.73 ha using geospatial technology. Time series satellite imageries (IRS LISS IV) were used to analyse land-use patterns during the years 2011 (pre-project), 2017 (after completion), and 2020 – three years of completion.

The study revealed a significant increase in cropland, expanding from 1,212.63 ha in 2011 to 1,473.40 ha in 2020, indicating enhanced agricultural productivity. Concurrently, fallow land decreased from 332.03 ha to 155.31 ha, while scrubland reduced from 174.80 ha to 140.29 ha. Water conservation efforts, including the development of farm ponds and check dams, improved water availability, supporting sustainable land use. Forest cover remained stable at 179.98 ha, preserving ecological balance. The study demonstrated that geospatial tools are essential for long-term impact assessment, proving that effective watershed interventions can lead to lasting agricultural and environmental benefits. The sustained improvements even after

project completion underscore the importance of continued maintenance and reaping of benefits by the farming community in the project area.

### 12.3.2 Overview of achievements

NABARD, through its various interventions and watershed development programmes, has not only boosted rural economy and livelihoods in terms of land development, good yields, diverse cropping, plantations, etc., but also ensured the supply of nutritious food to people in rural areas. The overview of achievements of participatory watershed development projects implemented by NABARD is presented in Table 12.2.

**TABLE 12.2** Overview of achievements of participatory watershed development projects implemented by NABARD

<i>Parameter</i>	<i>Achievements under watershed projects</i>
<b>Ecological</b>	<ul style="list-style-type: none"> <li>• Intensive soil and water conservation measures, leading to reduced soil erosion and minimised runoff</li> <li>• Improved ecosystem</li> <li>• Development of farmlands and increased area under cultivation</li> <li>• Increase in vegetation/green cover</li> <li>• Reduction in wasteland</li> <li>• Improved groundwater table</li> </ul>
<b>Social</b>	<ul style="list-style-type: none"> <li>• Community organised into farmers' institutions (watersheds/FPOs/farmers' clubs, etc.) and women self-help groups (SHGs)</li> <li>• Community institutions with a capital base (share capital, revolving fund, maintenance fund, and linkages with financial institutions)</li> <li>• Intensive social mobilisation and backup facilitation by civil society organisations</li> <li>• Key role of women in decision-making process (1/3 of village watershed committee members are women)</li> <li>• Dedicated livelihood component under WDP – opening up opportunities for women to take up income-generating activities, leading to livelihood security</li> </ul>
<b>Human</b>	<ul style="list-style-type: none"> <li>• Technically trained human resources</li> <li>• Community-level leadership</li> <li>• Reduced migration</li> <li>• Enhanced capacities in the conservation and regeneration of natural resources</li> </ul>
<b>Physical</b>	<ul style="list-style-type: none"> <li>• Infrastructure in terms of soil erosion control, soil moisture conservation, and water harvesting structures</li> <li>• Vegetation (fruits, forestry, and fodder)</li> </ul>
<b>Economic</b>	<ul style="list-style-type: none"> <li>• Enhanced income due to additional area brought under cultivation, improved cropping intensity, and crop production, boosting of rural economy</li> <li>• Sustainable source of income by building resilience to climate change</li> <li>• Livelihood security of farmers, women, and the landless</li> </ul>

*Source:* Authors' compilation.

Notably, the aforementioned achievements cover most of the SDGs, such as alleviation of poverty, removal of hunger, climate action, gender equality, clean water, and sanitation, reducing economic disparity, health, education, and infrastructure. By integrating climate resilience into watershed management, the WDP of NABARD aligns with the revised NDCs of the Government of India. Further, a key strength of NABARD's approach is its focus on inclusivity. Women-led self-help groups and the active participation of women in village watershed committees have significantly enhanced decision-making, access to credit, and nutritional security at the local and household level. Further, the livelihood component under WDP has enabled women to engage in income-generating activities, leading to their economic empowerment and livelihood security.

#### **12.4 Lessons learnt from failed projects and interventions**

Although many watershed projects supported by NABARD have been successful in addressing complex issues in rainfed farming, some projects faced challenges. In areas with low community participation, poor community mobilisation, and limited capacities of project-facilitating agencies, shifting to high-water-consuming crops, looking at increased water availability, improper site selection for soil, and water conservation measures, coupled with increased variability of climate parameters, lack of convergence with the works of line departments, lack of scaling up of impactful interventions, etc. were the key challenges faced that varied from project to project.

Addressing these gaps through community-driven approaches; targeted capacity-building initiatives; scientific planning, including use of geospatial techniques; integration of post-project sustainability plan from the first year of implementation; water budgeting and crop diversification; ensuring convergence; integration of climate adaptation strategies; etc. is the key lesson drawn and built into the operational guidelines, over a period of time, for the long-term success of NABARD-supported watershed development projects.

#### **12.5 Summary and conclusions**

NABARD's watershed development programme, launched with the support of the Government of Germany through the KfW in 1992–1993 as a pilot under the IGWDP, has evolved as a holistic and inclusive initiative that addressed challenges in India's rainfed areas through community-led action. Since then, its watershed development programme has been instrumental in addressing rural poverty and environmental sustainability throughout the country.

Through its initiatives, NABARD promotes integrated watershed management practices that aim to conserve rainwater, enhance soil fertility, and improve agricultural productivity. The programme emphasises community participation, empowering local communities to manage and sustain natural resources effectively.

The IGWDP caught the attention of policymakers regarding watershed development programmes in India. A few best practices from the IGWDP were taken to mainstream watershed development programmes (based on the recommendations of the Hanumantha Rao Committee 1994 and the Parthasarathy Committee 1999). The work done under the IGWDP laid the foundation for a direct foray of NABARD into natural resource management (NRM). The programme evolved as a holistic, participatory approach, now enhanced to overcome the challenges posed by climate change under WDF of NABARD and to ensure long-term sustainability of interventions in rainfed ecosystems.

By providing financial support and technical expertise, NABARD facilitates the area treatments viz. contour trenches, bunds, farm ponds, trench cum bunds, along with grass seeding and plantation and drainage line measures, namely, stone gully plugs, gabion structures, earthen embankments, construction of check dams and percolation tanks, and other water conservation structures, thereby mitigating droughts and ensuring water availability for irrigation and domestic use. Over a period, climate change adaptation measures, including climate-resilient and regenerative agriculture practices, have also been integrated in WDP following agroecology principles. This holistic approach not only boosts rural livelihoods but also fosters resilience against climate change impacts, making it a pivotal strategy for sustainable development in India's rural areas.

Throughout NABARD's WDP, the role of NGOs is pivotal, from developing a capacity-building methodology by the WOTR in partnership with implementing NGOs and the phasing of the IGWDP to setting the mechanism of engaging local communities and building their ownership of projects.

By treating the village watershed comprehensively, equity and sharing benefits could be ensured. It helped marginal landowners benefit by soil and water conservation. Also, poor households and women could acquire representation in village committees because of it. And economic benefits through off-farm activities could reach the poor through it. Now, successful and sustainable impacts are visible because local committees and women are empowered with the knowledge of maintenance and mechanisms for inclusivity.

## 12.6 The way forward

To ensure long-term sustainability of supported watershed development programmes to revitalise rainfed ecosystems and ensure climate justice to vulnerable and marginalised sections of society and livestock, the following steps are suggested.

First, the promotion and upscaling of climate-resilient agricultural practices in watershed projects are essential for sustainable development. These

would include agroforestry, agro-horticulture, integrated farming systems, and other agroecological approaches.

Second, attention should be given to vulnerable (to climate change), aspirational, and credit-starved districts, considering their susceptibility to climate change, to ensure equitable progress.

Third, expanding agroecology initiatives, like the JIVA programme, across diverse agroclimatic zones, and supporting various pilots, such as wasteland development, integrated dairy farming, participatory groundwater management, use of AI/IOT in efficient water management, rural eco-tourism, etc., will enhance resilience and community involvement.

Fourthly, incorporating water budget-based crop diversification and promoting banking plans in project villages are crucial for sustainable agriculture and financial inclusion.

Fifth, and finally, integrating carbon credit frameworks, utilising geospatial technology for planning and monitoring, and encouraging post-project sustainability through the formation of FPOs in watershed clusters will ensure a long-term effect and efficiency in watershed development projects.

## Acknowledgements

The authors express profound gratitude to the National Bank for Agriculture and Rural Development (NABARD) for leading the watershed development programme. They also acknowledge the financial and technical support provided by international development agencies, including the German Federal Ministry for Economic Cooperation and Development (BMZ), KfW, GIZ, and SDC, and the Government of India. Special thanks are also extended to the Watershed Organisation Trust (WOTR) for its knowledge partnership and implementation support. The authors gratefully acknowledge contributions of implementing agencies, grassroots partners, and watershed communities for their dedicated efforts in shaping the outcomes and insights presented.

## Notes

- 1 *Kreditanstalt für Wiederaufbau* (KfW) is a German state-owned development bank.
- 2 GIZ stands for *Gesellschaft für Internationale Zusammenarbeit*, which translates to 'German Society for International Cooperation'. GIZ is a federal enterprise responsible for international development cooperation in Germany.
- 3 *Participatory net planning* (PNP) emphasises a participatory approach, involving community in the planning and implementation processes to ensure that interventions are tailored to local needs and conditions. PNP is a method in which every local stakeholder/farmer/family of farmer contributes to determining the best conservation and land-use practices for each plot of land, starting from ridge to valley of the watershed. In essence, PNP integrates local knowledge and priorities into watershed management, fostering community ownership and sustainability of natural resource initiative.

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# APPENDIX I

## Findings of impact assessment in the Ahmednagar district of Maharashtra

The findings of the impact assessment studies conducted in NABARD-supported watershed projects in the Akole and Sangamner blocks of the Ahmednagar district in Maharashtra (2009–2018) highlight changes in crop productivity, water availability, and livelihood diversification across different agroclimatic zones.

### 1 Agricultural productivity gains

#### 1.1 Hill region (paddy and chickpea cultivation)

Paddy and chickpea yields doubled in intervention villages, whereas the control village (Shinde) saw only moderate improvements (Table 12.3).

**TABLE 12.3** Productivity gains for paddy and chickpea crops in the intervention villages of the Ahmednagar district

<i>Village</i>	<i>Crop</i>	<i>Pre-intervention yield (quintals/ha)</i>	<i>Post-intervention yield (quintals/ha)</i>	<i>% increase</i>
Ghoti	Paddy	18	34	+87%
Khadki Budruk	Paddy	19	34	+79%
Shinde (control)	Paddy	20	24	+20%
Ghoti	Chickpea	6.5	14	+115%
Khadki Budruk	Chickpea	7	14.5	+108%
Shinde (control)	Chickpea	6	11	+85%

*Source:* Authors' compilation.

### 1.2 Plateau region (soybean and wheat cultivation)

Significant productivity gains, particularly in wheat cultivation, more than doubling in intervention villages (Table 12.4), were noted:

**TABLE 12.4** Productivity gains for soybean and wheat crops in the intervention villages of the Ahmednagar district

<i>Village</i>	<i>Crop</i>	<i>Pre-intervention yield (quintals/ha)</i>	<i>Post-intervention yield (quintals/ha)</i>	<i>% increase</i>
Warudi Pathar	Soybean	8.5	15.2	+79%
Mahalwadi	Soybean	9	17.2	+91%
Pimpalgaon Matha (control)	Soybean	9.2	11.6	+26%
Warudi Pathar	Wheat	12	29.5	+146%
Mahalwadi	Wheat	13.5	31	+130%
Pimpalgaon Matha (control)	Wheat	14	25.5	+81%

*Source:* Authors' compilation.

### 1.3 Rivulet area (pearl millet and chickpea cultivation)

Pearl millet productivity doubled in project villages compared to the 52% rise in control villages (Table 12.5).

**TABLE 12.5** Productivity gains for pearl millet and chickpea crops in control villages of the Ahmednagar district

<i>Village</i>	<i>Crop</i>	<i>Pre-intervention yield (quintals/ha)</i>	<i>Post-intervention yield (quintals/ha)</i>	<i>% increase</i>
Kauthe Khurd	Pearl millet	10	20.6	+106%
Kauthe Budruk	Pearl millet	9.8	21.5	+119%
Chas (control)	Pearl millet	11	16.7	+52%
Kauthe Khurd	Chickpea	7	14.9	+113%
Kauthe Budruk	Chickpea	7.2	16	+123%
Chas (control)	Chickpea	6.8	13	+91%

*Source:* Authors' compilation.

## 2 Water availability improvement

Post-intervention, project villages completely eliminated tanker dependency, whereas the control village still required eight tankers per year (Table 12.6).

**TABLE 12.6** Improvement in water availability for the Ahmednagar district

<i>Village</i>	<i>Water requirement (tankers per year, 2008)</i>	<i>Water requirement (tankers per year, 2017–2018)</i>	<i>% reduction</i>
Warudi Pathar	16	0	100%
Mahalwadi	10	0	100%
Pimpalgaon Matha (control)	20	8	60%

*Source:* Authors' compilation.

The findings demonstrate that NABARD's watershed interventions led to substantial improvements in crop productivity, water security, and rural incomes. The elimination of tanker dependency and significant expansion in cultivated land highlight the long-term sustainability of these programmes.

## APPENDIX II

### Impact evaluation study of the Banar–Barbati watershed, the Mandla district of Madhya Pradesh state, using geospatial technology

The Banar–Barbati watershed, located in the Mandla district of Madhya Pradesh, has a geographical area of 2,063.73 ha. The impact evaluation study aimed at checking the performance of a watershed development project with a geospatial approach using satellite images of pre- and post-project implementation and three years after completion.

The study used medium spatial resolution satellite data (i.e. the LISS IV) of the Indian Remote Sensing (IRS) satellite series of ISRO to generate time series land-use and land cover maps to check the status of NABARD interventions. The results showed a significant increase in area under cropland surface water bodies, like water harvesting structures, farm ponds, check dam backwaters, etc., proving the success of interventions over a period of seven years.

The land-use and land cover maps of the watershed before taking up the project in the year 2011, upon completion of the project in the year 2017, and three years after the completion of the project are given in Figure 12.1. In 2011, the area under crop cultivation was 1,212.63 ha, followed by forest and scrubland that covered 179.98 ha and 174.80 ha, respectively.

The change in LULC pattern meant that current fallow and scrublands in the watershed had been converted to cropland in different parts of the watershed after treatment of these lands with suitable soil and water conservation measures. This resulted in an increase of cropland area from 1,212.63 ha in 2011 to 1,473.40 in 2020 (Figure 12.2). Consequently, current fallow land and scrubland areas had decreased from 332.03 ha to 155.31 ha and 174.80 ha to 140.29 ha, respectively (Table 12.7).

Substantial growth in area under cropland is observed with the implementation of watershed development projects (Figure 12.3).

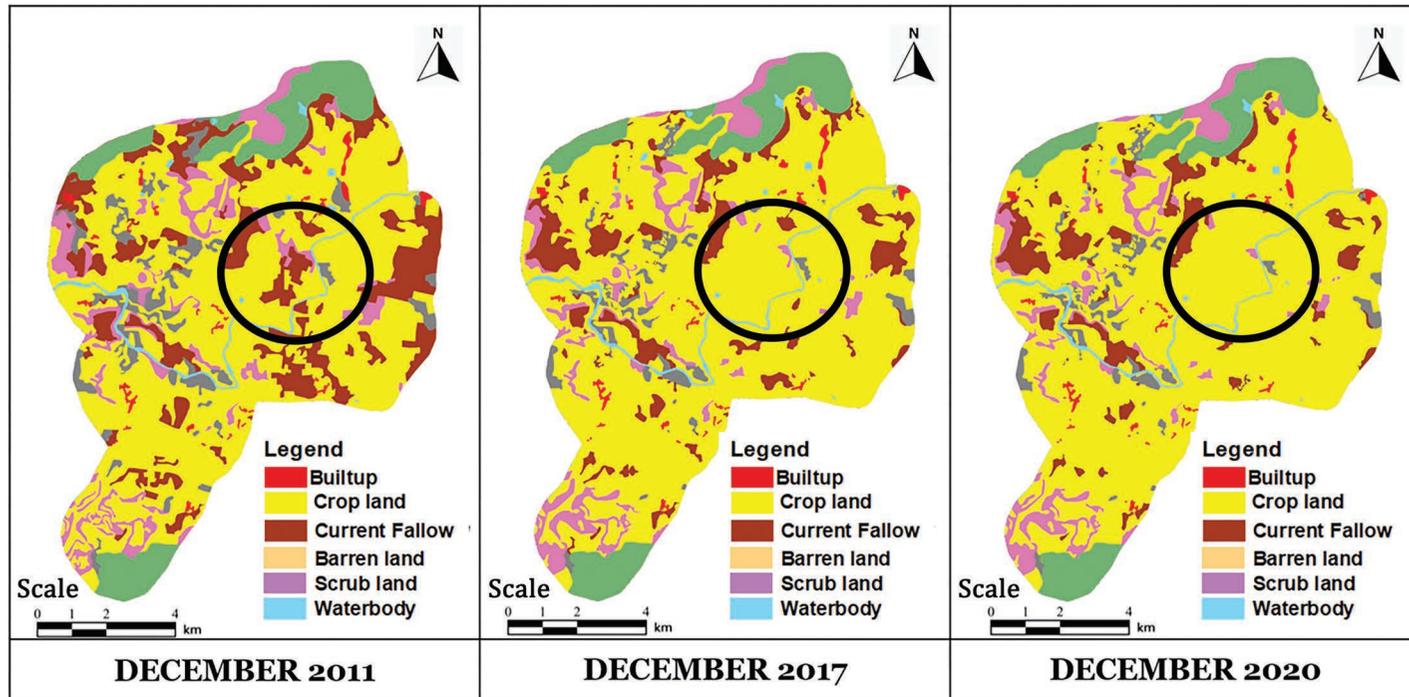


FIGURE 12.2 Land-use and land cover maps of the Banar-Barbati watershed.

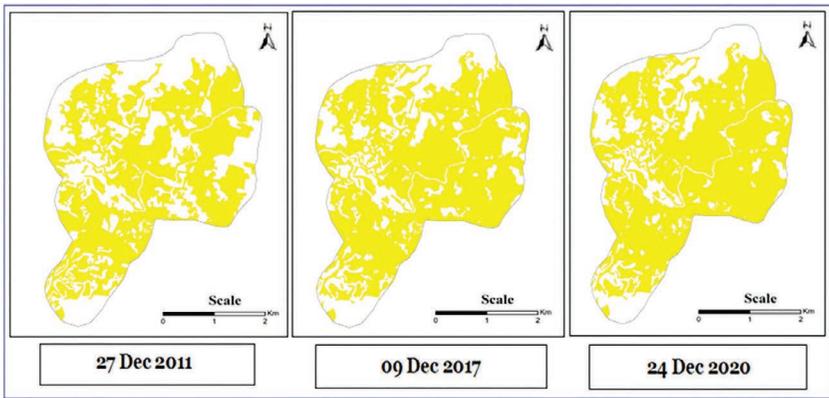
Source: Authors.

The Google Earth image (Figure 12.4) shows that the green cover increased in 2020 compared to 2011 (pre-project) and 2017 (post-project). This is evidently a positive effect, even in the post-project completion phase of NAB-ARD interventions.

**TABLE 12.7** LULC distribution of the Banar–Barbati watershed project

LULC	Area under different LULC (in ha)		
	2011	2017	2020
Cropland	1,212.63	1,424.26	1,473.40
Current fallow	332.03	191.11	155.31
Scrubland	174.80	150.26	140.29
Built-up land	22.90	23.06	23.44
Water body	26.37	27.53	27.53
Forest	179.98	179.98	179.98
Wasteland	115.03	67.53	63.78
<b>Total area</b>	<b>2,063.73</b>	<b>2,063.73</b>	<b>2,063.73</b>

Source: Authors.



**FIGURE 12.3** Area under cropland in the Banar–Barbati watershed.

Source: Authors.



**FIGURE 12.4** Google Earth images of the watershed.

Source: Google Earth.

# 13

## CLIMATE ACTION IN DRYLAND REGIONS

### Insights from Telangana

*Bhavana Rao Kuchimanchi*

#### 13.1 Introduction

Drylands constitute 46.2% ( $\pm 0.8\%$ ) of the global land area (Práválie, 2016; Koutroulis, 2019). Three billion people inhabit dryland regions, and nine in ten of such people reside in developing countries (UNEP, 2011; van der Esch et al., 2017). A diverse range of land-use systems characterises dryland regions. For instance, given the limited availability of precipitation for crop production, people living in these regions depend heavily on domesticated animals for agricultural production and livelihood (Koochafkan & Stewart, 2009). Agricultural systems in dryland regions are believed to have developed in response to the availability of natural resources (Thornton et al., 2007; Hodges et al., 2014; Kuchimanchi et al., 2021a).

Dryland farming systems have undergone a long history of evolution; they are moving away from localised agricultural practices to intensive, specialised, market-oriented ones (Tarawali et al., 2011; Udo et al., 2011; Reardon et al., 2019). Although these developments have enhanced crop production and rural incomes, concerns about environmental and socio-economic sustainability are unsettling (Lebacqz et al., 2013; Clay et al., 2019). These changes in the farming system occur most notably in Asia and Africa (Alexandratos & Bruinsma, 2012; Masters et al., 2013; Reardon, 2015; Reardon et al., 2019), predominantly characterised as dryland regions because of their biophysical disposition.

On similar lines, a large percentage of India's land is categorically located under drylands (69%). Within this category, arid regions take up 15.8%, while semi-arid regions take up 37%. Drylands accommodate about 40% of

the population in India and account for about 37% of the total food grain yield (Kalsi, 2007; Harriss-White, 2008; Rao, 2008; Government of India, 2019; Kuchimanchi et al., 2022) (see Figure 13.1).

Despite decades of development and the attainment of food self-sufficiency, India's dryland states continue to fall behind on socio-economic indicators, such as land productivity, employment opportunities, social development

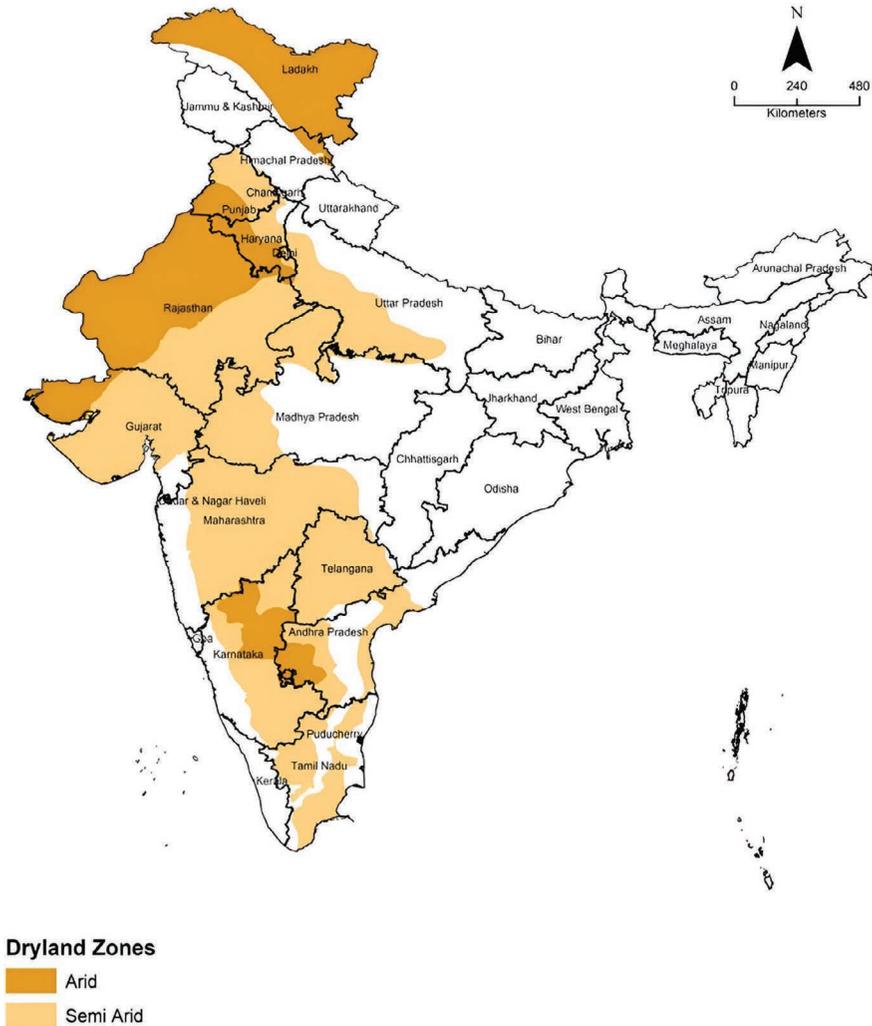


FIGURE 13.1 Arid and semi-arid regions of India.

Source: Figure redrawn based on National Bureau of Soil Survey and Land-use Planning, Government of India (MoA&FW) (2019).

indices, and infrastructure. For instance, although the state of Telangana (the focus of our study) has better socio-economic standards and infrastructure than most other Indian states (Indian National Human Development Report, 2018), the economic performance in farming is subpar (Kuchimanchi et al., 2021a, 2021b).

Further, robust initiatives designed expressly for dryland regions, such as watershed development to benefit the rural poor, also began yielding unsatisfactory programme outcomes over time (Bouma & Scott, 2006; Shiferaw et al., 2008; Calder et al., 2007; van Ginkel et al., 2013; Bharucha et al., 2014; Reddy & Syme, 2015; Kuchimanchi, 2022).

The vulnerability of farmers to climate change has been increased by agricultural transitions in dryland areas due to soil depletion, the rising frequency of pest and disease outbreaks, and the lowering of groundwater levels, as indicated by a report from the Central Institute for Dryland Agriculture (2011). Ecosystem services will be significantly affected in Indian drylands due to climatic variations, as Rao et al. (2019) highlighted, jeopardising the livelihoods of millions. They also observe that fluctuations in precipitation in drylands can modify aridity indices, hence necessitating adaptation and mitigation strategies.

Higher near-surface climatic modifications will exacerbate land degradation when dryness is further intensified and more intensive land-use practices are adopted, according to D'Odorico et al. (2013) and Berg et al. (2016). IPCC reports have indicated that these changes will result in water scarcity and food insecurity in the drylands (IPCC, 2014, 2018; Berg et al., 2016; IPCC, 2019a, 2019b). This situation brings to the fore a nagging concern: that small and marginal farmers in dryland states, who are most susceptible to climate change, make up an excessively high number of their populations (Banerjee, 2015; Singh et al., 2016; Kuchimanchi et al., 2019).

Many studies have been conducted on various aspects of climate change vulnerability, adaptation policies and related measures, and effects of climate change on livestock in India – for example, Taylor, 2013; Banerjee, 2015; Dubash & Jogesh, 2014; Singh et al., 2014; Udmale et al., 2014; Maiti et al., 2017). Yet there is a significant gap of information regarding vulnerability to climate change, with particular reference to dryland environments. This needs to be filled by research on the subject matter. The following text attempts to address this, with emphasis on livestock management for better resilience through fodder support under stressed environments. Even so, generally speaking, this gap likely contributes to the ongoing challenge of differentiating development-as-usual programmes and implementing substantial changes, despite widespread awareness, increased investment in adaptation measures, and the existence of national policies aimed at combating climate change in India (Adhikari & Taylor, 2012; Singh et al., 2016; Kuchimanchi et al., 2021b).

This chapter discusses a change in strategies to address farmers' vulnerability to climate change in dryland ecosystems based on a longitudinal study of agricultural traditions in a dryland region in Telangana. The intersection of climate justice and climate action in dryland regions is crucial for understanding and addressing the challenges farmer communities face in dryland regions (Stringer et al., 2022).

Firstly, it is essential to recognise the disproportionate impact of climate change on vulnerable populations, particularly in dryland areas (Burrell et al., 2020; Stavi et al., 2021). Despite their ecological significance and contribution to food production, these regions often harbour marginalised communities with limited resources and infrastructure. Most of India's population resides in dryland regions, with low land productivity and limited employment opportunities (Reddy et al., 2021). This disparity underscores the need for climate justice, ensuring that the consequences of climate change do not burden these communities inordinately (Srivastava et al., 2022).

Secondly, agricultural practices in dryland regions are intricately linked to climate variability (Mandal & Roy, 2024). Fluctuations in temperature and rainfall patterns can significantly affect crop yields, exacerbating food insecurity and economic instability for small and marginal farmers. Climate justice demands equitable solutions that empower these farmers to adapt to changing weather variations and mitigate risks associated with agricultural production (Chakravarty et al., 2020).

Thirdly, the limitations of existing development initiatives and adaptation strategies in dryland regions should receive centre attention. Despite investments in programmes such as watershed development, sub-optimal outcomes indicate a need for more comprehensive and sustainable approaches to address climate vulnerabilities (Kuchimanchi et al., 2022). This points to the importance of integrating climate justice principles into policy frameworks and development agendas, ensuring that interventions effectively support the resilience and livelihoods of vulnerable communities.

Lastly, the knowledge gap regarding vulnerability to climate change in dryland ecosystems highlights the need for research and capacity-building initiatives tailored to these regions. Policymakers and stakeholders can develop evidence-based strategies that prioritise the nuanced needs of communities most affected by climate change.

Addressing climate justice and action in dryland regions requires a holistic approach, considering local communities' socio-economic context, ecological dynamics, and vulnerabilities (Sachan, 2020). By promoting equitable access to resources, enhancing adaptive capacity, and fostering inclusive decision-making processes, stakeholders can work towards building resilience and promoting sustainable development in these critical regions.

## 13.2 Methodology

The study was carried out in two watersheds spanning 27,814 ha and comprising 6,572 households (HHs) across seven villages, focusing on a representative sample of 17,164 ha and 3,006 HHs. Watershed 1 (WS-1) is found in Talakondapally Mandal, which includes four villages; watershed 2 (WS-2) is found in Veldanda Mandal, which covers three villages. These mandals are situated in the Rangareddy and Nagarkurnool districts of the Telangana state (Kuchimanchi, 2022) (see Figure 13.2).

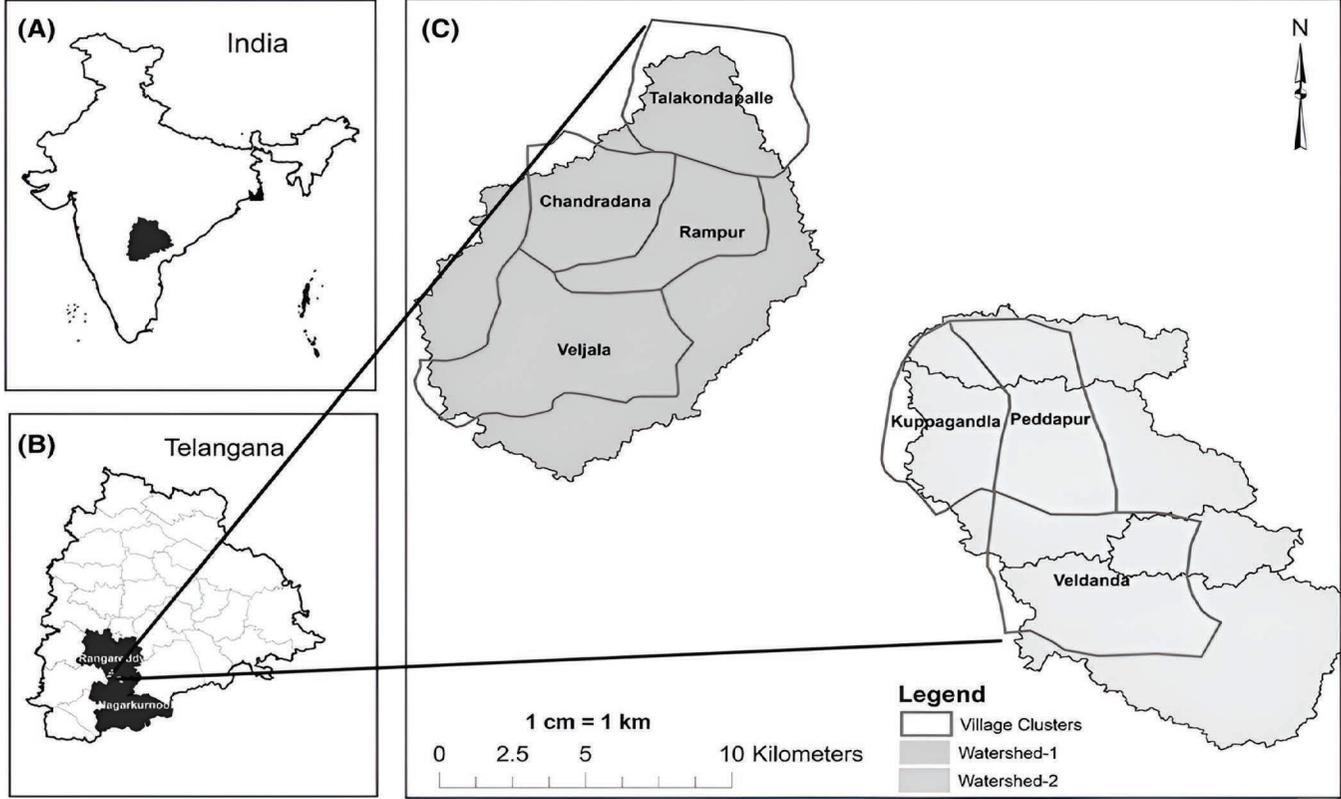
Both watersheds are found within the Deccan Plateau (Telangana) and Eastern Ghat agroecological sub-region 7.2. Due to drought, rainfall at the district level ranges from about 500 mm to about 700 mm per year. The major soils in this area comprise deep loamy and clayey mixed red-black soils with a medium to very high available water capacity. At the same time, the growing season lasts for between 20 and 150 days. The climate is marked by hot, humid summers and warm, dry winters, with an aridity index of 0.2–0.5 (Rao et al., 2019); this makes it a semi-arid region.

### 13.2.1 Data collection

The research employed a watershed as its analysis unit, embedded in the theory of social-ecological systems. Since social-ecological interactions can be complex within a watershed, a mixed-methods design was used to build a comprehensive picture of the transitions and their effects on farming HHs in the region (Kuchimanchi, 2022). The longitudinal study had four major components: mapping agricultural transitions across the region, characterising emerging farming systems and their economic performance, quantifying water use by the emergent system at a watershed level, and examining the vulnerability of these systems to climate change.

Quantitative methods were employed, including household surveys, a longitudinal household study on water usage, borewell discharge tests, and secondary data from local government offices and online government sources, and a land-use, land cover (LULC) analysis. These sources showed how important these characteristics are in this context. On the other hand, qualitative research techniques, such as focused group discussions (FGDs) and participatory timeline mapping exercises, provided insights into why such phenomena happened and offered a holistic perspective.

Regarding limitations, it is important to note that the large sample size and the proximity of the study area to the metropolitan city of Hyderabad could have created biases or affected the pace of transitions. Besides, the interdisciplinary study could not cover all aspects in depth. Nevertheless, the study touches upon criticalities that need attention. The findings also hold relevance for dryland regions across India, even informing agricultural transitions in other Asian and African nations with comparable development policies.



**FIGURE 13.2** Location map of the study region: (a) Location of the state of Telangana in India. (b) The study region (districts) within the state. (c) The two watersheds within which the study villages are demarcated.

Source: Figure redrawn based on ISRO BHUVAN portal ([https://bhuvan.nrsc.gov.in/bhuvan\\_links.php](https://bhuvan.nrsc.gov.in/bhuvan_links.php), accessed 2016) and Kuchimanchi (2022).

### 13.3 Results

#### 13.3.1 Agricultural transitions in the region

Rapid and unidirectional shifts in farming systems occurred from 1997 to 2015. This was despite the social and cultural diversity of Indian agriculture, which is often likely to influence the evolution of transitions in a region. The main factors that led to change processes were technological interventions, holistic development programmes, a growing market demand for specific agricultural commodities, and proximity to a metropolis. As a result of these changes, there has been an increase in regional agriculture production. This was beneficial for lower social groups, but for women it had a dual bearing (Kuchimanchi et al., 2021a).

Several environmental consequences accompanied the increase in regional agricultural production. The transitions induced extensive land-use change within the watersheds, significantly increasing cropland and substantially reducing wastelands and natural surface water bodies (Table 13.1). These changes brought about major regional shifts, forcing HHs to intensify production or become marginalised. The transitions were unidirectional, pushing for intensification and specialisation with a strong market focus (Kuchimanchi et al., 2021a).

Another worrying environmental issue was the aspect of water use by the predominant farming systems in the region. The characterisation studies revealed that 96% of the HHs fell in three main farming systems: crop without livestock (CWL), crop with dairy (CD), crop with small ruminants (CSR). Of the three farming systems, the highest consumer of water was by the CD system, followed by the CSR and CWL systems. The CD and CWL systems accounted for 92% of HHs and the highest consumers of water.

Water balance calculations conducted in WS1 revealed a prominent overuse of water resources (Table 13.2). This excessive use, which led to

**TABLE 13.1** Changes in land use and land cover, 1997–2015, in both watersheds combined

<i>Land classification</i>	<i>LULC area, 1997 (in ha)</i>	<i>LULC area, 2005 (in ha)</i>	<i>LULC area, 2015 (in ha)</i>
Cropland, irrigated	999	2,427	1,733
Cropland, rainfed	8,807	7,841	12,500
Plantations	52	612	612
Wasteland	7,093	5,925	1,763
Surface water bodies	177	105	80
Settlement area	36	253	475
Total	17,164	17,164	17,164

*Source:* Satellite imagery from National Remote Sensing Centre (1997), LANDSAT (2005, 2015) (where land-use, land cover [LULC] area is the area within both watersheds), and Kuchimanchi et al. (2021a).

TABLE 13.2 Water balance in watershed 1 at village level

	<i>Thallakonda- palle</i> V1	<i>Chandra- dana</i> V2	<i>Rampur</i> V3	<i>Veljal</i> V4	<i>Total at WS level</i>
Area of villages in the WS (ha)	2,718	1897	1,604	3,244	9,463
Population ( $n \times 1,000$ )	5,157	2,352	3,255	5,188	15,952
Average rainfall over five years (mm/y)	687	687	687	687	687
Runoff volume <sup>1</sup> (mm <sup>3</sup> )	13.7	9.6	8.1	16.4	47.8
Groundwater recharge <sup>2</sup> (mm <sup>3</sup> )	1.4	1.0	0.8	1.7	4.9
<b>Water available</b> (mm <sup>3</sup> /y)					
Surface water runoff	12.3	8.6	7.3	14.7	42.9
Water in surface water bodies <sup>3</sup>	2.5	1.7	1.5	2.9	8.6
Water not available as ground- or surface water for farm production	9.9	6.9	5.8	11.8	34.3
<b>Water available for use</b> (groundwater recharge + surface water bodies)	3.9	2.7	2.3	4.6	13.5
<b>Water use</b> (mm <sup>3</sup> /year)					
Water used for domestic purposes	0.10	0.05	0.03	0.07	0.25
Water used for farm production					
Crop without livestock system	3.1	1.3	1.6	3.7	9.7
Crop with small ruminants system	0.6	0.2	0.2	0.5	1.5
Crop with dairy system	10.6	5.9	5.0	9.6	31.0
Other farming systems	0	0	0	0.1	0.1
<b>Total water consumed</b> (TWC) (mm <sup>3</sup> )	14.5	7.5	6.8	13.9	42.7
<b>Water balance (deficit/surplus)</b> (mm <sup>3</sup> )	-10.7	-4.8	-4.5	-9.3	-29.2

Source: Kuchimanchi et al. (2023).

<sup>1</sup> *Runoff volume* is the total amount of water expected in a given period (in this case, season) in the catchment (in this case, a watershed).

<sup>2</sup> *Groundwater recharge* is part of the runoff that gets infiltrated into the ground and reaches the groundwater storage in the soil.

<sup>3</sup> Assumption is that only 20% of the total surface water available is stored in surface water bodies since they are few and evapotranspiration in the region is high.

<sup>4</sup> It is the water stored as soil moisture, evapotranspiration (1,500–1,950 mm/y), transpired by vegetation, and other surface runoff not captured as groundwater or in surface water bodies.

<sup>5</sup> Extrapolated to the total number of households in the villages using government population census data based on the percentage of households per farming system in the sample.

groundwater depletion, resulted from intensive agricultural practices, like specialised farming and growing water-thirsty, non-dryland crops.

It is important to note here that requirements for intensive and specialised farming tend to go beyond the biophysical capacity of watersheds. This means that farming systems must align with the region's water resource-carrying capacity for sustainable agricultural production (refer to Kuchimanchi et al., 2023, for details).

### ***13.3.2 Economic performance of current farming systems***

The CWL, CD, and CSR farming systems are variants of specialised, intensive, and market-oriented farming. Among them, the CD system has the maximum revenue, but also high production costs, that reduced profits or resulted in negative returns. On the other hand, the CWL system records the lowest gross margins, again due to high production costs involved in cash crop growing and price instability in the market. The CSR system demonstrated the best economic performance mainly due to lower production costs and a higher price and demand of small ruminant meat in the market. HHs from CWL and CD systems experience the highest credit and debt levels.

In addition, these transitions point out increased risks, low economic performance, and declining circularity within farming. These factors lead to less resilience to shocks, thereby plunging HHs in the area into a poverty trap (Kuchimanchi et al., 2022). For instance, CWL systems face more risk with limited opportunities for diversification. But specialisation does not guarantee a uniform income because the CD system exhibits highly variable economic performances, even with similar output intensity levels. In consequence, intensifying and/or specialising in farming activities within dryland areas may not necessarily translate into improved economic performance (Kuchimanchi et al., 2022) (see Table 13.3).

This is supported by the fact that average daily per capita incomes for specialised or intensive systems are below 0.2 USD for the CWL system and 1.2 USD for the CD system, respectively. Compare this to the minimum daily wage rate of INR 150 prescribed by the Ministry of Labor and Employment (2017) in India as well as the extreme poverty threshold (1 USD) of the World Bank's 2018 benchmark (Kuchimanchi et al., 2022).

### ***13.3.3 Farm development pathways of smallholders – the vulnerability connect***

HHs in different farming systems were found to have differing vulnerabilities (see Table 13.4). This could be for several reasons. For instance, due to dissimilar perceptions of climate change exposures within the area and how they access the five livelihood capitals. Although HHs within the region

**TABLE 13.3** Economic performance of CWL, CD, and CSR farming systems in the study region (in USD)

<i>Income sources</i>	<i>Agricultural seasons<sup>1</sup></i>	<i>Revenue<sup>2</sup></i>	<i>Cost of production<sup>3</sup></i>	<i>Total gross margin</i>
<i>Crop without livestock (CWL)</i>				
<i>Crop</i>	Monsoon	309.7 (286.5)	224.4 (197.7)	87.4 (96.6)
	Winter	–	–	–
	Summer	–	–	–
<i>Off-farm livelihood</i>	Monsoon	56.9 (36.6)	–	56.9 (36.6)
	Winter	51.7 (34.9)	–	51.7 (34.9)
	Summer	107 (52.4)	–	107.0 (52.4)
<b>Total</b>		525.2 (359.2)	224.4 (197.7)	303 (210.4)
<i>Crop with dairy (CD)</i>				
<i>Crop</i>	Monsoon	1,171.8 (2,208.3)	138.9 (222.3)	1,032.8 (1,994.1)
	Winter	–	–	–
	Summer	–	–	–
<i>Livestock</i>	Monsoon	324.1 (1,037.8)	1,174.3 (163.4)	149.7 (260)
	Winter	2,176.0 (1,892.8)	1,059.3 (925.6)	1,116.6 (1,461.3)
	Summer	889.6 (788.7)	1,570 (1,659.2)	–680.4 (1,270.9)
<b>Total</b>		5,561.4 (5,927.6)	3,924.7 (3,870.6)	1,618.7 (4,992.2)
<i>Crop with small ruminants (CSR)</i>				
<i>Crop</i>	Monsoon	1,012.9 (1,383.4)	194.0 (216.8)	818.8 (1,313.0)
	Winter	441.4 (557.7)	210.9 (235.0)	444.9 (495.1)
	Summer	–	–	–
<i>Livestock</i>	Monsoon	245.9 (449.1)	298.9 (170.2)	–53.1(443.5)
	Winter	1,255.5 (1,770.8)	176.7 (127.9)	1,078.7 (1,772.2)
	Summer	1,567.9 (1,422.9)	154.4 (77.3)	1,413.2 (1,382.3)
<b>Total</b>		4,738.1 (5,720.5)	1,040.8 (736.9)	3,538.2 (5,302.0)

*Source:* Household-level longitudinal study (2015–2016) and Kuchimanchi et al. (2022).

*Note:* Figures in USD; conversion factor used: INR 71. *SD* = standard deviation values in brackets.

<sup>1</sup> Monsoon agricultural season (July–September); winter agricultural season (October–March); summer agricultural season (March–June).

<sup>2</sup> The milk sales price is 0.36 USD/kg, and the meat sales price is 3.5 USD/kg at Farmgate.

<sup>3</sup> Cost of production of crops includes costs of land preparation (rent of machinery/bullocks), hired labour, and input; the cost of production for livestock includes costs of animal health-care, leasing lands for grazing, purchased fodder, hired labour, and fodder production in owned land.

**TABLE 13.4** Farmers' perception of climate change exposures in the region

<i>Farming system</i>	<i>Types of climate change exposures</i>						
( <i>n</i> = 10/system)	Increased maximum temperature	Delayed onset of monsoon	Dry spells	Erratic rainfall	Reduced precipitation	Warmer winters	High-intensity rainfall
CWL system	H	H	H	H	M	M	M
CSR system	H	H	H	L	H	L	L
CD system	H	H	H	L	H	L	L

*Source:* Household survey and Kuchimanchi et al. (2021b).

*Note:* *H* = high exposure, score  $\geq 8$  responses; *M* = medium exposure, score 5–7 responses; *L* = low exposure, score  $< 5$  responses; *CWL* = crop without livestock; *CSR* = crop with small ruminants; *CD* = crop with dairy.

**TABLE 13.5** Farming strategies of households in different farming systems

<i>Farming strategies to cope with the effects of climate change</i>	<i>CWL HHs</i>	<i>CSR HHs</i>	<i>CD HHs</i>
<i>Crop farming–related</i>			
Shift to commercial crops	H	L	L
Shift to cash crops with residue	-	H	H
Partial shift to cash and food crops	L	-	M
Higher usage of inorganic inputs	H	M	L
Adoption of farm mechanisation	H	H	H
<i>Water-related practices</i>			
Investment in borewells	M	M	H
Lease of borewells for livestock		H	-
Adoption of water-efficient system	-	-	M
Change in crop choices (less water-intensive)	-	-	M
Reduction in crop cultivation, water diversion for dairying	-	-	H
<i>Livestock rearing–related</i>			
Improve management of livestock	-	H	H
Improve fodder management	-	L	H
Leaving croplands fallow for grazing	-	H	H
Purchase of fodder from markets/other farmers	-	H	M
Lease of land for grazing	-	H	H
Increase investment in animal healthcare	-	H	H
Infrastructure for livestock	-	L	M
<i>Food-, assets-, and livelihood-related</i>			
Higher dependence on government subsidies	H	H	H
Crop and/or livestock insurance	M	H	L
Higher dependence on formal/informal credit	H	M	H
Increased dependence on wage work	H	L	-
Migration for work	L	-	-
Lease-out of land to others	H	-	-
Sale of assets	H	-	L
Dependence on middlemen for sale	H	H	M
Higher dependence on markets and public food distribution systems for food	H	H	M

*Source:* Household survey, FGDs, and Kuchimanchi et al. (2021b).

*Note:* H = high adoption, score  $\geq 8$  responses; M = medium adoption, score 5–7 responses; L = low adoption, score  $< 5$  responses; CWL = crop without livestock; CSR = crop with small ruminants; CD = crop with dairy.

acknowledge climate-related risks, asset accessibility and specific agricultural product market dynamics apparently influence their farming strategies (Kuchimanchi et al., 2021b).

Table 13.5 shows that HHs in the three farming systems have differential pathways of development as well as show variation in climate change vulnerability. For example, CWL households have the least access to all livelihood capitals. Consequently, they opted for farm strategies that addressed their immediate needs. This group, as a result, shows the highest degree of vulnerability.

On the other hand, CD households engage in short-term adaptation caused by high dependence on depleting groundwater sources, despite having all essential livelihood capitals. CSR system HHs, in turn, with limited access to capital assets, show long-term adaptation based on their traditional knowledge and customary practices as part of their ethnic identity. The most vulnerable groups are within the CWL system and belong mainly to small farmer groups and scheduled castes (SC).

In addition, women were found to be more exposed in comparison to men to climate change effects because of the feminisation in agriculture. Notably, caste communities with strong ethnic identities and deep-rooted traditional knowledge appeared more resilient (Kuchimanchi et al., 2021b).

The study's results show that farmers take many complex decision and development pathways that are influenced by available livelihood capitals. However, despite an integrated climate change policy, the continuous drive for economic growth in dryland regions poses risks to their farming systems' climate resilience (Kuchimanchi et al., 2021b).

## 13.4 Discussion

### 13.4.1 *Policies, farming system pathways, and climate change vulnerability*

Desk review of associated policies led to an understanding that current policies tend to define farmer decision-making and their farming system choices, which, in turn, influence their vulnerability to climate change (Kuchimanchi et al., 2021b). These vulnerabilities are more pronounced in developing countries like India because policies, programmes, and subsidies are often shaped by development priorities entwined with political dynamics (United Nations, 2019; Brown et al., 2021) and do not account for or anticipate climate-related risks.

An explicit case in point relates to the government of India's budget for the financial year 2020. It planned to be able to process twice as much milk by 2025 without considering climate change forecasts, mounting water scarcity, and land degradation within India's arid and semi-arid regions (World Bank, 2012; Kumar & Kumar, 2013; IPCC, 2019a, 2019b).

The preceding provisions indicate how development policies still promote agricultural intensification as an option for livelihood improvement that can be counterproductive to natural resource management objectives, inadvertently increasing farmers' vulnerability to climate risk (Kuchimanchi et al., 2021b).

'Policy incoherence' is another challenge India faces. This incoherence stems from the need to tackle multifaceted goals to maintain the country's fast-paced economic development, leading to disjointed efforts and contradictory or unanticipated results (Weitz et al., 2014; Muscat et al., 2021; Kuchimanchi, 2022). For example, driven by support in the form of power subsidies and irrigation infrastructure, together with high market demands, smallholder farmers in dryland regions turn to unrestricted groundwater pumping and undesirable land-use changes (Shiferaw et al., 2008; Fishman et al., 2015; Sishodia et al., 2016; Duraisamy et al., 2018; Thomas & Duraisamy, 2018). So for developing countries in particular, multi-objective approaches and coordinated actions are a must to minimise unintended social and ecological consequences, manifesting as vulnerability to climate change in the long term (Kuchimanchi, 2022).

The preceding cases point to an inadvertent increase in vulnerability and risks to climate change among the less-advantaged in rural areas. The policy on climate change in India is an example of such an approach. Although there is an explicit mandate concerning climate change at central government level, interventions being implemented at state level are still aimed more at livelihood and regional economic development than climate change adaptation measures. Such mismatches in policy often make people locally vulnerable to climatic dynamics unintendedly (Gajjar et al., 2018; Singh et al., 2019; Kuchimanchi et al., 2021b).

Evidence for this was found in our study as well. Communities need critical livelihood capitals to stay resilient, such as available water resources, livestock ownership, and access to common pool resources. But these have been altered or overused or become inadequate with the progression of agricultural transitions in the region. The loss of these capitals has dragged most of the HHs in the area (mainly the CWL and CD systems) into a state of higher climate change vulnerability by not only increasing risks due to agricultural specialisation and intensification but also leading to water scarcity over time (see Kuchimanchi et al., 2021a, 2021b, 2022, 2023).

Lastly, beyond policies, programmes, and subsidies, agricultural credit and financial systems also push agricultural transitions toward intensification and specialisation. This is particularly prevalent in developing countries, as they are geared to produce food at lower costs (Benton et al., 2021; Bernards, 2021) and favour farming systems that foster agricultural intensification and commercialisation (Bernards, 2021; Ripoll-Bosch & Schoenmaker, 2021). For fragile and resource-constrained dryland regions, this is deleterious in the long term (Kuchimanchi et al., 2021a, 2021b).

### **13.4.2 Sustainable intensification of dryland environments: a proposal**

According to IPCC (2018), global warming is expected to make current agricultural systems, already under stress, even less sustainable. This means that agriculture intensification will only exacerbate land degradation, water scarcity, and food insecurity in arid and semi-arid areas (IPCC, 2019a, 2019b).

Arid environments have considerably increased globally, with Asia having the largest expansion of dryland areas (Práválie et al., 2019). For this reason, current and future policies should have mechanisms enabling better foresight and coherence and be tailored to the local context (Adam, 2014; Dubash & Jogesh, 2014; Gajjar et al., 2018; Muscat et al., 2021), to overcome current environmental and social issues (Reardon & Timmer, 2014; Bais-Moleman et al., 2019; Baldock & Buckwell, 2021; Runhaar, 2021) and ensure regular vulnerability assessments to climatic risks (Kuchimanchi, 2022). Possible directions toward sustainable agricultural intensification for addressing existing challenges and initiating a transformational approach are discussed in the next section.

#### *13.4.2.1 Using the right literature for policy formulation*

Studies by Dale and Polassy (2006) and Bowman and Zilberman (2013), among other researchers, have shown that the effects of intensive agriculture can be mitigated through proper agricultural practices. The knowledge base is strong from many studies, such as Marty (2005), Thornton et al. (2007), Nori et al. (2008); IIED (2010); Köhler-Rollefson and Mathias (2010); Notenbaert et al. (2012); Hodges et al. (2014), and Tamou et al. (2018). The literature shows how farming systems in arid and semi-arid regions have evolved and highlights the values of mobile livestock farming systems, Indigenous livestock breeds, associated ecological processes, and traditional knowledge systems of pastoralists. Similarly, there exists much literature on the biophysical characteristics of dryland ecosystems, such as the paper by Gajbhiye and Mandal (1983), the Millennium Ecosystem Assessment Board (2005), and an UNEP document (2011). Nevertheless, these materials are not adequately employed in policy or practice.

To deal with climate change risks sustainably for food production in resource-poor areas, our study suggests that appropriate strategies should be developed using the right kind of knowledge. Existing literature contains successful strategies that can be upscaled also. For instance, our study shows how traditional herders themselves have changed the CSR system into a contemporary system. Findings also brought out that this system showed a higher economic performance and greater adaptive capacity compared to the other farming systems within an ever-changing regional context. This has also made HHs in the CWL system more resilient to climate change (Kuchimanchi et al., 2021b).

This may be attributed to their deep-rooted traditional knowledge, which is well documented in pastoral systems literature which indicate that these systems are economically and ecologically more compatible with dryland regions (Nori et al., 2008; IIED, 2010; Krätli & Schareika, 2012; Notenbaert et al., 2012).

#### 13.4.2.2 *Augmenting the science–policy–practice interface*

Like other developing countries, India has several rural development endeavours supported by bilateral collaborations aimed at poverty alleviation through enhanced agrarian livelihoods. Some of these initiatives have operational frameworks with good intentions. But they also have knowledge gaps which cause implementation issues, leading to incongruous results, particularly when viewed in the context of climate change vulnerability.

Studies by Tanner et al. (2006), Sietz et al. (2011), Chowdhury et al. (2021), and Lee et al. (2022) also state that lack of transfer of knowledge in context to climate change is a major barrier to the integration of climate-resilient strategies into development programmes in developing countries.

Issues related to knowledge transfer and the integration of climate-resilient strategies can be addressed through a strong science–policy–practice interface. For instance, our water balance calculations at watershed level indicate a high surface runoff in the region, despite watershed management measures. The reason could be climate-induced changes in rainfall patterns influencing runoff timing and magnitude (Marshall & Randhir, 2008).

But a robust science–policy–practice interface can overcome such consequences by appropriate runoff-preventing measures, suitable agricultural and conservations measures, and revised engineering structures within watersheds based on advances in climate science. Such a sound interface, apart from facilitating knowledge diffusion, can also enable government institutions to achieve implementable outcomes vis-à-vis climate change processes. The same interface can also drive an impact-oriented research agenda on climate risk and foster interdisciplinarity, as argued by Kuchimanchi (2022). Similarly, the same interface could enable ‘continuous process improvement’ to improve existing monitoring and evaluation mechanisms as well as check the performance of policies or programme interventions within the short, medium, and long term (Kuchimanchi, 2022).

#### 13.4.2.3 *Building partnerships to bolster sustainable agricultural development*

A shift to sustainable food production is a time-taking transformation and will vary in agroecological and socio-economic conditions. Appropriate

public–private partnerships and suitable incentives can buffer these discrepancies. Kuchimanchi (2022) gathered a few possibilities:

- 1 Incentives and investments towards promoting low-cost, climate-compatible technology development
- 2 Repurposing subsidies that increase the adoption of sustainable practices (Bowman & Zilberman, 2013; WRI, 2021)
- 3 Region-specific agricultural commodity pricing
- 4 Developing financial and credit mechanisms to support the adoption of agroecological crop-livestock production (Harding et al., 2021; Ripoll-Bosch & Schoenmaker, 2021)
- 5 Design policies that encourage the uptake of water conservation strategies (Fishman et al., 2015; Shao & Chen, 2022; WRI, 2021)

These measures will help in the smooth transition to a sustainable production by overcoming path dependencies and ‘lock-ins’ that restrict farmer choices, as Runhaar (2021) talks about.

To sum up, Kuchimanchi (2022) argues that there is a need for strategic public–private partnerships, along with a robust science–policy–practice interface, to power sustainable transformation in food production.

#### ***13.4.3 Integrating community-driven resource management into mainstream development***

Besides such interventions, desirable changes are impossible without ‘community involvement’, which is the core of sustainable development. Accordingly, village-level institutional capacity-building must be fortified with information and techniques that are not solely focused on making farming more intensive or specialised (Jayne et al., 2014; Amjath-Babu & Kaechele, 2015; Thornton & Herrero, 2015).

Approaches and tools for community engagement, such as mentioned in Kale et al. (2022), Farm Precise (2024), and India Observatory (2024), that have not been scaled up adequately can circumvent potential conflicts of interest (Nedumaran et al., 2013) and unintended consequences because they are based on scientific evaluations. Mainstreaming such approaches and tools for community engagement can also create knowledge related to social-ecological processes, allow interactive learning, and even mobilise innovations by harnessing traditional knowledge systems for effective dryland region management (Tamou et al., 2018; Kuchimanchi, 2022).

The aspirations of farming communities motivate their activities and investments (Nandi & Nedumaran, 2021). The transitions and farm development pathways encountered in our study also appear to be oriented to community aspirations and needs. Unfortunately, intergenerational aspirations

and related agricultural investment plans are not in alignment, warranting nuanced changes (Nandi & Nedumaran, 2021; Kuchimanchi, 2022). In the context of climate action, this aspect could usher in the necessary transformation to sustainable agriculture, because populations with high ambitions often demonstrate future-oriented actions and decisions (Dalton et al., 2016; Kosec & Mo, 2017).

### 13.5 Summary and conclusion

The findings from our study bring out several insights. First, dryland (arid and semi-arid) regions have limits to the ecosystem services they can provide, with implications for food production and livelihood security. Our findings also indicate that agricultural intensification and specialisation in dryland regions do not necessarily contribute to economic growth. They eventually deplete natural resources and cause marginalisation of rural HHs. That is to say, while the intensification of agriculture in these regions does increase food production, it also pushes rural HHs toward increased vulnerability to climate change.

In developing countries, the change from subsistence farming to specialised or intensive farming is taking place at a fast pace. This means our research findings are not about an isolated incident, for such shifts have occurred in developed nations and are still occurring despite negative environmental consequences and social effects. That is why sustainable development actions for dryland regions should be taken up more decisively, as they are more sensitive to environmental fluctuations than other agroclimatic regions.

In agriculture, developments that have already strained agricultural systems in these regions are foreboding further worst-case climate change scenarios. Consequently, any further moves towards agricultural intensification will only worsen land degradation, water scarcity, and food insecurity in such areas. For such a shift to take place, changes at multiple levels are warranted. Current policies and mechanisms need to be contextualised, have enough forethought, and align with approaches that enable suitable climate-resilient, sustainable development strategies. Critical changes in outlook are required in terms of (1) enhancing collaborations between science, policy, and practice, (2) building partnerships to bolster sustainable agricultural development, and (3) integrating community-driven resource management into mainstream development. These three strategies are expected to fix several gaps discussed in this chapter, outlining a roadmap for effective climate action.

Co-creation is also an innovative approach which can facilitate advancements between hierarchies of interested parties. Such work can be done well without worrying about the usual up–down or down–up methods. It could fit into the realm of climate change or climate action because it is characterised

by adaptivity and emergence. This is because it can blend various stakeholders, including Indigenous or ethnic communities, with a strong presence in these areas. This means that co-creation can help include traditional knowledge systems, views, and hopes essential to developing inclusive and sustainable futures that are resilient to climate variations.

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# 14

## COMBATING URBAN FLOODS IN CHANGING CLIMATE

A special perspective

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and Satish Regonda*

### 14.1 Introduction

Urban floods have become the new normal in cities and towns across the world. They have socio-economic repercussions, acting as a threat to the well-being of urban dwellers. In general, the chief causative factors of urban floods for any city are extreme rainfall, insufficient drainage, and rapid and unplanned urbanisation. A recent study by Singh et al. (2023) for cities in India mentioned the same causes along with a few additional factors, such as increased imperviousness. Because of impervious surfaces, infiltration reduces. This causes increasing surface runoff, thereby posing flood situations. Moreover, changes in climate exacerbate urban flood risk.

Together, urbanisation and climate change, particularly increasing temperatures, amplify the heat in urban environments, leading to the 'heat island effect'. This, in turn, potentially changes rainfall patterns (Li et al., 2020; Fowler et al., 2021a, 2021b; Tamm et al., 2023). Rainfall events with increased intensity and decreased return period are occurring, along with changes in spatial patterns. Further, projections pertaining to future urbanisation and climate change indicate an enhanced flood risk in terms of occurrence and magnitude (Rosenzweig et al., 2018). All this is making urban regions more vulnerable to flood hazards.

According to Assessment Reports 5 and 6 (AR5 and AR6) of the Intergovernmental Panel on Climate Change (IPCC), the frequency and intensity of heavy precipitation have risen over most of the land areas (IPCC, 2023, AR6, Chapter 2). The increasing trends in recent years in extreme precipitation and runoff suggest a heightened flood risk with regional variations. Costs related to flood damage worldwide have been escalating since

the 1970s. This is partly due to the increasing exposure of people and assets. Further, human interventions have likely increased the chances of occurrence of compound extreme weather events, such as heavy precipitation and floods (IPCC, 2023, AR5, Chapter 1). This is making flood modelling, management and mitigation a more complex problem. So in the wake of increased flood risk across global cities and the increased complexity of the problem, it is important to put systematic efforts to understand urban floods and to bring about mitigation of its effects.

Stormwater management is an important urban infrastructure system in managing floods, but in Indian settings, it is either inadequate or non-existent (Gupta, 2020). For cities with an inadequate stormwater drainage system, a redesign is needed. This should be based on future rainfall estimates.

Intensity–duration–frequency (IDF) curves are the plots that are commonly used in designing stormwater drainage systems. They are the plots of rainfall intensities of different durations for different frequencies (or return periods). IDF curves can be developed using either historical rainfall or future rainfall estimates. The latter are biased, unreliable, and coarser in resolution, which limits its usage in developing IDF curves.

On the other hand, historical data-based IDF curves implicitly assume temporal stationarity (Simonovic & Peck, 2009; Jacob, 2013). This implies that the occurrence of rainfall events of a certain intensity and duration is the same for the period that the design is considered. As changes do occur in rainfall intensity and duration – that is, non-stationarity is inevitable – periodical updating of IDF curves is warranted (Agilan & Umamahesh, 2017).

The updated IDF curves will also have challenges in terms of sample size that will be used. Use of a longer period of record with good sample size may not necessarily be a future representative since changes are drastic in recent times. While the most recent, short period of record with low sample size may represent changes, it might actually bring out large rainfall intensities, rendering a stormwater system cost-ineffective.

This raises the need to explore multiple remedial measures other than stormwater systems that are (also) sustainable and cost-effective, such as low-impact development (LID) practices. These would substantially supplement the designed stormwater systems so that a city becomes flood-resilient in a warming and uncertain climate.

LID practices are structural measures that are sustainable and cost-effective for urban stormwater management (Eckart et al., 2017). They focus on mimicking the functioning of drainage systems from a pre-urbanisation period, thereby reducing urban runoff and its impacts (Lee & Heaney, 2003). Typical LID practices include rainwater harvesting systems, infiltration trenches, bioretention cells, green roofs, swales, and permeable pavements. Several studies reported a reduction in urban runoff by applying these practises (e.g. <https://www.tandfonline.com/doi/abs/10.1080/01944369908976060>;

Balades et al., 1995; Booth & Leavitt, 1999; Bean et al., 2007; Lee et al., 2012; Kumar et al., 2022; Zhao et al., 2023).

A study by Hu et al. (2017) showed a 2–17% reduction in the flood-inundated area for an urban watershed in Nanjing, China, for individual and combined LID practices in terms of rainwater harvesting systems and permeable pavements. Palla and Gnecco (2015) considered both green roofs and permeable pavements for an urban catchment in Colle Ometti, in the town of Genoa (Italy). They observed the effectiveness of the LIDs in the restoration of the natural runoff regime with a reduced peak runoff and time to peak.

Further, the Bronx River watershed in the city of New York (catchment area of 124 km<sup>2</sup>) exhibited a reduction of 41% in annual runoff volume for three LID practices, namely, i.e., rainwater harvesting, bioretention cells, and porous pavement (Zahmatkesh et al., 2015). Palanisamy et al. (2020) conducted a study on Velachery and Pallikaranai catchments of Chennai City to evaluate the effectiveness of LIDs. They found a significant 35% reduction in peak runoff for a combination of green roofs and rainwater harvesting systems. To close these examples, Bae and Lee's (2020) study highlighted the importance of two LID practices, green roof and permeable pavements, for two urbanised catchments of Seoul, South Korea, in multiple runoff aspects, particularly reduced peak flows and runoff volume. These and other LID-focused studies suggest that LID practices are an effective solution in decreasing urban runoff, mimicking a pre-urbanisation hydrologic runoff regime. Clearly, both updated IDF curves accounting for non-stationarity and LID practices as such are key in managing urban floods, including mitigation of its effects.

Keeping this in view, our study:

- 1 Analysed variability in rainfall over space and time with respect to this decade
- 2 Developed intensity–duration–frequency (IDF) curves
- 3 Provided a critique on structural measures including the region-specific implementation of LIDs and associated challenges as well as non-structural measures including the necessity of updating existing IDF curves.

## 14.2 Study area

The city of Hyderabad is administered by the Greater Hyderabad Municipal Corporation (GHMC). It is the sixth largest metropolitan city in India. The GHMC is a highly urbanised, densely populated area. It is on track to become a megacity by the next decade (UN DESA, 2018); currently, the region spans an area of 680 km<sup>2</sup>.

The GHMC region is in the tropical zone (17.258°–17.608° N and 78.208°–78.758° E (Figure 14.1a). It is characterised by a semi-arid climate

(Peel et al., 2007). The GHMC region get most of their annual rainfall from the south-west monsoon from June through September (average rainfall ~604 mm), with August as the wettest month (average rainfall ~186 mm).

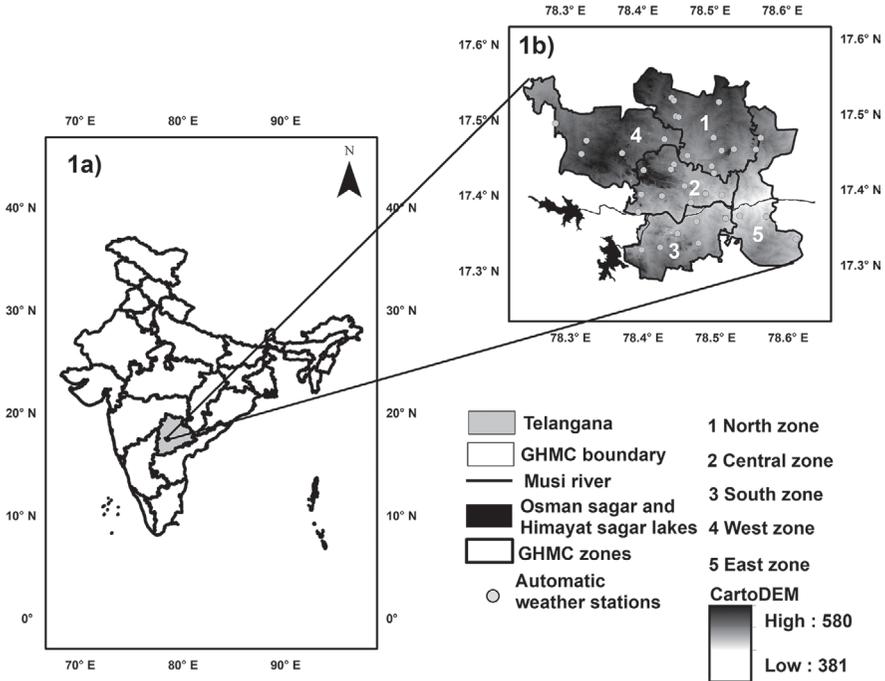
The region of the GHMC currently has 129 automatic weather stations (AWS), of which 37 were established in 2013, and the remaining 92 in 2019. The India Meteorological Department (IMD) had set up the oldest rain gauge station in Begumpet (78.45° E and 17.45° N). The station has rainfall records from 1971.

The western part of the region has isolated small hills; its elevation decreases from west to east, in general. The Musi River flows through the city from the south-west to the eastern part of the region, suggesting that the eastern region is at a lower elevation. Further, its geological features, basically granitic terrain and hard rock aquifers, make natural recharge below 10% (Sukhija et al., 1996). To compound matters, urbanisation of the region has increased imperviousness over the last two decades (Srikanth & Swain, 2022), reducing rainfall infiltration.

The first documented instance of flooding was on 28 September 1908, famously known as the Great Musi Flood. The city received a heavy downpour of 312 mm for two consecutive days. This resulted in 15,000 casualties, nearly one-quarter of the city's population at that time (Cohen, 2011). It also destroyed over 19,000 houses. Another notable flood event was the flood of 23 August 2000. The region experienced a deluge – the IMD Begumpet station recorded a heavy rainfall of 241.5 mm. The flood resulted in 24 human casualties due to drowning and collapsed houses. The most recent flood event, on 13 October 2020, was calculated to have a return period of 120 years (Rangari et al., 2021). The event recorded a heavy rainfall of 197 mm in a 24-hour period at the IMD Begumpet station. It resulted in 81 human casualties, affected 180,000 people, and caused an estimated USD 600 million in damage.

Apart from these three major events, the city experiences minor to major flooding in several locations, particularly during the monsoon season. A high spatiotemporal variability of rainfall and increased rainfall intensities over the past decade (Mohammed et al., 2022), in combination with the urban sprawl, which alters the frequency and timing of rainfall occurrences (Niyogi et al., 2020), as also climate change, make the region more and more vulnerable to floods.

In Figure 14.1, filled gray colour circles indicate automatic weather stations. Five polygons numbered from 1 to 5 correspond to five zones of the city. The black colour line and polygons represent the Musi River and the two lakes, the Osman Sagar (top polygon on left side) and Himayat Sagar lake (bottom polygon on the left side). Cartosat's digital elevation model (DEM) of 10 m spatial resolution is used to show the elevation of the region.



**FIGURE 14.1** Map of study area and Hyderabad City: (a) Location of study area and state boundaries in India. (b) Map of Greater Hyderabad Municipal Corporation for Hyderabad City.

Source: Authors.

### 14.3 Datasets

Rainfall data from the 37 AWS that have been there since 2014 are used for our study. Hourly rainfall data were put together from 9:00 a.m. of the previous day to 8:00 a.m. of the current day. This was taken as current-day rainfall from 1 January 2014 to 31 May 2019, while daily rainfall data were directly available from June 2019 to 2023. This means that the period of record (PoR) for our analysis is effectively from 2014 to 2023.

The city is divided into five administrative zones, named north, south, east, west, and central zones. The 37 AWS are densely distributed in the north (12 in 165 km<sup>2</sup>) and central (10 in 105 km<sup>2</sup>) zones, while there are fewer in the south zone (6 in 111 km<sup>2</sup>), west (5 in 163 km<sup>2</sup>), and east (4 in 128 km<sup>2</sup>). The hourly rainfall data went through quality control. The quality control criterion is detailed in Ponukumati et al. (2023).

Notably, it was considered an ‘hour’ only when the hourly rainfall data for the GHMC region were available from ten stations at least. That is to say,

when more than 25% of the 37 stations are considered. Additionally, zonal average hourly rainfall amounts were also calculated. For this, the ‘hour’ should have rainfall at half of the stations at least.

### 14.4 Methodology

Our study, apart from providing key insights into LID practices, aimed to understand the spatiotemporal variability of rainfall and develop IDF curves for the GHMC region. Accordingly, much of it was centred on the calculation of different rainfall aspects and then analysed. This would provide leads on LID practices for the mitigation of flood effects.

In this context, the following three tasks were formulated: (1) develop zone-wise spatially averaged rainfall; (2) calculate three different rainfall aspects, namely, the total number of rainfall events, the amount per rainfall event and the annual accumulated rainfall; and (3) calculate rainfall intensities for different return periods of daily rainfall amounts (Figure 14.2).

#### 14.4.1 Zone-wise rainfall estimates

Spatial rainfall interpolation schemes use gauge-based rainfall estimates over an area at finer resolution. We used these estimates to calculate the average rainfall for a catchment or administrative area.

The GHMC region was divided into grids of 0.01° resolution, and then inverse distance weighting (IDW), a well-known spatial interpolation technique (Shepard, 1968), was employed to estimate rainfall. Grids covering the entire GHMC region as well as the five administrative zones were identified.

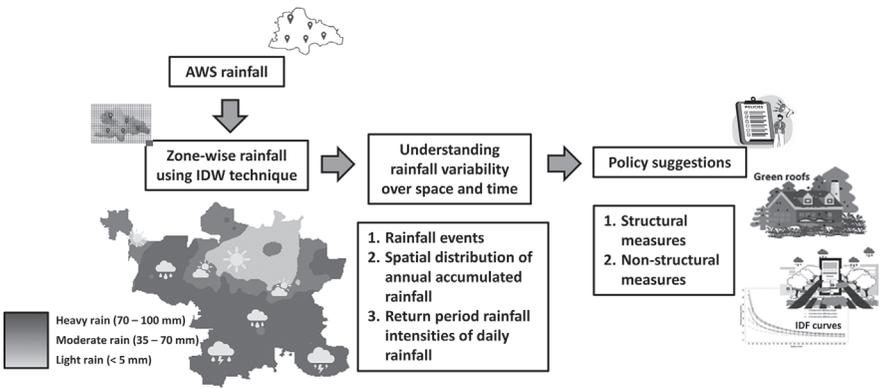


FIGURE 14.2 Methodology to understand zone-wise rainfall and space–time rainfall variability to provide policy suggestions.

Source: Authors.

With corresponding IDW-based grid rainfall estimates in proportion to their coverage, GHMC or zone-wise areal average rainfall estimates were calculated.

#### **14.4.2 Rainfall aspects**

A rainfall event corresponds to a rainy situation, when rain has occurred continuously or with a few breaks over a period, and accumulated rainfall in that period is termed as event rainfall. Event rainfall, being non-zero, will have information in it. So it is used in understanding the climatological aspects of rainfall for a region. But the identification of a rainfall event is difficult because of its intermittency, which causes its discontinuity. This raises the question whether to consider it a new rainfall event, when it rains again after a break, or still as part of the previous event. Recording time intervals of the rain also plays a role.

To simplify the problem, we considered spatially averaged, daily rainfall with a threshold of 10 mm as part of this criterion. In the case of zones, we calculated the zonal average rainfall, and in the case of GHMC, the GHMC average rainfall. With this criterion, the number of events for the entire GHMC as well as for all five zones were calculated and analysed. For each of these events, GHMC and zone-specific event rainfall were calculated. In sum, we analysed the three aspects, total number of rainfall events, event rainfall, and annual rainfall (simple sum of daily rainfall amounts in a year), considering space, using GHMC and zone-specific values as well as time on an annual scale.

#### **14.4.3 Rainfall intensities for different return periods**

One important element of the stormwater management system is design runoff, which is usually associated with a return period and determines the system's life. The design runoff is estimated using rainfall intensity, so rainfall intensity for a chosen or set of return periods needed to be calculated.

IDF curves can be utilised to calculate rainfall intensities for rainfall of any duration and set of return periods. Calculations of the IDF curves involve frequency analysis, which can be empirical or theoretical. In both cases, the length of data plays an important role. Short sample size-based IDF curves are associated with higher uncertainties so the results need to be interpreted with some degree of caution.

The IDF curves can be developed for different durations, but for our study we chose a 24-hour duration, because rain of a good intensity that only lasts for several hours (i.e., not even a day) causes floods in cities already. The IDF curve for sub-daily duration is good, but the lack of an hourly rainfall for the entire period of the record limits the calculations.

The annual maximum daily rainfall was calculated for all 10 years from 2014 to 2023, and then an extreme value type 1 (EVT1) distribution was fitted (Chow et al., 1988). Such a distribution requires three parameters: mean (location), standard deviation (scale), and the Gumbel frequency factor, which is a function of the return period.

The intensity for rainfall of a specific duration and return period is calculated as follows:

$$z = \sigma K + \bar{z} \quad (14.1)$$

$$K = -\frac{\sqrt{6}}{\pi}(\gamma + \log_e(\log_e T_M - \log_e(T_M - 1))) \quad (14.2)$$

where  $z$  is the rainfall intensity for the chosen return period,  $\sigma$  and  $\bar{z}$  are the standard deviation and mean of annual maximum rainfall intensity series, respectively.  $K$  is the frequency factor, and  $T_M$  is the chosen return period. A value of 0.5772 is considered for  $\gamma$ .

Overall, our study presents a methodology that consists of an analysis of rainfall attributes followed by structural and non-structural measures to mitigate urban flooding. As part of structural measures, LID practices were reviewed, while the necessity of updating the IDF curves is mentioned as part of non-structural measures.

## 14.5 Results

### 14.5.1 Spatiotemporal variability of rainfall

#### 14.5.1.1 Temporal distribution of rainfall event – relevant aspects

Two rainfall aspects – the total number of events and event rainfall – were plotted for the GHMC and its administrative zones, separately, for a period of 10 years (Figure 14.3).

The total number of rainfall events shows interannual variability, but the number of events does not differ significantly across the zones and the GHMC region as such. The number of events for the first half of the PoR – from 2014 to 2018 – is relatively small compared to the remaining half of the PoR, from 2019 to 2023. Both years 2014 and 2018 experienced a deficit rainfall (TGDPS, 2024). They were designated as drought years (Ramakrishna et al., 2017), explaining the lowest event count. In contrast, 2016 and 2017 received higher than average monsoon rainfall and consequently saw a rise in event count.

It is to be noted that 2018 had a deficit rainfall, although a few events of large rainfall were observed in the central and western zones (Figures 14.3b and 3e). Owing to a strong positive phase of the Indian Ocean Dipole (Ratna

et al., 2021) in 2019, the region received high rainfall, which is reflected in a high count of rainfall events. The four remaining years, 2020 to 2023, were years with excess rainfall compared to the average monsoon rainfall. Consequently, the events count was relatively higher, with 2020 having the highest count. Overall, a rising trend in event count was observed across all zones and in the GHMC as a whole (Figure 14.3).

In Figure 14.3, the boxplot of event rainfall indicates a year-to-year variability with increasing rainfall amounts, although the increase is not as strong as seen with the event count. While 2019 appears to have received a relatively high rainfall compared to preceding years (Figure 14.3a), the same pattern is not observed across all zones. This could indicate a clear spatial variability across the study region. While the central zone does not show any pattern (Figure 14.3b), the higher rainfall amount is clear for the northern zone (Figure 14.3c).

Here are two more observations from the boxplots:

- 1 The year 2018 presents a unique situation with a low event count compared to 2014 and 2015 but corresponding rainfall amounts are high for the Central, South, and West zones.
- 2 The highest value for all zones is observed in 2020; it corresponds to the rainfall amount of 14 October 2020.

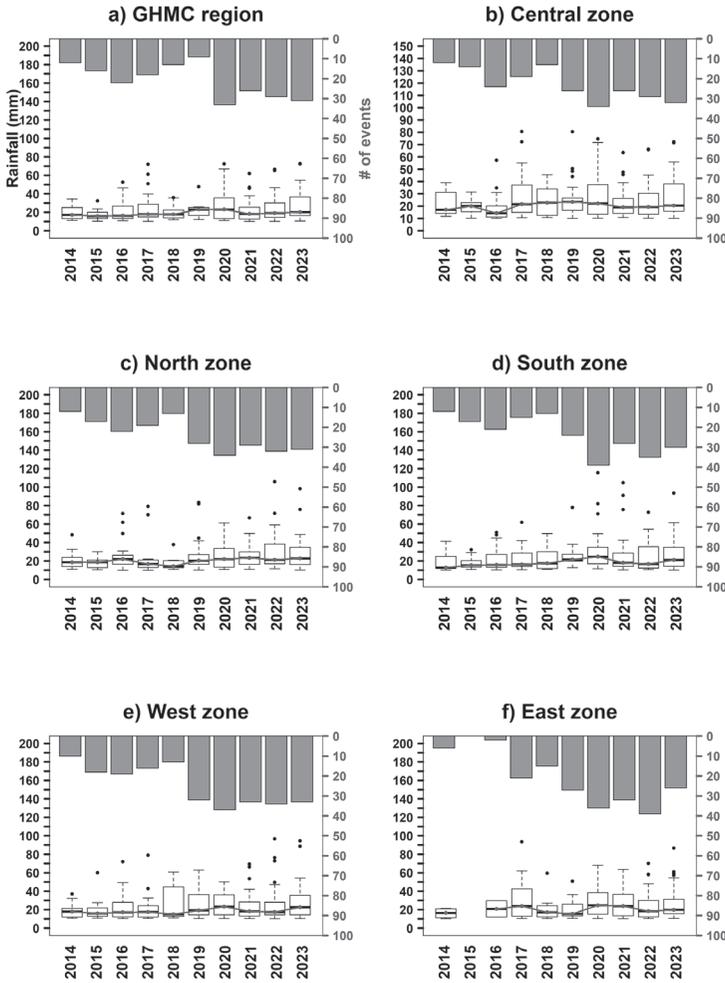
In summary, both plots – event count and boxplot of rainfall amount – indicate two significant patterns pre- and post-2019 across the two attributes, in addition to spatial variability across the zones.

#### 14.5.1.2 Spatial distribution of annual rainfall

*Annual rainfall*, the sum of daily rainfall in a year, was computed for each AWS of the study region. Then an inverse distance weighting method was applied to obtain spatially interpolated plots of rainfall (Figure 14.4).

The plots suggest both spatial variability of rainfall in any given year and interannual variability. In agreement with the findings in Figure 14.3, the mean areal rainfall amounts suggest that 2014 has the lowest rainfall amount, followed by 2018, 2017, and 2015, while 2016 received around 100 mm of rainfall more than 2015 did. The remaining years of the PoR showed relatively high rainfall amounts, with 2020 recording the highest rainfall, followed by 2022, 2023, 2021, and 2019.

Interestingly, the interannual variability in rainfall turned out to be relatively higher than the spatial variability of rainfall for any given year. The years with the lowest mean areal rainfall, 2014 and 2018, had a few regions with scant rainfall (<100 mm). On the other hand, 2018 had a few locations with high rainfall (>500 mm). In 2017, the year with the third lowest mean



**FIGURE 14.3** Year-wise distribution of rainfall and event-specific rainfall across zones: (a) Year-wise distribution of total number of rainfall events for the GHMC region across 2014–2023 (brown colour) and corresponding event-specific rainfall amounts (blue colour). (b) Similar to panel ‘a’, but for the central zone. (c) Similar to panel ‘a’, but for north zone. (d) Similar to panel ‘a’, but for south zone. (e) Similar to panel ‘a’, but for west zone. (f) Similar to panel ‘a’, but for the east zone.

Source: Authors.

Note: The X-axis corresponds to the years; the primary Y-axis represents the event-specific rainfall amounts, and the secondary Y-axis the total number of events.

areal rainfall, there was relatively high spatial variability with the north-central region recording the highest annual rainfall (~900 mm) and a few pockets in other parts of the region with less rainfall (~200 mm or less). The year 2015, with the fourth lowest rainfall, appeared to have a similar spatial rainfall distribution as 2017, with the north-central region receiving high rainfall compared to other pockets of the region.

Nonetheless, spatial variability turned out to be relatively low, generally speaking. That is to say, the annual rainfall for 2015 varied approximately from 0 to 660 mm, while in 2017, amounts varied approximately from 0 to 950 mm. Notably, the annual rainfall for the Telangana state was lower than the climatological value by ~20% for both 2014 and 2015, while the deficit for 2018 was approximately <10% (Figure 14.4) (TGDPS, 2024).

Both Telangana and the study region of the GHMC are broadly in agreement in terms of years with less rainfall. Yet the order of years with less rainfall is not the same because of spatial variability in the state's rainfall; also, rainfall in the GHMC region is not representative of the entire state.

The years with relatively large annual areal rainfall amounts exhibited no consistent specific pattern. The central region of the GHMC received decent rainfall in all these years, but the regions with the highest rainfall amount varied with each year were the southern region in 2020, a few isolated pockets in 2021, the northern region in 2022, and the north-eastern region in 2023.

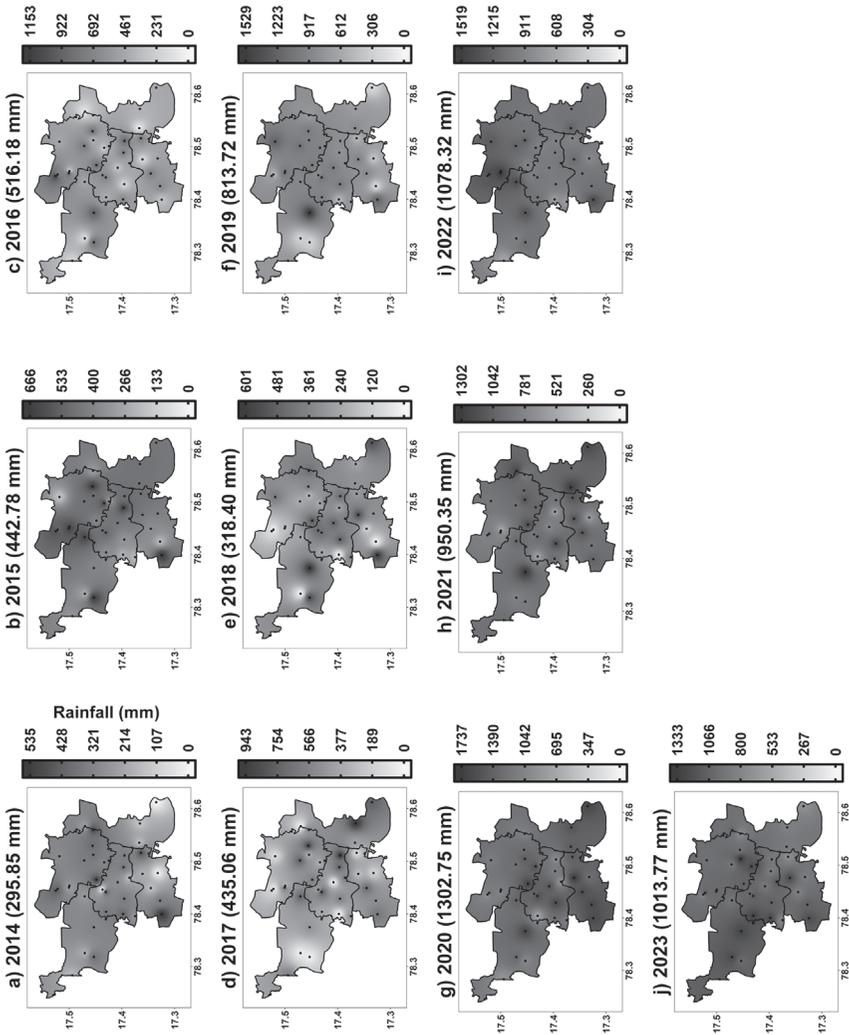
As was seen in previous sections, rainfall in the region had both spatial and temporal variability for the total number of events, the event rainfall amount, and annual rainfall amounts. While similar observations can be drawn for other rainfall aspects, the time series of the annual maximum daily rainfall indicates variability on both time and space scales (Figure 14.5).

In particular, the GHMC region exhibited steadily increasing values over the period of recording with similar values in the recent years except for 2020. A different pattern was observed in other zones, particularly the maximum daily rainfall values varied in recent years.

The plots suggest the following: The east zone recorded the lowest maximum daily rainfall and large variability across the years, the west zone showed moderate maximum daily rainfall with low variability, while the central zone gave values of low magnitude on the average with less variability. Both the northern and southern zones recorded the highest annual maximum rainfall values with a large variability (Figure 14.5).

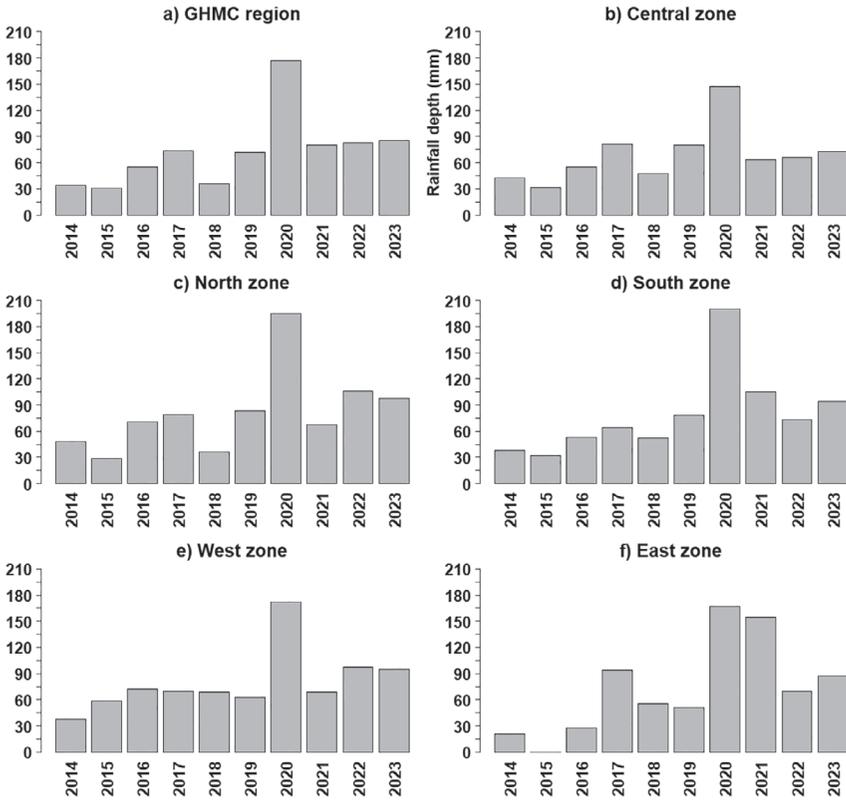
The observed interannual variability in annual maximum daily rainfall suggests changes in the likelihood of maximum daily rainfall amounts every year. This necessitated the calculation of maximum daily rainfall intensities for different return periods so that relevant information for drainage design could be obtained.

As these changes were observed for different regions of the study, the calculations of rainfall intensities and return periods were done for each



**FIGURE 14.4** Spatial distribution of annual rainfall from 2014 to 2023: (a) Spatial distribution of annual rainfall for 2014 (annual mean rainfall included in brackets). (b) Similar to panel ‘a’, but for 2015. (c) Similar to panel ‘a’, but for 2016. (d) Similar to panel ‘a’, but for 2017. (e) Similar to panel ‘a’, but for 2018 (f) Similar to panel ‘a’, but for 2019. (g) Similar to panel ‘a’, but for 2020. (h) Similar to panel ‘a’, but for 2021. (i) Similar to panel ‘a’, but for 2022. (j) Similar to panel ‘a’, but for 2023

Source: Authors.



**FIGURE 14.5** Annual maximum rainfall for GHMC region + zones: (a) The annual maximum daily rainfall values plotted for the GHMC region, where the X-axis represents the year and the Y-axis shows the annual maximum daily rainfall values. (b) Same as panel ‘a’ but for the central zone; (c) Same as panel ‘a’, but for the north zone. (d) Same as panel ‘a’, but for the south zone. (e) Same as panel ‘a’, but for the west zone. (f) Same as panel ‘a’, but for the east zone. Note that rainfall data in the east zone for 2015 are absent due to data quality issues.

Source: Authors.

region separately. Return periods of urban drainage range from 6 months to 100 years, depending on the type of infrastructure and its associated risk (CPHEEO, 2019). In our study, considering the fact that we have a small sample size, return periods ranging from 2 to 25 years were taken into account.

Broadly, the plots of rainfall intensity and return period suggest three different patterns, along with increasing rainfall intensities with increase in return periods (Figure 14.6). Maximum rainfall intensity values depend on both the absolute magnitude of the annual maximum daily rainfall and its variability (see equation 14.1).

Relatively speaking, lower rainfall intensities were seen for the central zone. This may be attributed to the region’s lower maximum daily rainfall values on average and their low variability (see Figure 14.5).

Compared to the remaining zones, the rainfall intensities for the western zone are of high magnitude for the smaller return periods. But they became less with an increase in the return period, showing similar values as for the GHMC period. This may be because of a combination of relatively large mean annual maximum rainfall values and low variability of maximum daily rainfall values of the western zone (see again Figure 14.5).

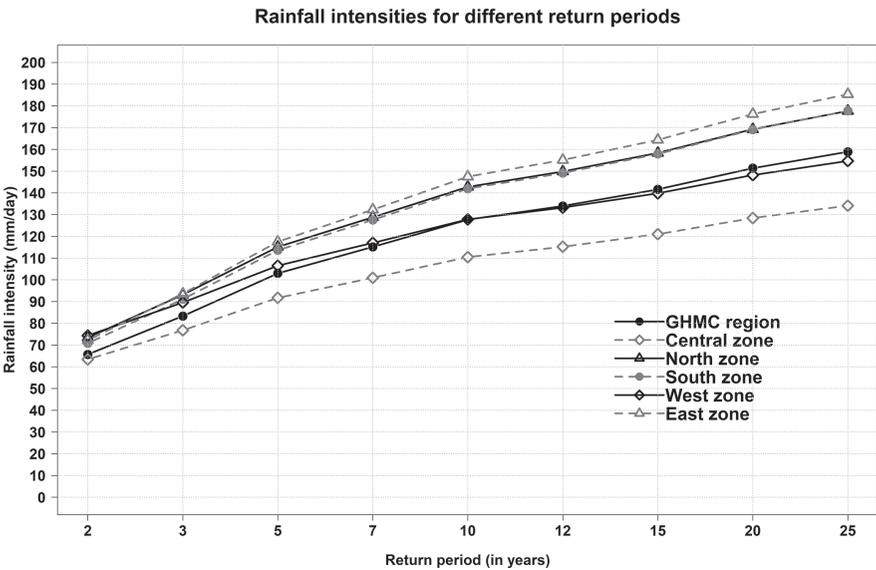


FIGURE 14.6 Rainfall intensities.

Source: Authors.

Note: The figure presents intensity–frequency curves for the annual maximum daily rainfall for the GHMC region as such and its five zones. The X-axis represents the return period in years, and the Y-axis corresponds to the rainfall intensity.

Further, the north, south, and east zones appeared to have similar rainfall intensities, with the east zone having relatively higher rainfall intensities at larger return periods (>10 years). Increasing values with two high values in successive years in recent times imply greatly variable annual maximum rainfall values for the east zone. This explains the highest rainfall intensities for this zone among all zones.

#### 14.5.2 *Structural and non-structural measures*

Both structural measures, which involve choosing an LID (or more) and its (or their) implementation, and non-structural measures, which involve the development of IDF curves for the design of drainage systems, have their own difficulties. The IDF curves correspond to a simple quantitative representation of the variability of maximum rainfall observed for different possible durations at a specific location. A major problem with IDF curves is accounting for the uncertainty associated with intensity estimates due to limited available data and their spatial and temporal resolution.

Further, changes in land use and land cover leading to different rainfall patterns pose challenges. Rainfall estimates based on a single or a few locations are not representative of the region because of spatial variability in the rainfall. As a consequence, the estimation of uncertainties accounting from limited spatial resolution needs to get attention.

Developing a single IDF curve based on mean areal rainfall estimates may not be informative from an urban storm design system aspect for the entire region. So we suggest the development of multiple IDF curves from stations in the selected region.

Another difficulty is the availability of rainfall data at necessary temporal resolutions. In the GHMC region, on average, rain comes down for around 6 hours. This means data at hourly or sub-hourly intervals should be recorded. But currently, data are recorded at an hourly scale, while it is easily accessible only at daily scale, facilitating calculations at a daily timescale. It may be noted here that calculations on coarser time resolution may not be effective because they may cause inadequate operation of drainage systems. Besides, some studies suggest intensification of short-duration rainfall extremes (Fowler et al., 2021a, 2021b; Yan et al., 2024). This development makes it imperative to design systems in such a way that they can withstand this type of extremes.

To overcome the problem of coarse resolution data, the use of satellite-based rainfall estimates may be explored. Satellite estimates of different temporal resolutions have their own limitations, though. For example, they may show a relatively higher information content on the daily scale compared to the hourly scale (Tang et al., 2020; Moazami & Najafi, 2021; Ponukumati et al., 2023).

These types of limitations prevent its wide application with room for research to improve satellite rainfall estimates for the urban relevant applications (Zhang et al., 2024). Additionally, disaggregation techniques, such as the Bartlett–Lewis rectangular pulses disaggregation (Rodríguez-Iturbe et al., 1988), the IMD 1/3 technique (Palaka et al., 2016), or machine learning-based methods (Chen et al., 2024), may be used to downscale daily rainfall to hourly, but they all require data at finer resolutions to develop robust models with validation.

While increased rain gauge density and data at finer resolutions may overcome apparent challenges, it may result in other problems, such as noise removal and information extraction. As a consequence, efforts to generate reliable IDF curves accounting for uncertainty in rainfall estimates and better representing region spatial temporal variability should be continuing.

The implementation of LID practices has its own problems, and it may not be possible to consider all available practices (Section 1). Dynamically changing urban environments with their haphazard development offer little or no room for the implementation of these practices. This is a limiting factor that necessitates innovative practices.

For example, replacing existing pavements with permeable pavements has financial and resource challenges. So such pavements are now placed only in newly constructed parking lots and driveways (Martin-Mikle et al., 2015). This highlights the fact that the implementation of LID practices requires efforts from hydrologists, urban planners, and various other stakeholders combined (Zhang & Chui, 2018).

Further, it is important to note that factors such as the spatiotemporal variability of rainfall, complexity of urban land use, topography, soil permeability, and groundwater conditions all have a role in the selection of LID practices.

There are two more challenging factors in the selection of an LID and its implementation: the study region is in the Deccan plateau that has rocky terrain, and the exponential rate of urbanisation that has brought a drastic increase in impervious surface (Srikanth & Swain, 2022). In this context, the application of green roofs appears to be an obvious choice because it increases rainfall interception. This, in turn, reduces the available rainfall for runoff. But green roofs should be irrigated periodically, and rainfall is seasonal in nature. This puts stress on water demand, causing groundwater supplies to dwindle.

Alternatively, rainwater harvesting, a cost-effective LID, may be preferred for regions that receive large rainfall and do not have a hard bedrock. Since the north and west zones of the city are at a higher elevation (see Figure 14.1b) and the region's steep terrain reduces rainwater travel time, it is essential to minimise the rain reaching the surface to minimise potential runoff issues. In this context, a blue roof, which is a kind of water reservoir roof (Shafique & Kim, 2017), is preferred.

This category of LID practices that can catch rain and store it as water is appropriate for the central zone too. For it is an already existing residential and commercial area for which major structural modifications are tough to make.

The southern and eastern zones are relatively at a lower elevation. Floods in these areas have occurred due to Musi River overflow and lake breaches. This was specifically evident in the Saroornagar area during the floods of 13 and 14 October 2020 (Vaddiraju & Talari, 2023).

For such regions, interconnected detention ponds are a good alternative to reduce flood runoff and peak flows, as well as to increase infiltration. This will also help in groundwater recharge as a result.

Finally, it is important to realise that the city of Hyderabad is known for many tanks and their connectivity. Reviving its tanks and nalas and integrating them into a decision support system that allows monitoring, regulating, and releasing water in the tanks is a unique solution for this city to become a flood-resilient ‘smart city’.

#### 14.6 Summary and conclusions

Urban floods are on the rise due to human intervention and climate change, necessitating immediate action to understand evolving weather and climate patterns as well as to develop mitigation strategies to combat floods and their effects. In this context, our study had made an effort to understand the spatiotemporal variability of rainfall in the Greater Hyderabad Municipal Corporation region.

Three different rainfall attributes – the event count, event rainfall, and annual rainfall – were calculated and analysed in terms of space and time. Considering the spatiotemporal variability of rainfall, we looked at rainfall intensities for multiple return periods, for different zones, and for the GHMC region as a whole.

Intensity–duration–frequency (IDF) curves were developed for a rainfall duration of 24 hours to aid the design of urban drainage systems. From the standpoint of policy, we reviewed a combination of structural and non-structural measures. Structural measures refer to the selection of LIDs as well as the difficulties in their implementation. Non-structural measures consist of calculations relevant to IDF curves and understanding the uncertainties affecting the accuracy and robustness of these curves.

The key conclusions are as follows:

- 1 Analysis of three rainfall attributes suggested the existence of two patterns, pre- (2014–2019) and post-2019 (2020–2023), with increased rainfall amounts in recent years. We observed a rising trend in the event count over the years. But we would point out that since the data are small in size, sampling relevant uncertainties could be a problem.

- 2 We also observed distinct spatial patterns of annual rainfall across all years, with the central zone receiving a good amount of rainfall in all this time with minimal variability. Additionally, we found that interannual variability in rainfall was relatively high compared to its spatial variability for any given year.
- 3 Three different intensity–return period patterns became evident across the zones. The central zone, with relatively lower rainfall intensities, formed one pattern, while the overall GHMC and the west zone, along with the other three zones, formed two separate groups, both with high rainfall intensities for large return periods. Variability in the annual maximum series of daily rainfall and higher rainfall intensities in the last four years were major factors for these variations across the zones.

To understand the threat of urban floods that anthropogenic activities and climate change have brought about, the focus must shift to a combination of structural and non-structural measures, in addition to understanding rainfall patterns at urban scale. A study by Vemula et al. (2019) found that RCPs 2.6, 4.5, 6.0, and 8.5 predicted a future extreme rainfall for the 2088, 2098, 2040, and 2068 as 693 mm, 431 mm, 282 mm, and 564 mm, respectively. A simulated runoff via a stormwater management model suggested that future extreme rainfall in Hyderabad may result in an increased runoff volume, causing flooding. Such findings emphasise devising action plans for mitigation and adaptation.

As part of mitigation measures, LID practices are promoted to minimise overland flow and inflow into traditional stormwater drainage systems. Understanding the challenges related to the selection of LIDs, we suggest to have a well-defined LID design standards. Their implementation should be prioritised via public awareness programmes.

With the evidence of high variability of rainfall in the region, it is essential to reconstruct the existing IDF curves incorporating high-resolution rainfall data at sub-hourly scales. Also, to develop an ensemble of IDF curves by employing ground-based measurements and satellite-based estimates. But considering the ever-changing nature of rainfall patterns, relying solely on historical data is insufficient. So to account for the uncertainty associated with rainfall estimates due to small sample size and low rain gauge density, a factor of safety needs to be applied to the IDF curves.

Designing stormwater drains on safety-based IDF curves will aid in better informed decision-making. Additionally, mapping of drainage networks and their periodic cleaning during monsoon and prior seasons are crucial for flood management.

In addition to mitigation, a city needs an information system that assists in various activities ranging from data collection and analysis to flood mitigation. To establish such a system, efforts should be made towards a holistic

understanding of floods. This would include studying flood history, assessing the drivers of flooding, and a modelling approach suitable for data-scarce regions.

Lastly, in conjunction with developing datasets and technologies, it is important to have a strong connection among stakeholders, decision-makers, engineers, and scientists so that the gaps can be addressed. Given future unpredictable weather patterns and continuing urbanisation, all aforementioned segments of society must share responsibility and work together to build a city that is climate- and flood-resilient, so one may proudly claim, ‘My city is a flood-resilient city’.

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## **PART 4**

# International collaboration and advocacy



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# 15

## CLIMATE ACTION

Linking international negotiation,  
Indian policy, and local community  
with focus on the Sundarbans

*Jayanta Basu*

### 15.1 Introduction

This chapter analyses the milestones and dynamics of international climate negotiation and their link with India's climate policy. It also examines how linked issues and developments embrace climate actions within local communities, both at the planning and the implementation levels.

The focus is on the Sundarbans in the state of West Bengal, India, off the Bay of Bengal, because it is considered a hotbed of global climate change.

The analysis looks at all three aspects, independently and in tandem, to understand the holistic qualitative and quantitative outputs of ground-level climate actions and how robust and adequate they are in combating the greatest existential crisis of modern times.

It will also bring to the fore that increasing awareness and discourse regarding all three aspects vis-à-vis undertaking climate action having hardly turned into action on the ground so far. Also that there have been yawning gaps within science-based emissions cut needs and implementation.

### 15.2 Methodology

Data and information for the first two aspects – international negotiation and Indian policy – were gathered from secondary sources. These consisted mainly of peer-reviewed and official reports and communiqués published by the United Nations or its subsidiary organisations and the Government of India, as well as various other research organisations, by adopting both vertical and horizontal approach to neutralise any bias in understanding and analysis.

Further, media reports from credible sources were consulted to assess the range of related perspectives. These reports included some of my own. As a frontline environmental journalist and columnist, I have regularly covered international climate summits and followed global climate negotiations since 2009. Lastly, oral submissions from key stakeholders have also been used. I had documented these over the last decade or more while discharging my professional responsibility.

### 15.3 Key issues: status and dynamics

#### 15.3.1 *International*

Since the early 20th century, the climate change agenda has evolved dramatically from a largely esoteric study linked to theoretical scientific discourse to a climate emergency, arguably the greatest existential crisis of modern times. Climate change has now become more prominent than general environmental agendas. Nevertheless, it may be argued that, despite its imminent threat vis-à-vis long-term global security, climate change has not yet been adequately mainstreamed in the overall environmental discourse.

India's climate performance vis-à-vis the environment may be a case in point. According to Burck et al. (2024), India was one of the top-notch countries, seventh globally, with respect to undertaking climate action but was found to be the poorest globally in terms of environmental performance, as reported in the Environment Performance Index Report 2022 (Wolf et al., 2022).

According to Hirst (2020), the first international summit on the environment held in Stockholm, Sweden, in 1972 mentioned climate change only in its footnote. The subject was then viewed predominantly as a concern of the scientific community and not as a critical political agenda. Only in the late 1980s was a section of global leaders and scientists emphasised that climate change was a much bigger issue than had been considered earlier.

#### 15.3.2 *The establishment and evolution of climate action frameworks: from IPCC to UNFCCC*

As a continuation of the evolving thought process, an international agreement was inked between the World Meteorological Organisation (WMO) and the United Nations Environment Programme (UNEP) in 1988 to establish a mechanism of intergovernmental assessment of the scientific process, impacts, and response patterns linked to climate change. Consequently, the Intergovernmental Panel on Climate Change (IPCC) was set up to undertake this responsibility. Between 1988 and 2024, the IPCC published six detailed assessment reports (ARs) that considered key direct inputs into the political

decision-making process and public movement, albeit, indirectly, vis-à-vis undertaking appropriate climate action.

While the role of the IPCC in facilitating appropriate global climate action has to be acknowledged at governance and societal levels, critics often find it too cautious and politically compromised. Once in 1990, the IPCC came out with its first assessment report (AR-1), highlighting that ‘emissions resulting from human activities are substantially increasing the atmospheric concentration of greenhouse gases’. The global call for an international treaty on climate change became stronger. It was supported by political leaders, including Mrs Margaret Thatcher, the then prime minister of the UK.

The UN stepped in as a follow-up to the IPCC reports; the UN General Assembly launched the UN Framework Convention on Climate Change (UNFCCC). It was adopted on 9 May 1992 and placed in the UN Conference on Environmental Development (Earth Summit) in Rio de Janeiro, Brazil, about a month later (Azam, 2021). The UNFCCC is the first global agreement on climate change signed by 197 countries. Its primary objective is stabilising greenhouse gas concentration in the atmosphere at a level that would prevent interference of dangerous, anthropogenic activities with the global climate system.

The treaty acknowledges the reality of human-induced climate change and divided countries into three main groups based on different sets of commitments. Industrialised countries, listed as Annex-I parties, were given the major responsibility of controlling the rising global emissions, considering their historic role in the process. Global climate negotiations began in 1995, formally christened as COP (Conference of the Parties), in Berlin, Germany. The UNFCCC focused on the principle of ‘common but differentiated responsibilities in countering climate change’, with the block of developed countries mandated to take the lead (Bushey & Jinnah, 2010).

### **15.3.3 Outcomes, compromises, and diversions**

Between 1995 and 2023, 28 editions of the Conference of the Parties (COP) have taken place. This was an annual event, except for 2020, when the Covid-19 pandemic led to the cancellation of the COP, then to be held in Glasgow, UK. While deliberations and decisions taken at all COP meetings are important in the context of the overall goal of combating climate change, few COPs stood out for their landmark outcomes.

In COP 3 in Kyoto, Japan, a unanimous decision called the Kyoto Protocol was adopted on 11 December 1997, but it took over seven years to enter into force formally on 16 February 2005. There were 192 parties to this agreement. The protocol mandated a 5.2% emissions reduction on an average compared to 1990 levels over five years, 2008–2012. The first commitment period involved Annex-I parties (developed and industrialised countries). It extended in the Doha COP in 2012, from 2013 up to 2020 (UNFCCC, 2019).

Despite being the first legally binding treaty on climate change, the Kyoto Protocol has clearly failed to stem the flow of global emissions. According to Bassetti (2022), in 2012, the year after the first commitment period ended, global emissions had risen by 44% compared to 1997 levels instead of having been reduced by 5.2% as mandated. The fact that the United States, the largest greenhouse gas-emitting country when Kyoto was inked, never ratified it and later withdrew from the process also hindered its success.

#### ***15.3.4 Climate negotiations and agreements: from Copenhagen's challenges to Paris's breakthrough and beyond***

COP 15, held in Copenhagen, Denmark, proved to be a negotiation failure despite having been initiated with high hopes thanks to the presence of most global leaders. The Copenhagen Accord was not accepted as a multilateral outcome by the UNFCCC. There was stiff opposition from several developing and least developed countries who did not agree with the narrative stitched by developed countries together with a section of emerging economies and developing countries. The Copenhagen document was criticised as imperfect, hastily done, politically engineered, and non-transparent. Developed countries led by the United States had committed funding for developing and least developed and vulnerable countries to the tune of \$30 billion in aggregate during 2010–2012. It had been scaled up to \$100 billion a year by 2020, but this committed amount was never fully realised, in fact, according to schedule.

During COP 17 at Durban in 2011, a new emission cut regime was initiated. All countries agreed to a 2015 timeline, a schedule set to be executed in 2020. This looked like a crucial step, but in hindsight, the general belief is that global action against climate change has received a severe pushback due to the shift of the emission cut mandate by half a decade. In COP 18 at Doha, apart from a Kyoto Protocol extension, decisions were made to assist developing countries suffering from 'loss and damage' resulting from climate change. A work programme was decided under the Durban Platform (Khor, 2013).

The Paris conference in 2015, COP 21, was a watershed moment in global climate negotiation because 196 countries unanimously agreed to a legally binding international treaty on climate change. This, for the first time, had brought all nations together to combat climate change and adapt to its effects. Interestingly, its ratification took much less time than for the Kyoto Protocol, less than a year now (12 December 2015 to 4 November 2016) compared to seven years then. This underlines a heightened global political commitment to take action against climate change. The overall goal of the Paris Agreement was to arrest global average temperature increase to 'well below 2°C above pre-industrial levels' and continue efforts 'to limit the temperature

increase to 1.5°C above pre-industrial levels'. The agreement also mentioned the need to shift to a zero-carbon economy in the coming years. This became a formal goal at the 2023 Dubai COP.

Nevertheless, the Paris Agreement had its share of flaws and ambiguities. On the one hand, it highlighted the need for more ambitious actions to cut emissions. On the other, it did not force developed countries to cut emissions fast enough – leave aside developing economies. Moreover, it left decisions on key issues to the future, be it to ramp up national pledges to cut emissions or increase financial support to help affected countries.

The agreement also diluted the obligations of developed countries by underplaying their historical responsibilities in pushing up global emissions. It also proposed removing compensation and liability aspects from the loss and damage negotiation process (Basu, 2023a).

During COP 26 in Glasgow and COP 27 at Sharm El Sheikh, Egypt, several key points emerged. Net-zero emission status came into the fore, with several major countries announcing net-zero targets: the United States and the UK by 2050, China by 2060, and India by 2070. But they remained predominantly aspirational targets, without any legal obligation, and stood decoupled from the reality of emission cuts required to keep global temperature rise within 1.5°C. According to UN reports, an estimated 43% emission cut is required by 2030, compared to 2019, to this effect. The United Nations Environment Programme 'Emission Gap' report shows that countries are still far off the target (UNEP, 2023b).

A key outcome of COP 27 was the acceptance of an independent loss and damage finance facility. This had been a long-term demand of the Global South, especially the least developed and vulnerable countries, as well as civil society. The developed countries rallied to tag loss and damage with the adaptation (Basu, 2023b). Incidentally, Gurung et al. (2023) claimed that climate-induced losses and damages are unavoidable and will increase further vis-à-vis the current regime of climate mitigation efforts; they further observed that even in more optimistic scenarios, it is well established that the most vulnerable communities, disproportionately affected by the impact of climate change, would have to face the brunt of those losses and damages.

COP 28 in Dubai at the end of 2023 was another negotiation landmark: A historical decision was taken to do away completely with a fossil fuel-driven economy from 2050, along with other key decisions especially related to energy use (Basu, 2023c; Darby et al., 2024a, 2024b).

These included thus:

- Tripling of the global renewable energy capacity and doubling of the global average annual rate of energy efficiency improvements by 2030
- Accelerating efforts to phase down unabated utilisation of coal power
- Utilising zero- and low-carbon fuels by the mid-21st century

- Transitioning away from fossil fuels and undertaking an accelerated mode of action during the present decade to achieve net-zero by 2050
- Accelerating zero- and low-emission technologies like renewable and nuclear technologies, and removing technologies such as carbon capture and low-carbon hydrogen production
- Accelerating efforts to reduce non-carbon dioxide emissions substantially, in particular methane, by 2030
- Accelerating the reduction of emissions from road transport through the development of infrastructure and rapid deployment of zero- and low-emission vehicles
- Phasing out inefficient fossil fuel subsidies which do not address energy poverty or just transitions
- Recognising the facilitating role of transitional fuels in energy transition while ensuring energy security
- Urgent, incremental, transformational, and country-driven adaptation action based on national circumstances

The Conference also decided to call for a high-level dialogue at the ministerial level on scaling up adaptation finance. It also recognised international efforts addressing loss and damage (Basu, 2023a, 2023b; Nevitt, 2023).

Cléménçon (2023) argued that three decades of international climate negotiation had not prevented the world from warming up more than 1°C compared to the pre-industrial period. The expert claimed that multilateral climate diplomacy has failed to drive adequate climate action. Several climate experts share the view, but the majority still consider that multilateral climate negotiation, encouraged by the UNFCCC process, remains key to achieving the desired global climate action, despite its limited effectiveness so far.

### ***15.3.5 Climate movement turned horizontal and vertical***

Though climate-related civil society movements had started already in some form earlier, they intensified after the Copenhagen Summit in 2009. It underscored how developed countries were adamantly clinging on to vested, narrow interests, notwithstanding the concerns from the scientific community expressed in an AR 4 report about possible climate change effects. The movement has intensified since the Paris Agreement (Solomon et al., 2007).

It is felt that one of the seeds of the burgeoning civil society-driven climate movement was the forced exit of a large section of civil society representatives from the Copenhagen COP Summit venue, Bella Center, in 2009. This was a decision said to have been taken for the security of top-level country heads. Several mayors from frontline global cities who were at the conference as ‘observers’ and part of a civil society group at the conference also had to suffer the ignominy of an inglorious exit.

In 2010, the first World Congress on Cities and Adaptation to Climate Change was organised at Bonn. At that time, sub-national leaders emphasised their frontline roles in climate combat and demanded recognition (Basu, 2010) and North–South cooperation (Beermann, 2017).

Over the years, the sub-national movement has grown stronger and has become part now of the formal UNFCCC negotiation process. It even received a prominent mention in the Paris Agreement. The civil society movement, initially spearheaded by well-known global nonprofits and networks like WWF, Action Aid, Climate Action Network, and Greenpeace since Paris, got a major fillip in 2018–2019 to a youth climate movement. This movement, driven by Greta Thunberg, the young activist from Sweden, has taken centre stage since (Leung, 2020).

### 15.3.6 Carbon space hijacked and equity issues compromised

The inequity in climate action is clear and embraces the negotiation process. Figures bear this out, as shown in Table 15.1. An unpublished document in India’s negotiation package of 2010 underscores this inequity. The document, updated till 2009, shows that the United States, with a per capita carbon emission of 18.8 t, had a 28.4% global sky share against a fair share of 4.6%, a huge 23.8% more than the equity obligates. The per capita emission figure of the United States has marginally reduced since then, at 14.44 t/person in 2022 (Tiseo, 2023), but the pattern remains the same. The respective statistics for most developed countries show similar trends.

On the contrary, India, with a per capita carbon footprint of 1.3 t in 2009, only held 2.6% of the sky share instead of a deserving share of 17.4%, as per the report. India’s per capita carbon footprint has only increased by 1.89 t.

The figures point out that, if arresting the global temperature rise at the 2°C benchmark is the target, then less than one-third of the total air space

**TABLE 15.1** Historic emission profile of key countries (1850–2009)

<i>Country</i>	<i>1850–2009 actual sky share, %</i>	<i>1850–2009 fair sky share, %</i>	<i>Per capita emission 2009, tCO<sub>2</sub>e/person</i>
USA	28.4	4.6	18.8
China	9.8	20.0	6.0
Russia	7.9	2.1	11.9
Germany	6.7	1.2	10.1
UK	5.6	1.0	8.9
Japan	3.9	1.9	10.0
France	2.7	1.0	6.0
India	2.6	17.4	1.3

*Source:* Indian negotiation document (unpublished).

of 3,000 Gt is presently available to accept emission. If the target is 1.5°, the remaining air space gets further diminished to around one-fourth.

Notably, while the developing and least developed countries demand a large chunk of this remaining air space, developed countries show no intention to minimise their emissions. This has led to a political standoff within the developed, developing, and least developed world. More so, developed countries demand that emerging economies like China and India reduce their gross emission levels, since they currently contribute significantly to the global carbon release.

It is felt that emerging economies have partially played into the hands of developed countries by agreeing to the Paris Agreement in its present avatar, for it has largely obliterated the developed countries' historical responsibility in shooting up global emissions. Several analysts feel India made a mistake in Copenhagen by drifting away from the G70 group of countries and forming the BASIC group alongside China, allowing the developed countries to bracket the two together. It is beside the point that there have been, and are, huge differences between the two countries regarding qualitative and quantitative carbon footprint.

### ***15.3.7 Developed countries dictate discourse and derail continuity***

A close look at the negotiation pattern at global climate summits over the years shows that often developed countries or country groups drop a new negotiation agenda at a COP. In this way, they are pushing the discourse over the following couple of days over a certain issue, because developing as well as least developed countries, caught slightly off guard, take time to respond adequately. In the process, key pending issues of negotiation are put on the back burner and continuity of negotiation gets derailed.

The examples are many. For instance, the Durban Action Plan during COP 17 in 2011 (Fuhr et al., 2011) proposed that all countries should bear the responsibility of emission cuts from 2020 onward. This has changed the dynamics of negotiation since then. Then there was the raking up of the old carbon market versus new carbon market discord at the Madrid climate summit in 2019 (Basu, 2019). Not to forget propping up the net-zero agenda in 2021 at Glasgow (Basu, 2021). Experts have subsequently argued that the market-based provisions tend to provide limited opportunities to hold countries accountable for their respective actions vis-à-vis protecting and enhancing adaptive capacity (Campbell-Durufié, 2019). As a matter of fact, it was pointed out that before the beginning of COP 26 in Glasgow, a report released by the Intergovernmental Panel on Climate Change (IPCC) was referred as 'code red for humanity' by the UN Secretary-General; that had set the tone for the COP deliberations despite the pandemic casting a shadow on its success and expectations (Jaiswal, 2021).

The trend, though, seems to have been re-positioned during recent COPs. The start of COP 27 at Sharm El Sheikh saw developing and least developed countries demanding action on loss and damage to be included in the formal negotiation, which was not on the agenda to begin with. In the bargain, they were able to force a formal UN acceptance of a loss and damage finance facility, after a prolonged negotiation process (Basu, 2022). It has been pointed out that although COP 27, organised in Sharm el-Sheikh, had made history by agreeing to establish a fund to address loss and damage caused by climate change, the summit did little to limit the occurrence of loss and damage on ground by containing the enormous extent of climate change (Obergassel et al., 2022).

### 15.3.8 *International funding*

Watson et al. (2024) pointed out that although developed countries had pledged financial support of USD 30 billion between 2010 and 2012 at the 2009 Copenhagen conference, it has largely remained unrealised. Moreover, there have been question marks with developing countries about the structure and pattern of funding. On the other hand, civil society representatives are often accused of double-accusing limited, elated financial support accorded by developed countries (Noel, 2023). The Paris Agreement (UNFCCC, 2015) reiterated that developed countries must take the initiative to mobilise and provide climate finance. The linked COP set a new collective, quantified goal by 2025, scaling up from the earlier-agreed amount.

Developing countries have long been arguing for financial support to address climate-inflicted loss and damage issues already occurring in their countries and for UNFCCC to accept it as the third climate finance pillar beyond adaptation and mitigation (Uri et al., 2024). In response, at COP 27, parties agreed to establish a loss and damage fund (LDF) facility, and its broad operational modalities were approved at COP 28 in Dubai (Basu, 2023a). As a matter of fact, not only withstanding the loss and damage, but also overall there is a raging debate on whether global climate talks are actually an effective mechanism for pushing the change, with several negotiation trackers claiming that these conferences are ‘all talk and no action’, but a section of experts claimed that still COPs can help influence global response and accelerate things in the right direction (Ozdemir et al., 2023).

An interesting collateral development is that the parties are undertaking the pledge to climate-linked funding outside the ambit of the official UNFCCC process. At the Dubai climate summit, several such key pledges were inked – 11 to be exact – to the tune of USD 85 billion collectively (Darby et al., 2024a, 2024b).

Our analysis indicates a global trend of climate funding that is highly biased towards mitigation, apparently buoyed by the market dynamics of a

higher rate of interest (ROI) from the mitigation sector (Adhikari & Safaee Chalkasra, 2023). Interestingly, the latest Adaptation Gap Report of the United Nations Environment Programme (UNEP, 2023a) also highlighted that adaptation finance needs 10 to 18 times more money than the current international public finance available (Basu, 2023a, 2023b).

#### 15.4 National: India at high risk

According to a study by the World Meteorological Organization 2020, India has already lost USD 87 billion (more than INR 6 lakh crore) due to climate-induced events, such as heat waves, tropical cyclones, and floods (Pandey, 2021). A ranking by HSBC identified the country as the most climatically vulnerable country (Nova, 2022).

The Global Climate Risk Index 2021, prepared by the non-profit Germanwatch, pointed out that India was in the seventh position in overall ‘climate vulnerability’ in 2019 according to a global benchmark. It had the third worst ranking in average climate-linked fatalities and second worst in average economic losses over two decades, from 2000 to 2019 (Eckstein et al., 2021).

##### 15.4.1 Policy and practice

The Indian government launched its national climate action plan (NAPCC) in 2008 to mitigate and adapt to the adverse effects of climate change (Press Information Bureau, 2021). Eight missions were set up to achieve the dual objectives of fulfilling India’s developmental needs and reducing its economy’s emission intensity.

The missions correspond to sectors identified under the NAPCC, viz., (1) National Solar Mission, (2) National Mission for Enhanced Energy Efficiency, (3) National Mission on Sustainable Habitat, (4) National Water Mission, (5) National Mission for Sustaining the Himalayan Ecosystem, (6) Green India Mission, (7) National Mission for Sustainable Agriculture, and (8) National Mission on Strategic Knowledge for Climate Change.

According to analysts, apart from the National Solar Mission, the government has implemented nothing substantial on other missions so far. Also, it has not reverberated much in related Indian policy discourse (Kumar & Naik, 2019). In 2015, India published its nationally determined contributions (NDCs) leading to the Paris COP. At that juncture, key targets included increasing the cumulative electric power installed capacity from non-fossil sources to 40% and reducing the emissions intensity of the GDP by 33–35% compared to 2005 levels by 2030. Data shows that these targets were overachieved (Raghunandan, 2019). For example, India’s carbon emissions had already reduced by 24% by 2016 compared to 2005 levels.

Subsequently, India revised its NDC in 2022 with new targets in alignment with the prime minister's *Panchamrit* announcements at COP 26 in Glasgow (Kumar, 2022). The updated nationally determined contributions bring out several major commitments. First, India aims to reduce the intensity of emissions in its GDP by 45% by 2030. Second, the country targets about 50% of its cumulative electric power installed capacity from non-fossil-fuel-based energy resources also by 2030. Additionally, India is advocating for a 'Lifestyle for Environment' (LiFE) initiative. More specifically, the targets are to raise the non-fossil-fuel-based energy capacity of the country to 500 GW by 2030. Also to reduce the total of projected carbon emissions by 1 Gt (billion tonnes) between 2021 and 2030. And finally, to achieve net-zero emission status by 2070 (Ministry of Environment, Forest and Climate Change, 2022).

#### 15.4.2 Carbon sink

Since 2015, India has declared several policies and initiatives, like the Green India Mission and the green highways policy, financial incentives for forests, plantations along rivers, and other steps, to increase its forest and tree cover. Nevertheless, the policies have contributed minimally at ground level, as India's total forest and tree cover, 24.16% in 2015, had barely increased to 24.62% by 2021.

The government has made several commitments, including restoring 26 Mha of deforested and degraded land ('Bonn Challenge') and sequestering an additional 2.5–3 Gt of CO<sub>2</sub> by 2030. Yet a commensurate budgetary allocation has been absent till date (Dagar & Gupta, 2022).

#### 15.4.3 State-level dialogue

Managing the environment as well as climate change is the responsibility of both the union and state governments. They are considered to be in the Concurrent List of the Constitution, given they are not listed in either the union government or the state government list. This means a cohesive and coordinated dialogue-based action is required involving both levels of government. Yet no such effort has been seriously pursued over the years, apart from the central government asking states to prepare state climate action plans. Notably, such plans had been made earlier already, but nothing substantial had been achieved through them. Preparations for fresh plans are underway.

#### 15.4.4 India's energy status

*Coal.* India's policy of continuing with coal has fetched international criticism on various platforms. On their part, the government has repeatedly pointed out that continuing with coal is a developmental priority for the

country. So despite such international criticism, it recently even announced promotion of the coal sector. According to a PIB Delhi publication of 3 May 2023, the Coal Ministry had proposed a 2023–2024 action plan targeting a 1,012 Mt coal production and allocation of 25 new mines for commercial mining for that financial year, as a policy under the *Atma Nirvor Bharat* (Press Information Bureau, 2023).

*Projected energy demand in India.* It is stated that India, with its population growing rapidly at a rate of 1.58%, is facing energy shortages, rising energy prices, and energy insecurity. An Expert Committee on Integrated Energy Policy projected that, by 2032, the country's primary commercial energy requirements will leapfrog four to five times compared to current levels. Electricity generation capacity will need to increase by 5.6 to 7 times, and oil requirements will rise by 3 to 6 (Kumar et al., 2010).

### 15.5 Climate risks in the Sundarbans – a case study

The Sundarbans delta is a transboundary, contiguous landscape of over 19,000 km<sup>2</sup>. It is split almost equally between Bangladesh and West Bengal, India. In its entirety, it is the largest mangrove delta in the world. It is the only forested mangrove tiger habitat in the world, spread over 10,260 km<sup>2</sup> (WWF-India, 2011). Though the Sundarbans hardly contribute to the global cauldron of greenhouse gases, they are among the worst sufferers at the global benchmark. The following statistics illustrate their position.

The Bay of Bengal region had been affected by 41 severe cyclonic storms and 21 cyclonic storms in May between 1891 and 2018, according to the Union Ministry of Earth Sciences (Government of India, 2022). A study of WWF India shows that for four decades leading up to 2009, the net loss of land in the Indian Sundarbans had been 210 km<sup>2</sup>, an area bigger than the city of Kolkata (WWF-India, 2011).

Forced migration is very high in the region, since at least 60–70% of the families have at least one member working outside the Sundarbans. They are driven by the shrinkage of traditional livelihood opportunities, like agriculture and fishery, mainly due to the effect of climate change and a lack of other opportunities (Garg et al., 2021; Hajra & Ghosh, 2018).

The Sundarbans have a unique vulnerability because they are affected by multiple drivers of climate change. Those often work in tandem and maximise the effect (Mondal et al., 2022). The sea level rise of the area is one of the highest in the world – about 8 mm per year against a global average of 3.1 mm. This rise is also the highest in the country, as stated by the Government of India in Parliament (Basu, 2014). Experts point out that the deltaic coast of the Sundarbans is vulnerable to erosion, sediment surface reactivation, flooding, overwash dynamics, shoreline retreat, and habitat destruction both at the sea-facing areas and as well as along the mouths of tidal rivers and estuaries (Paul & Paul, 2022).

According to a World Bank study (2015), the direction of cyclones has been shifting recently towards the West Bengal and Orissa coast in North-East India. This is particularly so in the Sundarbans area, which will make it even more disaster-prone in the not-too-distant future. The IMD has already stated that 24 South Parganas, which houses two-thirds of the Indian Sundarbans, is India's most cyclone-affected district (Government of India, 2022).

### *15.5.1 International negotiation vis-à-vis the Sundarbans*

In 2010, civil society groups from India and Bangladesh, spearheaded by the non-profit Environment Governed Integrated Organisation (EnGIO), organised a meeting in Kolkata focusing on the need for transboundary cooperation to conserve the Sundarbans. This was particularly relevant in the face of the changing climate. The meeting took place in the presence of central environment ministers from both countries, apart from other experts from the government of West Bengal. In follow-up, Bangladesh and India signed a memorandum of understanding (MoU) in 2011 on various issues to pave the way for joint actions concerning the Sundarbans, including its climate vulnerability (World Bank, 2015). The association expanded in 2016 when the prime ministers of both countries met in Dhaka (World Bank, 2019).

Since then, civil society engagement to push climate-related actions in the Sundarbans has continued with active support from the World Bank and other frontline organisations. The Bangladesh–India Sundarbans Region Cooperation Initiative (BISRCI) was formed, involving several organisations. Indian and Bangladeshi environment ministers met on the Sundarbans at the sidelines of the Paris COP (Basu, 2015). During 2019–2020, EnGIO prepared a strategy with ORF and Third Pole for a Joint Media Platform to push awareness and advocacy regarding the transboundary Sundarbans, with support from the World Bank (World Bank, 2019).

### *15.5.2 The Sundarbans global linkage to loss and damage*

'Loss and damage' refers to climate impacts already incurred by a community or a region. They include economic and non-economic as well as immediate and long-term losses. With a history of receiving such losses over decades, despite hardly contributing to the increasing carbon emission, the Sundarbans are an apt candidate for support in this regard.

Various factors contribute to making the Sundarbans claim for international support stronger, financial and otherwise, particularly under the recently created loss and damage fund. For one, over and above the critical current status of climate drivers, there is a prediction of heightened damages as spelt out in several international publications, including the

IPCC AR 6 report. Also, poverty is high in the area, with low resilience as a result. Although this matter has come up in UN transitional committee meetings, there has been little official movement so far, either from union or state government. Through civil society representations led by the Climate Action Network South Asia (CANSA), EnGIO has been working on the agenda.

A comparison with vulnerable island countries illustrates the heightened climate-linked risk of the Sundarbans (Tables 15.2 and 15.3).

**TABLE 15.2** Highly climate-vulnerable island countries and the Sundarbans

<i>Islands</i>	<i>Population</i>	<i>Population density per km<sup>2</sup></i>	<i>Annual per capita income, in 100,000</i>	<i>Sea level rise, in mm</i>	<i>Threat, natural calamities</i>
Marshall	52,634	291	2.39	7	HC, El Niño, flood, drought, CC
Kiribati	102,351	126	3.7	3.9	HC, El Niño, flood, CC
Tuvalu	9,876	380	2.56	5	1969–2010: 33 tropical cyclones, flooding, erosion, saltwater intrusion into groundwater, CC
Tonga	105,323	141	2.92	6	Last 40 years: 71 tropical cyclones, El Niño, CC
Micronesia	103,549	1,47.5	2.01	10	Tropical cyclone, sea level rise, CC
Cook Islands	10,900	46	6	4	Last 41 years: 47 tropical cyclone, SLR, CC
Maldives	345,023	1,150	4.4	2.9	Tropical cyclone
Antigua and Barbuda	89,985	204	8.8	3.1	Tropical cyclone, hurricane, earthquake, tsunami, CC
Saint Kitts and Nevis	54,191	207	9.33	3.1	Tropical cyclone, hurricanes, earthquake, tsunami
Sundarbans	4.5 million	812	0.12	8 (actually 12)	Tropical cyclone, erosion, SLR, mangrove destruction, biodiversity loss

*Source:* IPCC reports and Government of West Bengal reports.

**TABLE 15.3** Climate vulnerability prediction of the Sundarbans

<i>Parameter</i>	<i>Scenario</i>	<i>Baseline</i>	<i>2021–2040</i>	<i>2041–2060</i>	<i>2081–2100</i>	<i>Value</i>	<i>Baseline</i>	<i>2021–2040</i>	<i>2041–2060</i>	<i>2081–2100</i>
Mean temp. (Celsius)	8.5	1850–1900	0.9	1.8	4.1	30.4	1995–2014	0.5	1.4	3.6
Maximum temp. (Celsius)	8.5	1850–1900	0.5	1.7	4.2	45.8	1995–2014	0.2	1.4	3.9
Days with TX above 35°C	8.5	1850–1900	3.7	12.4	49.2	69.7	1995–2014	2.3	11	47.8
Sea level rise (mm)	8.5	1850–1900					1995–2014	0.1	0.2	0.6
Total % rainfall	8.5	1850–1900	2.40	5.20	18.10	4.2 mm/day	1995–2014	1.10	3.90	16.70
Maximum 1-day rainfall (%)	8.5	1850–1900	9.30	17.20	46.10	128.9 mm	1995–2014	6.20	13.90	42.0

*Source:* IPCC AR 6 report.

## 15.6 Challenges and opportunities in global and regional climate negotiations

Several key findings and discussion points have emerged from the assessment.

Global negotiation has been largely slow-paced and shows little forward movement in general, particularly since COP 21. Moreover, there is not enough continuity in thought and decision-making from one COP agreement to another. An example of such interrupted continuity of thought processes is the finance restructuring proposed in COP 27 that has hardly been taken forward in COP 28. This trend was bolstered by a significant COVID spread in 2020–2022 and a spate of international wars from 2022 onward. It has largely hampered achieving climate justice for vulnerable countries.

Global agreements search for low-hanging, soft solutions and long-term timelines. Examples are setting net-zero targets with little emphasis on the institutional process and setting scientific, evidence-driven, realistic, aggressive, immediate, and intermediate targets. There is more focus on market-driven mitigation actions and far less on adaptation and its finance, despite the huge, documented gap in adaptation. Moreover, institutionally, linking the latter with the loss and damage phenomenon is necessary but not really pursued.

While the quantity of financial support on the ground from industrialised countries to developing and less developed vulnerable countries remains a sticky issue since 2009, there have also been little efforts in UN declarations to make the process transparent.

Many feel that the financial discourse needs to be more layered and transparent with respect to the source of funding, public or private, and type of funding, grant or loan, bilateral or multilateral. Also, modalities for the calculation of funding and prevention of double accounting are to be made clear. All this to put an end to the long-drawn controversies on climate funding, which seems to be a mesh by design.

While climate action-related discussions at UN platforms, such as the COP, remain critical in the global discourse, having more engagements at bilateral and multilateral levels (outside the UNFCCC) is equally important. It also seems appropriate that the climate discourse is linked with other, multilateral discourses, whether at the International Monetary Fund or the World Trade Organization.

Yet it must also be acknowledged that the trend has built up some momentum in recent times: A recent India-led G20 discourse and earlier G7 meeting had deliberated climate change. Still, there have been little efforts to integrate it with global political and economic processes. ‘Pledges’ made at COPs that were and are outside the UNFCCC process need to be followed up to achieve realisation.

A region- and city-related climate action discourse needs to be promoted more. Often, the country-centric discourse fails to reflect and accommodate

the heterogeneity of intra-national regions with regard to climate risk. The process was initiated quite some time ago and gathered steam to an extent, but it needs an institutional push to become more relevant. Less than required follow-up institutional frameworks are currently in place to build up on the positives of recently achieved negotiation outcomes, such as the operationalisation of the loss and damage fund facility, fossil fuel discontinuation, and achieving global net-zero status by 2050.

In this context, it may be argued that the net-zero targets must be converted from wishful announcements to legally binding commitments, like the 'nationally determined contributions' (NDCs) of various countries, with intermediate timelines.

India's international negotiation policy on climate change often seems to be in contradiction and reflects a lack of continuity. Moreover, it has not done enough to facilitate the forging of a South Asian conglomerate to speak in unison about climate change impacts on the region, billed as one of the most vulnerable parts of the world.

The country has done reasonably well in climate action performance at a global benchmark, as exemplified by its 'Panchamrit' commitments at the Glasgow COP and their subsequent conversion into NDCs, despite its continuing dependence on coal. It has also provided solar leadership globally by taking a key role in forming the International Solar Alliance along with France in 2015. But its domestic climate policy and implementation require far more strengthening, considering the high climate vulnerability of several areas within the country. If one looks closely at the performance of its national climate action plan, one can see two sides: It has done quite well on solar energy, but not enough on other agendas under the plan.

Further, data indicate that climate actions undertaken over the last decade, or in the pipeline, at community level in India in general and the Sundarbans in particular are greatly inadequate. Especially in the context of the large-scale vulnerability of the region, even in context to the global benchmark.

State-level climate action plans are largely the compilation of sector plans and lack adequate connection. There have been little efforts to embed local vulnerabilities within the global process. This delays, if not denies, climate justice to hapless and frequently climate-affected populations, like in the Sundarbans. Political understanding of the climate vulnerability in India, and the need to set in motion climate action, is extremely poor, also for vulnerable regions like the Sundarbans. As a result, quite expectedly, it does not influence institutional climate action on the ground positively.

## 15.7 Summary and conclusions

The overall findings clearly underline a gap in global climate negotiation, both quantitatively and qualitatively speaking. They also point out an interplay of

vested narrow and often commercial interests, upsetting a process that came into motion at the Paris Agreement in 2015. The process needs to be more transparent and based on science and evidence. As for India, the country needs to shrug off its internal confusion about its actual positioning and posturing in the context of global negotiation and assume a leadership role in the Global South by not allowing regional political differences to cloud the process. The Sundarbans, extremely vulnerable even at global benchmark, should be showcased globally to draw attention to how a poor region that virtually contributes nothing to the global cauldron of climate change is getting affected by a series of high-intensity, immediate, and gradual climatic events. The country should also explore how fiscal, technical, and other support systems, both global and national, may be brought in to address the situation and undertake disaster risk reduction in the area. Once that is done, the Sundarbans model may be replicated globally.

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# 16

## EQUITY, CLIMATE RESILIENCE, SUSTAINABLE DEVELOPMENT

### Bundling for social well-being

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#### 16.1 Context setting: three pillars

The attainment of societal well-being is high on agendas that rationalise action on climate change, sustainable development, and equity. How do we pursue social well-being without compromising the three pillars of development, equity, and climate resilience?

In terms of grounded realities, reducing air, soil, and water pollution and waste management have to move necessarily in synchronisation with providing adequate nutrition and healthy diets as much as reducing morbidity and mortality of vulnerable communities from extreme events. The solution is to bundle planning and implementation for these three pillars and sequence strategies to achieve societal well-being. This is not a wish list but a necessity for social and political stability transformation.

The role of wealth creation is important. History shows that large gains in human well-being have been made possible through economic growth, especially in enabling demographic and health transitions. The effects of climate change and the adverse fallouts of reaching tipping points in nature, such as biodiversity loss, have driven home the point that wealth accumulation has to include the creation and accumulation of natural capital as well as social and human capital. Examples abound. Nations have moved towards accepting that human health can be significantly advanced through the adoption of a nuanced ‘one health’ approach, integrating human, animal, and environmental health (WHO, 2023).

Post-Covid-19, the paradoxical experiences with cleaner air and water co-existing with various humanitarian crises caused by the loss of livelihoods in cities brought home the stark realities of the lack of choices and the presence

of co-costs and co-benefits of most real-world actions (Dasgupta & Srikanth, 2021a, 2021b; UN Network, 2022).

The realisation of the synergies in action on any two pillars has progressed substantially in recent decades, especially in meeting developmental goals and climate mitigation. An example often cited is that of providing solar energy in an energy-deficient setting, where it is a means of providing both energy security and an alternative to fossil fuel-based greenhouse gas (GHG) emissions.

In developing country contexts, one may not assume that the third pillar, equity, is automatically served. Evidence suggests that the net effect hinges on many factors around situational inequities. On the one hand, ensuring access to modern energy is a key stimulus to reducing inequalities, as incorporated under Sustainable Development Goal 6, for instance; on the other, in terms of implementation, outcomes vary widely.

Inequities can worsen due to energy prices and access issues, non-climate factors can lower the positive environmental effects of shifting to renewables, and inequalities can push up overall energy demands and resource allocation requirements for specific policies and programmes to ensure distributive and procedural justice (Markkanen & Anger Kraavi, 2019; Taconet et al., 2020; Millward-Hopkins, 2022). The key point is to bring in equity, bundling it with sustainable development and climate action, to serve the cause of social progress and well-being, thereby reducing costs from climate action.

Evidence makes clear that an economic system prioritising conventional development first, with its pollution consequences to be tackled later on, is as problematic as an ecological framing prioritising provisioning services over the regulatory services of nature and biodiversity. The difficulty lies in the availability of context-specific solutions where prioritising nature and its conservation can also deliver at the pace and scale required to meet the immediate needs of human societies in low- and middle-income countries.

There is no implementable model for the future where climate action alone can deliver sustainable development. Several international assessments from bodies, such as the IPCC and the IPBES, have helped put together evidence and toolkits with regard to operationalising the links between the two systems.

But challenges remain in replicating, upscaling, and developing context-specific applications to address vulnerabilities. We advocate in this chapter that in low- and middle-income contexts, social and economic progress hinges critically on how well sustainable development, equity, and climate action are bundled together, from planning to implementation. Most importantly, the outcomes of policies, action plans, strategies, and deliverables must be rigorously assessed regarding achievements considering all three pillars combined.

The agriculture sector provides an interesting case study when we examine the relevance of equity concerns in this context. The sector is at the forefront of facing the risks of significant losses from climatic variability and climate change. These could range from slow-onset events, such as salinity intrusion on farmlands due to groundwater withdrawals and rising sea levels, to extreme events, such as droughts and floods (Thornton et al., 2009; Anita et al., 2010; Antón et al., 2013; Van Pham et al., 2024).

Planned adaptation options are increasingly being implemented to reduce risks of losses. These options could be in the form of cultivation of drought-resistant varieties and insurance schemes to cope with damages (Linnerooth-Bayer & Mechler, 2006; Tirado & Cotter, 2010; Swain, 2014).

In this context, we conducted an empirical analysis with six equity-oriented variables categorised under three domains: policy, risk management, and resilience capacity. The goal was to examine evidence from available data on the relationship between sustainable development, climate action, and equity.

This chapter is organised as follows. Section 2 focuses on key aspects of operationalising equity, with particular emphasis on using integrative approaches and applying the principles of justice to pursue outcomes that facilitate climate resilience and social well-being. Section 3 describes the variables, data, and computations for an empirical analysis to illustrate links between vulnerability and climate change and developmental goals for the agricultural sector. Section 4 presents the findings from the empirical analysis and maps the potential for achieving Sustainable Development Goals with selected equity indicators. Section 5 concludes with a discussion of the opportunities to further an equity-led future, where bundling delivers on sustainable development and climate resilience.

## 16.2 Engaging beyond the obvious: ‘actioning’ equity

### 16.2.1 *Public policy and actors*

*Public policy* is the overarching enabler for incorporating equity and justice. It refers to all those actions and drivers of action that enable the state, society, businesses, and the individual to act towards market correction in the economy and social progress in society (Klinsky & Winkler, 2014; Prakash et al., 2024).

For too long, public policy on the environment was about the state imposing penalties, levying taxes, or providing subsidies in what should actually be seen as a command-and-control framing. While this could still be the mainstay of a policy prescription, increasingly, public policy has become about what it enables actors outside the government to do. This is a key factor for the way ahead in making equity ‘actionable’ (Mossalanejad, 2011).

Advancing equity within climate action and sustainable development can be promoted by engaging actors and institutions that have conventionally been well accepted by society as important for advancing equity in society, such as the health and education sectors. The roles of these sectors can extend well beyond the conventional ways in which they have been understood.

The healthcare sector, for instance, has mostly focused on coping or adaptation as far as the environment is concerned (Dasgupta, 2016). But if this sector can be encouraged to move to renewable sources of energy and water conservation, it would mean 24/7 power and water supplies for hospitals, clinics, and health centres, as well as for OTs and OPDs. This would, of course, be for the comfort and convenience of patients, practitioners, and caregivers alike, ensuring both efficiency and cost-effectiveness. Some states have already taken such progressive measures.

Similarly, reducing waste and pollution, encouraging green infrastructure and blue and green spaces for mental health and well-being, promoting diversified and nutritious diets, and including traditional cultural practices beneficial for well-being need to be actively supported by stakeholders across such sectors.

In addition, the health and education sectors have a very important role in promoting healthy and sustainable lifestyles and advancing sustainable development. This means stakeholders in these sectors have an important role in advancing equity – in terms of distribution, procedure, and recognition. They should hence be included in discussions related to climate action and human development.

Recognising that both economic and ecological systems are linked encourages interdisciplinary and integrated approaches. These bring together implementors, knowledge generators, and policymakers.

### ***16.2.2 Integration in decision-making***

Spatiotemporal variations, the heterogeneity of developmental gaps, and cultural diversity characterise a large economy (Minkov, 2011; Brelsford et al., 2017). The ask from the solution space will no doubt be varied. Equity can provide the overarching principle for integrative approaches to close developmental gaps (Pouw & Gupta, 2017) while respecting context as cascading.

The spillover effects of climatic events can be felt well beyond local boundaries. A single drought and heat event at one location can lead to heat stress among farm workers elsewhere, reduce crop yields (Siebert et al., 2014), affect the physical and mental well-being of workers, bring down labour productivity (Gupta & Somanathan, 2022), reduce household incomes, and increase food prices (Hill & Porter, 2017). These local effects can cascade

at scale to have global effects through trade and international prices (Dasgupta & Sharma, 2024).

Then, solutions may not come from one sector or from an entrenched value system, for the latter continues only to prioritise the accumulation of wealth in a conventional development paradigm; rather, a paradigm change that prioritises equity in terms of access, affordability, and availability to the most vulnerable could bring about the right coping strategies. These could include correctly valuing and pricing drought-resilient products; promoting appropriate farming practices and water conservation technologies, as well as energy efficiency in agriculture; investing in value chains; allowing private actors through contract farming with adequate safeguards; encouraging insurance; and contributing food security measures – to name some priority approaches.

Change is complex and challenging, and there is inertia to change. Equity can be a motivating factor in effecting change before tipping points are reached. Environmental issues have typically not been known to include equity as a key principle when planning strategies, including those for implementing technological solutions.

In the case of preventing pollution, for instance, air pollution is a predictable, extremely high-probability occurrence in winter in Delhi (Talukdar et al., 2021; Singh et al., 2020). Source apportionment studies establish the sources of pollution; medical reports tell us the consequences. Science is doing its job.

The economics is that Delhi has the country's second highest per capita income. There are examples of successful investments that have helped transitions in the past, be it in building the metro rail network or switching to CNG vehicles. Many international, national, and state-level organisations have their headquarters and offices in the capital.

There are voices from all strata in society to pay immediate attention to the urgent need for pollution abatement and prevention in the city. Public sector solutions take time to upscale and become cost-effective. For those who can afford to make choices, moving out of the city temporarily, relocating permanently, or buying air filters are simply coping strategies.

In these circumstances, focusing on equity can be a strong basis for leadership in thought and action and possibly provide adequate motivation to take bold steps. This could include motivating the privileged to refrain from buying filtration systems, stop running away from the city in peak pollution, and instead stay and act.

There is evidence of success in preventing pollution (Sullivan et al., 2018; Gautam & Bolia, 2020) and tackling the fallouts. This includes greening cities in ways that make parks accessible to low-income residents for their mental and physical well-being, taking up pollution control with supportive humanitarian packages, and deploying technological solutions that do not discriminate between where the rich and the poor reside in the city.

### 16.2.3 *Applying the principles of justice*

The application of the principles of justice, as commonly understood, has been rare in the context of climate change, especially in India (Kashwan, 2021, 2022). The one dimension which has been the focus of much debate and discussion in policy, academia, and media is that of distributional justice at an international scale (Meyer & Roser, 2006; Büchs et al., 2011; Caney, 2018).

Here, the principle of common but differentiated responsibilities (CBDR), now extended to include respective capabilities (CBDR-RC), is among the most well-recognised principles incorporating the notion of fairness across countries in the distribution of responsibilities for GHG emissions and their consequent reduction.

A recent international development that has attracted attention is the use of a carbon border adjustment mechanism (CBAM) in the European Union (L'Heudé et al., 2021). On one hand, this can be interpreted as an attempt to create 'fairness' between producers who meet stringent carbon emissions and those who do not with respect to goods entering EU markets. This may also contribute to the global good of reducing GHG emissions, by encouraging producers to adopt cleaner technologies, thereby meeting restorative justice from a global point of view.

The important distinction is between recognising the need for a price on carbon, which is well accepted, and the labelling of a price as 'fair'. 'Fairness' has multiple dimensions (Colquitt & Rodell, 2015) and can be assessed in terms of specific contexts of geographies and actors (producers, consumers) to whom the benefits, costs, and cascading effects accrue.

So with respect to recognitional and distributive justice, the CBAM may be seen as a tool that is exclusionary and unfair from the point of view of LDCs whose exports will be hit. This may also apply at individual producer level, in terms of creating differentiation between EU and non-EU producers, where the former may enjoy the capacity to meet stringent emission standards. It would, at the least, perhaps call for re-visiting whether some procedural justice-related dimensions can be strengthened. This would, in the shorter term, ensure that progress towards the global good of reducing inequality is not hampered, even as the global goal for climate action is pursued (e.g. Perdana & Vielle, 2022; Ghosh & Tyagi, 2023).

### 16.3 **An empirical exploration with bundling equity, sustainable development, and climate action**

Concerns in the discussion on operationalising equity revolve around issues of replicability, scalability, and the contextual nature of addressing vulnerability through adaptation action. It could be argued that no one notion of vulnerability can be applied to Indian states.

On several of these counts, progress has been made. For instance, moving from single indicators to multidimensional ones (Duclos & Tiberti, 2016) will help assess and evaluate outcomes such as poverty. Perhaps one of the most burning questions is how developmental efforts by public policymaking have served the cause of climate justice and equity.

In this section, we present a preliminary exploration of data from several Indian states to understand how developmental action for the vulnerable sections of the population across states has fared with regard to climate action. To this effect, we examine the case for vulnerability in the agricultural sector and its associations with equity from action that can promote sustainable development.

### 16.3.1 *Variables of interest*

*Climatic vulnerability.* The purpose is to examine how vulnerability relates to two distinct paradigms using available state-level data. The first is to examine how climatic vulnerability is associated with actions that can improve vulnerability; the second is to understand how actions meant to affect climatic vulnerability can influence sustainable development.

The term ‘vulnerability’ has been used widely and in varying contexts of research. This also applies to implementation across disciplines, such as disaster management, ecology, economics, public health, development studies, poverty, livelihoods and famine literature, sustainability science, and climate science and policy (Adger, 2006; Füssel, 2010; Ford et al., 2018).

In the context of climate, *vulnerability* is mostly understood as the propensity or predisposition to be adversely affected due to climatic variability and climate change (e.g. WGII, AR5). It can also mean a sensitivity or susceptibility to harm, and lack of capacity to cope and adapt to adverse situations or events (IPCC, 2014a).

So it combines ecological, social, and economic characteristics to generate information representing the context within which it is being defined and used (e.g. see O’Brien et al., 2007). It is important to note that our attempt here is not to estimate vulnerability – that is typically done by combining variables capturing exposure, sensitivity, and the adaptive capacity of specified populations (IPCC, 2014b, p.3). Exposure maps the presence of farmers and others with agriculture and related livelihoods, agricultural lands, and ecosystems as also built infrastructure, and economic, social, and cultural assets that climatic events could adversely affect.

Sensitivity captures the degree to which any of these can be affected, whether directly or indirectly. For instance, a change in crop yield in response to variations in temperature is a direct effect. A rise in sea levels due to rising temperatures can have an indirect effect through increased coastal flooding, which could damage agricultural assets and crops.

Adaptive capacities represent the ability of human societies, institutions, and other organisms to adjust to the resultant damages and losses. Such

capacities also take advantage of any opportunities to prevent damages and respond to the adverse consequences of a climatic event. Exposure, sensitivity, and adaptive capacity are interrelated, and their internal interaction determines overall vulnerability.

For the agricultural sector, a high sensitivity may refer to the relationship between yield and other factors. Exposure to climatic changes manifested in multiple ways may deeply affect farmers' income, while more advanced adaptive capacities may help reduce losses from climate effects. It is also obvious that for any given level of two of these components, the third may act as a countermeasure, reducing or enhancing an effect.

We considered three sets of variables to examine the first paradigm. We also looked at interstate variability in the relationship between vulnerability and equity-oriented measures. The variables were classified into three distinct categories. Their selection took place with the availability of consistent and the latest data in mind. This would allow for the comparability of findings across states. The variables reflect three categories of enabling factors for a transition to equitable, sustainable, and climate-resilient outcomes: policy, risk management, and the capacity to transform.

### **16.3.2 Policy variables**

The variables under the policy category seek to capture the role played by the public sector (and its institutions) in addressing the myriad inequities at the individual scale that feed into determining vulnerability. The variables selected include the percentage of beneficiaries covered under the National Food Security Act (NFSA) 2013 and claims paid per farmer application benefiting under the Pradhan Mantri Fasal Bima Yojana (PMFBY).

The NFSA 2013 is a central Act that aims to provide food and nutritional security by ensuring access to adequate-quality food at affordable prices. The Act embodies a policy-oriented effort to reduce vulnerabilities at the individual level, by enhancing food access and affordability. It is a key indicator of the public sector's commitment to promoting equity and resilience by addressing vulnerabilities.

The PMFBY is also a Government of India initiative. It aims at supporting sustainable production in agriculture by providing financial support to farmers suffering crop loss or damage arising out of natural calamities or unforeseen weather events. This way, it helps stabilise the income of farmers. It also encourages farmers to adopt modern agricultural technologies, ensuring an adequate flow of credit in the sector. This policy-oriented effort can potentially contribute to food security, crop diversification, and enhanced agricultural sector growth and competitiveness, besides protecting farmers from production risks. To sum up, this equity variable captures the effect of financial support provided to farmers and the public sector's role in mitigating risks, addressing vulnerabilities, and promoting resilience.

### 16.3.3 Risk management variables

The indicators chosen to capture risk management aspects are the share of gross state value added (GSVA) of the agriculture and allied sector in the total GSVA, and the labour force participation rate (LFPR) for ages 15 years and above at usual status. Both variables capture a mix of underlying efforts from state and non-state actors to strengthen the overall economy by managing vulnerabilities in the agriculture sector.

These variables express the relevance of multiple actors in taking forward risk management. They also encapsulate the interdependencies in decision-making across sectors and communities, going beyond the sector to the integrative dimensions that affect well-being in the economy.

The LFPR is a crucial indicator of resilience to external shocks and vulnerabilities. It reflects the percentage of individuals working or actively seeking or are available for work in the population. The determination of the activity status in the variable is based on a reference period of the last 365 days preceding the survey date. Monitoring LFPR over time can help stakeholders identify potential risks and vulnerabilities, so that more effective risk management strategies can be implemented.

The GSVA of the agriculture and allied sectors in the total GSVA represents the total economic value generated by agriculture and related sectors as a proportion of the gross value added per state. It reflects the economic contribution of the sector. This is crucial in assessing the overall resilience of a sector that is susceptible to various risks, such as extreme weather events and market fluctuations. Notably, these variables are highly dependent on goods and services as much as on economic conditions prevailing beyond the agricultural sector.

### 16.3.4 Resilience capacity

The capacity to adapt and transform into a resilient state depends on a mix of autonomous and planned actions. In climate and development contexts, these capacities hinge on many variables, which are context-dependent and drive the levels at which various justice principles prevail in specific circumstances.

A range of sources of water has been clubbed into determining this variable. They comprise bottled water, piped water into dwelling, piped water to yard or plot, piped water from neighbour, public tap or standpipe, tube well, hand pump, protected well, public tanker truck, private tanker truck, protected spring, and rainwater collection (NSO, 2019).

The second variable under this category is the per capita net state domestic product (NSDP). It is a high-level measure at the other end of the spectrum. It is commonly used to measure economic progress because it can enable social, environmental, and economic resilience. As a measure of the average income of a person in a state, it is a representative variable for capturing the progression towards, and the attainment of, quality of life in terms of basic as well as aspirational aspects of well-being.

It can potentially promote the capacity for transformation into a resilient state by enhancing socio-economic resilience and guiding resource allocation across sub-national scales.

### 16.3.5 Data and methods

We collected state-wise data for 20 states for the period 2019–2020 on these six variables:

- The percentage of beneficiaries covered under the NFSA
- The share of the GSVA of agriculture and allied sectors in the total GSVA of the state (current prices)
- The LFPR for age 15 years and above at usual status
- The percentage of rural population getting safe drinking water using improved drinking water sources
- The per capita NSDP at current prices
- Claims paid per farmer applications benefitting under the PMFBY (For clarity's sake, data on this last item were available for 14 states only.)

Table 16.1 summarises the statistics for the six equity-oriented variables of the study.

The next visual summary, Figure 16.1, shows that there is variability across states regarding their attainment under the six selected variables. To be specific, in terms of beneficiaries covered under the NFSA, the states of Andhra Pradesh, Gujrat, Himachal Pradesh, Kerala, Madhya Pradesh, Maharashtra, Rajasthan, Uttarakhand, and West Bengal stand out as top performers,

**TABLE 16.1** Descriptive statistics of equity-oriented variables

<i>Categories</i>	<i>Equity-oriented variables</i>	<i>Max</i>	<i>Min</i>	<i>Mean</i>
Policy	NFSA coverage (in %)	100	77.8	98.01
	Claims paid per farmer applications benefitting under PMFBY (in Rs)	26,400	1,611.11	12,441.76
Risk management	Share of GSVA of agriculture and allied sectors in total GSVA (in %)	40.59	6.42	19.363
	LFPR for age 15 years above at usual status (in %)	73.2	41.8	55.4
Resilience capacity	Rural population getting safe drinking water using improved sources (in %)	100	90.06	98.236
	Per capita NSDP at current prices (in Rs)	435,949	44,320	169,033.5

*Source:* Authors' compilation.

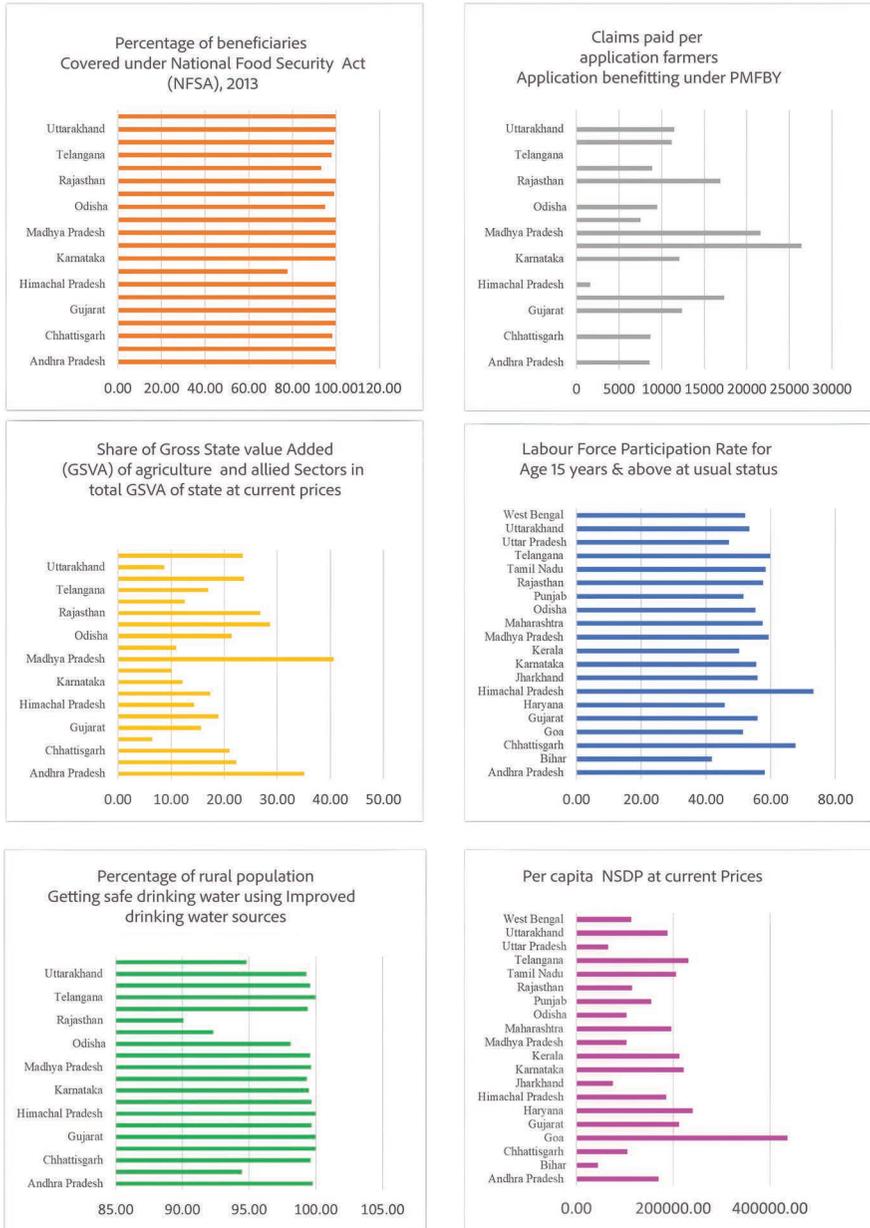


FIGURE 16.1 State-wise distribution of selected variables.

Source: Authors' compilation.

with maximum 100% coverage. Jharkhand lags, with only around 77% of beneficiaries covered under the NFSA. Interestingly, the mean percentage of beneficiaries here is around 98%, indicating a high average coverage rate.

Moving on to the claims paid per farmer applications benefitting under the PMFBY, the average amount paid stands out at around Rs 12,441. Data range from a minimum of Rs 1,611 for Himachal Pradesh to a maximum of Rs 26,400 for Kerala. This shows a significant variability in the number of claims paid per application across states.

Under the risk management aspects, Madhya Pradesh has the highest share of GVA in agriculture and allied sectors, at 40.59%, while Goa has the lowest, at 6.42%. Additionally, Himachal Pradesh boasts the maximum LFPR for ages 15 years and above among all the states analysed. At the same time, Bihar is the last performer in the indicator, with an LFPR of only around 41%. Bihar, Goa, Haryana, Kerala, Odisha, Punjab, Uttar Pradesh, Uttarakhand, and West Bengal have below-average labour force participation rates. The average LFPR stands at 55.4%.

Regarding access to safe drinking water, on average, around 90% of the rural population have access to safe drinking water using improved sources among the 20 states analysed, with Goa, Gujarat, Himachal Pradesh, and Telangana being the top performers. Lastly, per capita NSDP shows significant variation across states, with Goa at the top, with the NSDP at Rs 435,949 and Bihar being the last performer, with the NSDP at Rs 44,320.

### 16.3.6 Vulnerability

A risk and vulnerability assessment of Indian agriculture to climate change conducted by CRIDA (2019) selected 15 indicators related to five dimensions of capital endowment (natural, human, social, physical, and financial) to show vulnerability.

The 15 indicators are related to agricultural performance. They encompass (Kumar et al., 2019) thus:

- Annual rainfall, the area under degraded land and wasteland, available water holding capacity of the soil, groundwater availability, and livestock population – under natural capital
- Literacy – under human capital
- Gender gap and self-help groups – under social capital
- Net irrigated area, road connectivity, rural electrification, market access, fertiliser use – under physical capital
- Income, income equity – under financial capital

These indicators were then normalised and given weights after consultations with experts. The number of districts for each state was subsequently divided into five vulnerability categories – very low, low, medium, high, and very high –

based on their vulnerability to climate change. For example, five districts in Andhra Pradesh are in the low-vulnerability category, four in the medium-vulnerability, and four in the high-vulnerability one.

We used this information on the indicators to develop an aggregative state-level score across districts in each state to assess and compare vulnerability at state level. The low and very low categories were clubbed together, and the high and very high categories of vulnerability as another, to form three categories overall along with the medium category.

We subsequently assigned weights to each category based on the number of districts falling under these three categories. Accordingly, we generated a vulnerability score at state level.

Figure 16.2 shows the distribution of vulnerability across Indian states, according to our calculations. The numbers on the map represent the score

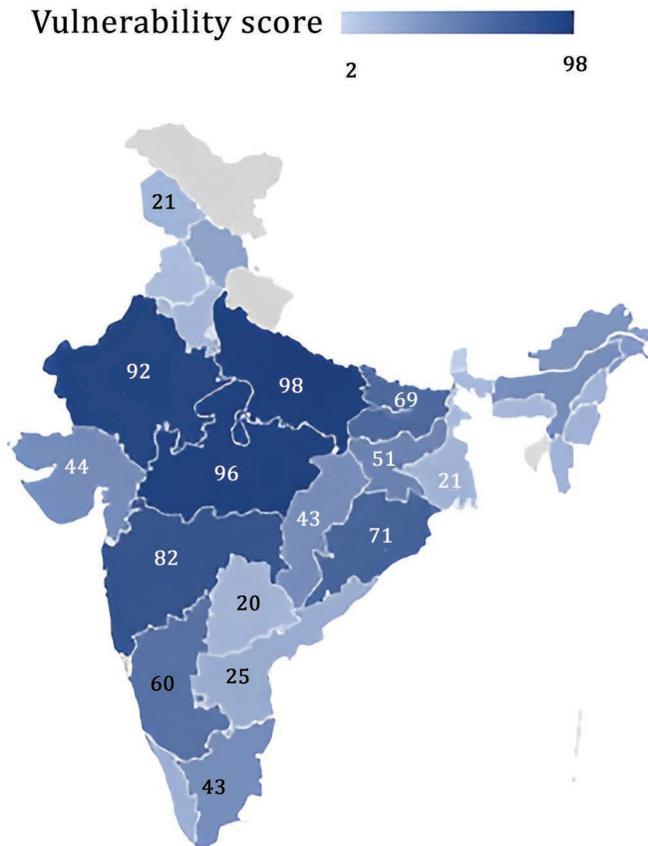


FIGURE 16.2 Distribution of state-wise vulnerability scores.

Source: Authors' compilation, based on data from a risk and vulnerability assessment of Indian agriculture to climate change (2019) conducted by CRIDA.

for the concerned state; the higher the number, the higher the vulnerability to climate change.

Madhya Pradesh, Uttar Pradesh, Rajasthan, and Orissa were the most vulnerable states according to this analysis. On the other hand, Goa, Punjab, Haryana, Kerala, Telangana, and West Bengal have low vulnerability scores.

## 16.4 Analysis insights

### 16.4.1 Relationships between equity-oriented variables and vulnerability

We calculated the correlations between the selected variables and the computed vulnerability scores (see Table 16.2).

The percentage of beneficiaries covered under the NFSA shows a negative correlation with the agriculture vulnerability score of the states. This is justified as a higher coverage of the NFSA indicates better food and nutritional security measures, thereby reducing the overall vulnerability of the population.

A positive correlation exists between the score and the claims paid per farmer applications benefitting under the PMFBY. States with a higher vulnerability score also pay a higher amount per application under the PMFBY. This highlights the importance of allocating more resources to regions more at risk to build resilience in these states.

**TABLE 16.2** Association between vulnerability and equity-oriented variables

<i>Categories</i>	<i>Equity-oriented variables</i>	<i>Correlation with vulnerability</i>
Policy	NFSA coverage	↓
	Claims paid per farmer applications benefitting under PMFBY	↑
Risk management	Share of GSVA of agriculture and allied sectors in total GSVA	↑
	LFPR for age 15 years and above at usual status	↓
Resilience capacity	Rural population getting safe drinking water using improved sources	↓
	Per capita NSDP at current prices	↓

Source: Authors' compilation.

The share of the GSVA in agriculture and allied sectors in the total GSVA shows a positive correlation with the vulnerability score. It indicates that a high dependence on agriculture is associated with a higher vulnerability. This could arise particularly from exposure to risks such as crop failures, natural disasters, and price fluctuations. A multifaceted approach is required to provide safety nets to vulnerable populations in agriculture-dependent regions.

The LFPR for ages 15 years and above correlates negatively with the vulnerability score. This confirms that individuals actively participating in the labour force are less vulnerable to economic shocks, poverty, and the like. Conversely, individuals not participating in the labour force may face higher levels of vulnerability due to a lack of income and economic security.

Under the third category, access to safe drinking water using improved sources shows a negative correlation with the vulnerability score. Improving drinking water is associated with better health outcomes and better economic and social well-being of the rural population. It reduces their vulnerability and enhances resilience.

The negative correlation between the per capita NSDP and the vulnerability score underscores that a high per capita NSDP is often associated with increased access to resources, social protection, and an improved standard of living. This, in turn, indicates a lower vulnerability and enhanced community and individual resilience.

#### ***16.4.2 Relationship between SDGs and equity-oriented variables***

The link between SDGs and equity variables is crucial. This is because it is essential to ensure that the SDGs are completed in an equitable and sustained manner, ensuring development for all.

In this section we explore how different SDGs are addressed in the six selected equity variables following the three categories of policy, risk management, and resilience capacity. The goals are mapped with equity variables based on specific targets and indicators integrated under each goal. Understanding this association will help in more targeted and effective interventions, promoting community resilience.

We start with an understanding of how the specified equity variables help accomplish the various Sustainable Development Goals. Coverage under the NFSA addresses multiple SDGs by ensuring food security and individual well-being while enhancing resilience to the changing climate. A higher NFSA coverage is a step ahead in achieving the goal of zero hunger (SDG 2) by ensuring the availability of quality food to all. In the bargain, it also promotes good health (SDG 3), which is essential to build resilience against the adverse health effects of climate change.

Additionally, this equity indicator reduces the financial burden on households, thereby making a step forward in achieving the no-poverty goal (SDG 1). Food security will also ensure equitable quality education (SDG 4) by ensuring cognitive development through better and nutritious food. It also reduces inequalities (SDG 10).

More so, by ensuring the equitable provision of nutritious food, this variable will help make communities and human settlements inclusive, resilient, and sustainable in the long term (SDG 11) and, beyond that, contribute to climate action (SDG 13).

The second equity variable under the policy category – claims paid per farmer application – is also essential in achieving various SDGs while addressing climate change challenges. By providing financial protection to farmers and safeguarding their incomes against unforeseen losses and extreme weather events, the no-poverty goal (SDG 1) is attended to. It also helps achieve food security and having equitable access to quality food (SDG 2). In addition, it will ensure good health and well-being (SDG 3) among communities, safeguarding them against adverse health impacts due to changing climate and increasing GHG emissions.

By providing a safety net to farmers, the PMFBY also ensures decent work and productive employment for those employed in the agriculture sector (SDG 8), thereby reducing inequalities (SDG 10).

Overall, this equity variable also promotes climate-resilient agricultural practices, ensuring sustainable development for all (SDG 13).

Similarly, the share of the GSVA of agriculture and allied sectors in the total GSVA addresses multiple SDG goals and targets. A higher economic growth of the sector leads to job creation, moving ahead in the no-poverty goal (SDG 1). Thereby, it ensures food security (SDG 2).

This higher economic growth and prosperity will also take care of the availability and sustainable management of water and sanitation for everybody (SDG 6). Opportunities for investments in renewable energy sources will also be created with an increased growth in the sector (SDG 7), which also promotes sustained economic growth (SDG 8).

This way, the agricultural sector can promote the sustainable use of natural resources, restore degraded lands, and preserve ecosystems. In short, a higher growth in the sector contributes to the overall resilience of the ecosystem as well (SDG 15).

The LFPR is another crucial equity variable that is related to multiple SDGs. By ensuring employment opportunities (SDG 8) and income generation, the goal of no poverty (SDG 1) is addressed. Income generation will also provide quality education for all (SDG 4). This, in turn, will empower women and girls who are more susceptible to the adverse impacts of climate change (SDG 5). A higher LFPR will also lead to a reduction in inequalities

through income generation, promoting equitable and sustainable development for all (SDG 10).

Per capita, the NSDP is another powerful variable that potentially covers the most Sustainable Development Goals, including climate change-related ones. Per capita, the NSDP can facilitate progress in various developmental indicators and enable the achievement of relevant targets. It is crucial to make resources available to invest in sustainable technologies and support policy decisions to ensure a sustainable future for all.

Figure 16.3 maps the selected equity-oriented variables against each of the SDG goals. The bar's length and composition show how many variables are likely to influence the corresponding goal.

Figure 16.3 shows that the equity-oriented variables of our study are relevant to most of the SDGs. Exceptions are:

- Goal 16: Promote peaceful and inclusive societies for sustainable development, and provide access to justice for all and build effective, accountable, and inclusive institutions at all levels.
- Goal 17: Strengthen the means of implementation, and revitalise the Global Partnership for Sustainable Development (UNDP, n.d.).

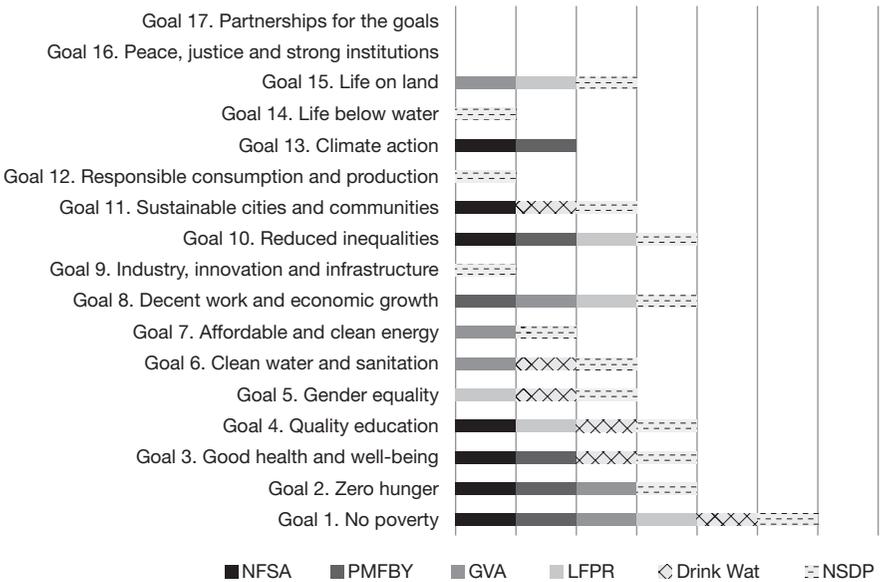


FIGURE 16.3 Distribution of equity-oriented variables corresponding to each Sustainable Development Goal.

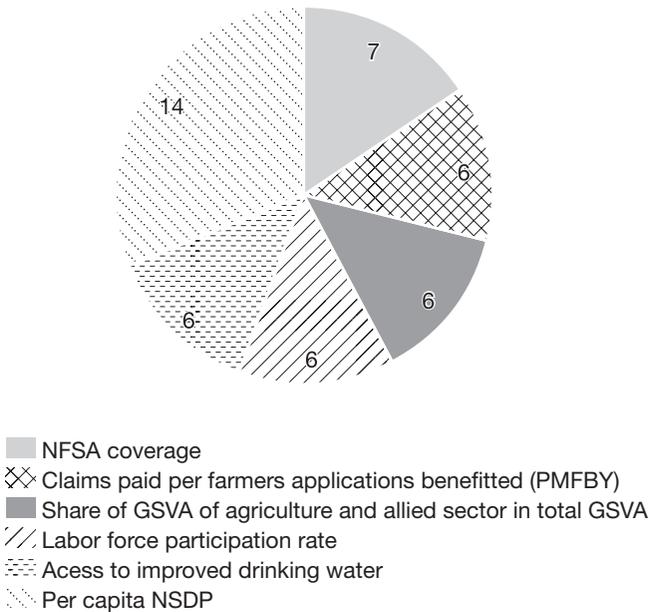
Source: Authors' compilation.

SDG 1, that is, no poverty, is well addressed by all the variables. It confirms a strong equity effect on poverty. This is followed by SDG 2 (zero hunger), SDG 3 (good health and well-being), SDG 4 (quality education), SDG 8 (decent work and economic growth), and SDG 10 (reduced inequalities). These are related to four equity-oriented variables. In contrast, only one equity variable – the per capita NSDP – deals with SDG 9 (industry, innovation, and infrastructure), SDG 12 (responsible consumption and production), and SDG 14 (life below water).

Additionally, the NFSA, apart from the obvious impacts on food security, is highly likely to affect goals that address inclusiveness, by promoting equity in health, education, and settlements. Similarly, access to safe drinking water is likely to affect goals that safeguard sustained and equitable long-term development of communities and individuals.

Figure 16.4 represents the distribution of several SDGs likely to be affected by equity-oriented variables. The number in each slice of the pie represents the number of SDGs that each corresponding equity variable may affect. The per capita NSDP is likely to be important to many Sustainable Development Goals. NFSA coverage is a close second: It will likely affect seven SDGs.

Figure 16.5 shows how the policy, risk management, and resilience capacity variables map onto the SDGs. This mapping is based on a detailed exercise



**FIGURE 16.4** Sustainable Development Goals likely to be affected by equity-oriented variables.

*Source:* Authors' compilation.

Sustainable development goals	Policy	Risk management	Resilience capacity
			
			
			
			
			
			
			
			
			
			
			
			
			
			

FIGURE 16.5 Policy, risk management, and resilience capacity and the SDGs.

Source: Authors' compilation.

Note: links are not established for SDG 16 and SDG 17.

correlating the likely influence of the six variables on targets and indicators specified under each goal. The blue colour represents the SDGs addressed by policy variables, green for SDGs likely to be affected through risk management, and yellow for the SDGs likely to be affected by resilience capacity variables.

Figure 16.5 shows all three variables are likely to affect five SDGs. These are the ones related to poverty (SDG 1), hunger (SDG 2), quality education (SDG 4), inequalities (SDG 10), and decent work (SDG 8). SDG 9 (industry, innovation, and infrastructure), SDG 12 (responsible consumption and production), and SDG 14 (life below water) are affected by building up resilience capacity variables, whereas goal 16 (peace, justice, and strong institutions) and goal 17 (partnerships for the goals) are not impacted by any of the variables. On the other hand, SDG 3 (good health and well-being), SDG 5 (gender equality), SDG 6 (clean water and sanitation), SDG 7 (affordable and clean energy), SDG 11 (sustainable cities and communities), and SDG 15 (life on land) are likely to be addressed and impacted by various combinations of two variable groups.

### **16.5 Conclusion: equity as a catalyst for integrated sustainable development and climate resilience**

Sustainable development is complex, interdisciplinary, and value-driven. The market cannot solve all problems, and ensuring the quality of growth has never been as challenging as it is today. A wide range of expectations that question traditional thinking on what different actors in society can deliver to ensure well-being is prevailing.

Examples are governments putting in place effective regulation and supportive programmes for environmental risk management, the private sector supporting pollution prevention and safeguarding habitat for biodiversity, and communities coming together to blend adaptation and mitigation action with aspirational objectives.

Sustainable development can be achieved only with an integrative approach. Bundling sustainable development with climate action and equity is the way forward for social well-being. While sectoral action can deliver, to some extent, over time and scale, ecosystems have exhibited tipping points in terms of their ability to act as sources and sink in perpetuity to meet the needs of human societies.

The SDGs themselves were based on the understanding that action in one area influences outcomes in others. Also, that creativity, know-how, technology, and financial resources from all of society are necessary to achieve them. But today, too much evidence has accumulated – the latest being a progress report card on SDG attainment across the world – that shows multiple failures of targets across the world.

Empirical analysis for the agriculture sector identified three domains – policy, risk management, and resilience capacity – to examine the interstate variability in the relationship between vulnerability and equity-oriented measures that support climate resilience and sustainable development. The equity-oriented variables selected for the analysis were NFSA coverage and claims paid per farmer applications benefitted under PMFBY for the *policy* domain, labour force participation rate and share of GSVA in agriculture and allied sectors under the *risk management* domain, and access to safe drinking water using improved sources and per capita NSDP for the *resilience capacity* domain. Vulnerability scores were computed for the states.

There is a significant and high correlation between climate vulnerability and equity indicators, suggesting the high interconnectedness among these. It underlines the importance of adopting equity as a means of addressing both sustainable development and climate resilience. Mapping the equity-related variables with the SDGs substantiates the point that equity-led strategies lead to SDG attainment, quite in alignment with reducing vulnerability to climate. It is evident that equity can be the key anchor for an approach that wishes to advance simultaneously on both sustainable development and climate resilience. Equity appears much more than a goal among multiple goals for sustainable development; it is not a spontaneous consequence of climate action. This is applicable for global to sub-national scales.

Raising the bar on what constitutes well-being for human society calls for dynamism in invoking and operationalising equity. Neither sufficientarianism nor Rawlsian principles can be applied in a static way. People are now looking at a post-2030 world that centre-stages both people and planetary well-being in an integrative way. It is the value systems that can drive change and halt nature's degradation through values that provide prominence to equity in society.

The reality is that we live in a world where various aspects of well-being interact and where wide disparities exist across countries and communities within countries. The application of the principles of equity calls for setting the bar as high as possible in terms of coming up with solutions where the interaction among global goals is recognised. The call for climate action is best served when raised in tandem with a call for sustainable development. This has, in theory, been accepted; in practice, however, this is often not the case yet. An understanding and *ex ante* incorporation of equity can be used to craft strategies and policies that help integrate the two.

What binds society together is a value system where even the smallest probability of major harm to the smallest size – a group of people – is to be prevented wherever it is preventable. Bundling equity, sustainable development, and climate action, with the first playing a key role, is likely to achieve societal well-being best, at all scales and across geographies. It would be rather optimistic to consider that climate action by itself can achieve climate

resilience and equitable and sustainable development. Centre-staging equity, on the other hand, can serve to align favourable outcomes on all three pillars.

The way forward is to recognise that every discipline, actor type, governance model, and community has to be involved from the design and planning stages onward. From economics to philosophy to ethics, there has to be joint action that considers the removal of inequity and the promotion of fairness as a core pathway for society's well-being.

The choices we make reveal our values and value systems. Equity is a core pillar of such a value system. Equity is served in different ways by various disciplines. From an economic perspective, for instance, wealth and income redistribution is something that can be done to enhance societal well-being. Other disciplines can move forward the agenda on power sharing; the intersectionality of ethnicity, class, and gender; and others again on the inseparability of extrinsic and intrinsic values – to name just a few.

Policymakers and other decision-makers facing situations of possible multiscale and cascading effects of climate change can bring together multiple actors to define solutions, using equity to bundle diverse perspectives on sustainable development and climate action. Actors from diverse sectors, on their part, can improve procedural justice, help recognise underlying inequities, and push society towards attaining better justice, all in the pursuit of a socially progressive and nature-sustainable society.

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### Data sources of variables used

- State-wise data for percentage of beneficiaries covered under NFSA is sourced from the SDG India Index and Dashboard 2020–21, published by NITI Aayog (n.d.)
- Claims paid according to farmers applications benefitted under PMFBY from a press release by the Press Information Bureau on ‘compensation to farmers for crop loss due to unseasonal climate’
- Share of gross value added of agriculture and allied sector in total GSVA is sourced from Agriculture Statistics at a Glance report 2020 by the Ministry of Agriculture and Farmers Welfare (Government of India, 2020)
- Data for labour force participation rate is sourced from Periodic Labour Force Survey 2019–2020
- Percentage of rural population getting safe drinking water using improved drinking water sources is obtained from Ministry of Statistics and Programme Implementation (MOSPI) (NSO, 2019)
- Per capita Net State Domestic Product is taken from the Economic Survey.

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