

# Chapter 18

## Resilience & Vulnerability: Concepts and Policy Contexts



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**Abstract** Climate change is an unparalleled global challenge, with profound implications for the environment, societies, and economies. As the Earth's climate continues to evolve, the twin concepts of resilience and vulnerability have emerged as essential lenses through which to understand and address its complex, multifaceted impacts. This chapter provides a comprehensive exploration of these critical concepts, alongside a detailed analysis of the policy frameworks and strategies that underpin the global response to climate change. The foundation of this chapter lies in a meticulous examination of the evolving climate landscape, the intricate web of factors contributing to climate change and its far-reaching impacts. Setting the stage for the urgent need for resilience and vulnerability assessments. We then delve deeply into the concept of resilience, dissecting its multifaceted nature by encompassing not only ecological aspects but also social and economic dimensions. We elucidate the methodologies for assessing and measuring resilience, essential for informed policy development. Vulnerability, another key concept, is scrutinized with equal rigor. We explore established frameworks and methodologies for assessing vulnerability, providing readers with a comprehensive understanding of the existing tools available to policymakers, researchers, and practitioners. Drawing upon the rich tapestry of Indian and international research, the chapter explores the

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specific challenges and vulnerabilities faced by India in the context of climate change. Case studies and empirical evidence from India provide real-world insights into the complexities of resilience and vulnerability, offering valuable lessons for both national and international audiences. Internationally, the chapter conducts a comparative analysis, revealing how different countries face unique climate challenges and employ a myriad of strategies to address resilience and vulnerability. It explores the significance of international agreements and frameworks, such as the Paris Agreement and the Sendai Framework, in shaping the global response to climate change.

The chapter highlights the emerging trends in climate research and policy development, discussing evolving paradigms and innovative solutions. It also highlights the ongoing challenges that require concerted global efforts. It serves as a comprehensive guide to the fundamental concepts of resilience and vulnerability in the context of climate change. It presents a wealth of scientific knowledge, empirical evidence, and policy insights from India and around the world. By advancing our understanding of these concepts and their policy implications, it equips readers with the knowledge needed to tackle one of the most pressing challenges of our time – climate change.

**Keywords** Climate change · Climate resilience · Vulnerability · International agreements · Climate adaptation finance · Environmental governance · Climate resilience indicators

## 18.1 Introduction

The concepts of resilience and vulnerability are central to understanding and addressing various challenges across multiple scientific disciplines. These concepts have gained significant attention over the years due to their crucial role in a wide range of fields, including environmental science, psychology, public health, disaster management, and social sciences. Resilience refers to the capacity of a system, whether it's an individual, community, or ecosystem, to withstand shocks and disturbances and adapt to changing conditions while maintaining essential functions and structures. Resilience emphasizes the ability to bounce back and even thrive in the face of adversity. Whereas vulnerability represents the susceptibility of a system to harm, often in the context of specific stressors or risks. Vulnerability can be influenced by various factors, including socioeconomic status, access to resources, infrastructure, and governance structures. Vulnerable systems are more likely to experience negative consequences when exposed to stressors or shocks. This study of resilience and vulnerability is very closely knitted, a few of the significance of this study is mentioned:

### ***18.1.1 Climate Change and Environmental Resilience***

The concept of resilience is vital in understanding how natural and human systems can adapt to climate change. Resilience is crucial for communities, ecosystems, and infrastructures to withstand the impacts of climate change, such as extreme weather events and rising sea levels. Research in this area explores how resilience can be enhanced to mitigate and adapt to these changes (Adger et al. 2005).

### ***18.1.2 Public Health and Pandemic Resilience***

The COVID-19 pandemic highlighted the importance of resilience in public health systems. Resilient healthcare systems are better equipped to handle sudden surges in patients and adapt to evolving challenges. Research in this domain examines how healthcare systems can build resilience to effectively respond to pandemics and other health crises (Kruk et al. 2017).

### ***18.1.3 Social Vulnerability and Inequality***

Vulnerability is often closely tied to socio-economic factors, which play a significant role in determining who is most affected by crises. Research on social vulnerability and inequality investigates how disparities in access to resources, education, and healthcare contribute to differential outcomes during crises (Cutter et al. 2003).

### ***18.1.4 Disaster Management***

Resilience and vulnerability concepts are fundamental in disaster management and emergency response. Research in this area helps in assessing risks, preparing for disasters, and aiding communities in recovery after natural and human-made catastrophes (Paton et al. 2010).

### ***18.1.5 Policy and Governance***

Resilience and vulnerability assessments inform policy decisions at various levels of government and international organizations. Researchers study how these concepts can be incorporated into policy frameworks to enhance resilience and reduce vulnerability in different contexts (Pelling 2011).

### ***18.1.6 Psychological Resilience***

Resilience is not limited to physical or environmental contexts; it also applies to individual and psychological resilience. Research in psychology explores how individuals cope with adversity and build resilience, which can inform mental health interventions and support systems (Masten 2011).

## **18.2 Climate Change and Its Impacts**

Climate change is a global challenge, and understanding its trends and projections is critical for addressing resilience and vulnerability. Global temperatures have been steadily rising due to the increased concentration of greenhouse gases in the atmosphere, primarily carbon dioxide. The IPCC's Sixth Assessment Report (AR6) outlines that if emissions continue on the current trajectory, global warming is likely to exceed 1.5 °C above pre-industrial levels by as early as 2030, with severe consequences for ecosystems, weather patterns, and sea level rise (IPCC AR6 2021). There is a growing trend of more frequent and severe extreme weather events, including hurricanes, heat waves, droughts, and heavy rainfall. These events can disrupt communities, agriculture, and infrastructure, making resilience crucial (IPCC AR6 2021). Polar ice caps and glaciers are melting at an accelerated rate. This contributes to rising sea levels, which threaten coastal communities and low-lying regions. Global sea levels could rise by more than a meter by the end of the century under high-emission scenarios (IPCC AR6 2021). The world's oceans are absorbing a significant portion of the carbon dioxide emitted into the atmosphere, resulting in ocean acidification. This impacts marine ecosystems, including coral reefs and fisheries, which are critical for many coastal communities (Doney et al. 2009). Climate change is disrupting ecosystems, affecting biodiversity and potentially leading to shifts in the distribution of species. Such disruptions can have far-reaching consequences for food security, human health, and livelihoods (Bellard et al. 2012). Increasingly, people are being displaced due to climate-related factors, including sea-level rise, droughts, and extreme weather events. Addressing the vulnerability of displaced populations is an urgent global concern (UNHCR 2020).

## **18.3 Resilience: Concepts and Frameworks**

Resilience is a multifaceted concept with various definitions across disciplines. However, a common theme in these definitions is the ability of a system or entity to withstand shocks and disturbances, adapt to changing conditions, and recover its essential functions and structures. Ecologist C.S. Holling defined resilience as

“the capacity of a system to absorb disturbance and reorganize while changing to still retain essentially the same function, structure, identity, and feedback” (Holling 1973). In engineering, resilience is often described as the ability of a system to return to its normal state following a perturbation or shock. Resilience can also be refer as the capacity of individuals, communities, or societies to adapt to and recover from adversity, such as economic crises, natural disasters, or health emergencies.

### ***18.3.1 Components of Resilience***

The various components of resilience are from different dimensions, including social, ecological, and economic components that contribute to the overall resilience of a system. Social resilience refers to the ability of communities, institutions, and societies to withstand and recover from shocks or stressors. It encompasses social capital, community cohesion, adaptive capacity, and the effectiveness of social safety nets (Pelling 2003). Ecological resilience relates to the capacity of ecosystems to absorb and recover from disturbances. It is influenced by biodiversity, ecosystem health, and the presence of feedback mechanisms that can maintain ecological stability (Walker et al. 2004). Economic resilience is the ability of an economy or a business to adapt to economic shocks and disruptions. It involves factors like diversification, flexibility, and access to resources (Cimellaro et al. 2010).

### ***18.3.2 Resilience Assessment and Measurement***

Assessing and measuring resilience is a complex task due to its multidisciplinary nature. Researchers and practitioners have developed various frameworks and tools to assess resilience across different contexts. For resilience assessment researchers often develop resilience indices that combine various indicators to measure the resilience of a system. These indices can include ecological, social, and economic factors (Folke et al. 2010). Scenario planning involves creating multiple possible future scenarios and assessing how a system responds to each scenario. This approach helps identify vulnerabilities and potential adaptive strategies (Peterson et al. 2003). Composite indicators combine multiple variables to provide a comprehensive view of resilience. These indicators are used in various contexts, such as measuring the resilience of cities or regions (UN-Habitat 2016). Qualitative methods, such as interviews and case studies, are used to understand the specific resilience challenges and capacities within a system. Qualitative data provide insights that quantitative measures may not capture (Obrist et al. 2010). Agent-based models simulate the behavior of individual agents within a system. These models are used to study the resilience of complex systems, including ecosystems and social systems (Janssen et al. 2006).

## 18.4 Vulnerability: Concepts and Frameworks

Vulnerability is a complex concept with multiple definitions across various disciplines. In general, vulnerability refers to the susceptibility of individuals, communities, or systems to harm or adverse impacts. It encompasses a range of factors and conditions that increase the likelihood of negative outcomes in the face of stressors or shocks. Intergovernmental Panel on Climate Change (IPCC) defines vulnerability as “the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes” (IPCC 2014). Vulnerability is often used to describe the susceptibility of individuals or groups to adverse social, economic, or health outcomes. It is influenced by various social, economic, and environmental factors (Cutter et al. 2003). In environmental contexts, vulnerability relates to the sensitivity of ecosystems or natural resources to environmental changes and perturbations (Turner et al. 2015).

### 18.4.1 *Factors Contributing to Vulnerability*

Vulnerability can be influenced by a wide range of factors, which can be broadly categorized as socio-economic, environmental, and institutional. Socio-economic factors include income, education, health, access to resources, and social networks. Low income, limited access to healthcare, and inadequate housing are factors that can increase vulnerability (Pelling 2003). Environmental vulnerability relates to the sensitivity of ecosystems or regions to environmental changes, including climate change, natural disasters, or land degradation. Factors such as proximity to coastlines or geological hazards can contribute to environmental vulnerability (Turner et al. 2015). Institutional factors encompass governance structures, policies, and the effectiveness of institutions in managing and responding to risks. Weak governance, corruption, and inadequate disaster preparedness can increase vulnerability (Birkmann 2006). Climate change itself is a major factor contributing to vulnerability, as it leads to increased risks, such as extreme weather events, sea-level rise, and altered disease patterns (Adger et al. 2007).

### 18.4.2 *Vulnerability Assessment and Measurement*

Assessing and measuring vulnerability is essential for understanding and addressing it. Researchers and practitioners have developed various methods and frameworks for vulnerability assessment. Composite indicators for vulnerability combine multiple socio-economic, environmental, and institutional variables to measure overall vulnerability. The Human Development Index (HDI) and the Multidimensional Poverty Index (MPI) are examples of composite indicators used

in socioeconomic vulnerability assessments (UNDP 2020; Alkire et al. 2010). Geospatial tools and Geographic Information Systems (GIS) are used to map and analyze spatial patterns of vulnerability. This is particularly valuable for understanding environmental and climate-related vulnerability (Turner et al. 2015). Socio-economic vulnerability assessments often rely on census and survey data to capture factors such as income, education, healthcare access, and housing conditions (World Bank 2020). Qualitative methods, such as participatory research and case studies, are employed to understand the nuances of vulnerability in specific contexts and to capture local perspectives (Eakin and Luers 2006). Various vulnerability indices have been developed for specific purposes, such as the Social Vulnerability Index (SoVI) for disaster risk assessment (Cutter et al. 2003).

## 18.5 Climate Resilience and Vulnerability in India

India faces significant challenges related to water scarcity due to population growth, inefficient water management, and climate change impacts. Prolonged droughts in regions like Maharashtra and Karnataka have led to agricultural distress (Dutta et al. 2019). India is prone to extreme weather events such as cyclones, floods, and heat-waves. The 2013 Phailin cyclone in Odisha and the 2015 Chennai floods are examples of such events that have caused extensive damage (Mukherjee et al. 2016). Agriculture, a major source of livelihood in India, is vulnerable to climate change. Erratic monsoons and changing rainfall patterns affect crop yields, impacting food security (Parry et al. 2005). India's Coastal areas, including cities like Mumbai and Kolkata, are at risk due to rising sea levels. Empirical studies have shown that sea levels are rising along India's coastline (Nayak et al. 2019).

### 18.5.1 Case Studies and Empirical Evidence from India

*Kutch Region, Gujarat:* The 2001 earthquake in the Kutch region led to significant loss of life and property. Subsequent efforts to rebuild the area incorporated resilience measures in infrastructure development (Papathoma-Köhle et al. 2009).

*Kosi Floods, Bihar:* The recurring Kosi River floods in Bihar have displaced communities and led to loss of livelihoods. The government has implemented various flood control measures in response (Mishra et al. 2008).

*Chennai Floods, 2015:* The 2015 Chennai floods, exacerbated by heavy rainfall and poor urban planning, highlighted the need for improved urban resilience and flood management (Mukherjee et al. 2016).

*Climate Change Impacts on Agriculture:* Research indicates that climate change could lead to a decline in wheat and rice yields in India by 2050, emphasizing the need for adaptive agricultural practices (Lobell et al. 2008).

### ***18.5.2 Government Initiatives and Policies Addressing Climate Resilience and Vulnerability***

India's National Action Plan on Climate Change (NAPCC) outlines various national missions to address climate change, including the National Water Mission and the National Mission for Sustainable Agriculture, focusing on water management and sustainable farming (Government of India 2008). Pradhan Mantri Fasal Bima Yojana (PMFBY), launched in 2016 Kharif season onwards by Ministry of Agriculture & Farmers Welfare, Government of India, is also a crop insurance scheme that provides financial support to farmers in case of crop failure. It aims to reduce the vulnerability of farmers to climate-related risks (Ministry of Agriculture & Farmers Welfare, Government of India 2016). National Cyclone Risk Mitigation Project (NCRMP 2011), is a comprehensive policy that aims at reducing the vulnerability of coastal communities to cyclones and storm surges. It includes measures for strengthening infrastructure and early warning systems established under the National Disaster Management Authority, Government of India. Policy like National Adaptation Fund for Climate Change (NAFCC 2015) is designed to provide financial support for adaptation projects in vulnerable states and sectors. It supports initiatives related to water resource management, agriculture, and infrastructure development under the Ministry of Environment, Forest and Climate Change, Government of India.

## **18.6 International Perspectives on Climate Resilience and Vulnerability**

Countries' vulnerability to climate change and disasters varies based on a combination of socio-economic, environmental, and institutional factors. Socio-economic factors include poverty levels, access to healthcare, and education. Environmental factors include exposure to climate-related hazards, such as coastal or riverine areas prone to flooding or drought-prone regions. Institutional factors involve governance, disaster preparedness, and adaptive capacity. Vulnerability and resilience profiles differ within countries and regions. For example, in India, the northern region of Ladakh may have unique resilience and vulnerability characteristics compared to coastal regions like Kerala. Comparative analysis often considers specific climate risks faced by countries, such as hurricanes in the Caribbean, sea-level rise in low-lying island nations, or droughts in African countries. Researchers conduct case studies and vulnerability assessments to provide empirical evidence of resilience and vulnerability in specific countries. These studies often consider local contexts, including socio-cultural factors (e.g., gender, indigenous knowledge). Comparative

analysis of climate resilience and vulnerability plays a crucial role in identifying disparities and addressing the unique challenges faced by different countries and regions. These efforts are essential for guiding international policies and climate adaptation strategies, particularly in the context of the Paris Agreement and the Sendai Framework.

### ***18.6.1 International Agreements and Frameworks***

*Paris Agreement (2015)*: The Paris Agreement is a landmark international treaty under the United Nations Framework Convention on Climate Change (UNFCCC). It aims to limit global warming to well below 2 degrees Celsius above pre-industrial levels, with an aspirational goal of limiting it to 1.5 degrees Celsius. Signatory countries commit to enhancing their adaptive capacity and resilience and making financial flows consistent with a pathway towards low greenhouse gas emissions.

*Sendai Framework for Disaster Risk Reduction (2015–2030)*: The Sendai Framework, adopted at the Third UN World Conference on Disaster Risk Reduction, focuses on reducing disaster risk and building resilience to disasters. It emphasizes the importance of understanding and addressing underlying risk factors and vulnerabilities, including climate-related risks.

*Sustainable Development Goals (SDGs)*: The United Nations' Sustainable Development Goals (United Nations 2015) encompass a broad range of objectives, including climate action (SDG 13) and resilience (SDG 11 - Sustainable Cities and Communities). These goals provide a global framework for addressing climate change and building resilience.

*Adaptation Initiatives*: Various international initiatives and funds support adaptation efforts in vulnerable countries. Examples include the Green Climate Fund, the Least Developed Countries Fund established in the 7th Conference of parties in 2001 (LDCF 2001), and the Adaptation Fund (Adaptation Fund 2001). These mechanisms provide financial resources to help countries enhance their resilience to climate change.

*Global Climate Risk Index (GCRI)*: As reported by Germanwatch (2021). The GCRI, published annually by Germanwatch, ranks countries based on their vulnerability to climate-related events. This comparative analysis considers factors such as exposure, sensitivity, and capacity to adapt.

*Climate Resilience Index*: Some organizations and researchers develop their resilience indices to assess and compare resilience across countries. These indices consider various factors, including economic, environmental, and social indicators.

## 18.7 Policy Responses to Climate Change

Mitigation involves actions that reduce the emission of greenhouse gases and alleviate the drivers of climate change. Common mitigation strategies such as Transitioning to renewable energy sources (e.g., solar, wind, and hydropower) (Jacobson et al. 2015), Energy efficiency improvements in buildings, transportation, and industries (IEA 2018) and reforestation and afforestation to sequester carbon (Bastin et al. 2019) have been found very effective in mitigating climate change.

Adaptation Strategies however focus on enhancing resilience to the impacts of climate change. Some of the strategies, for example, building climate-resilient infrastructure, such as flood defences and drought-resistant agriculture (Hallegatte et al. 2016), Developing early warning systems for extreme weather events (UNDRR 2015) and Integrating climate adaptation into urban planning (Setiadi et al. 2020) were significantly impactful in dealing with climate change crisis.

The role of policies becomes very crucial in handling climate change problems. Through time international agreements such as the Paris Agreement and the Sendai Framework emphasize the importance of policy to address climate change and disaster risk (UNFCCC 2015; UNDRR 2015). Policymakers use assessments to identify vulnerable areas and populations, as well as to develop targeted policies and strategies for building resilience (O'Brien et al. 2004). The researchers have focused on Disaster Risk Reduction and Climate Adaptation strategies. They believe that by integrating disaster risk reduction and climate adaptation into policy frameworks helps reduce vulnerabilities and enhance resilience (IPCC 2012; UNDRR 2017). Policies that allocate funding, such as the Green Climate Fund, support climate resilience and mitigation efforts in vulnerable regions (Green Climate Fund 2021). Few studies emphasized that policies for sectors like agriculture, water resources, and public health are vital for addressing vulnerabilities and building resilience (Hansen et al. 2009; UN-Water 2016).

Some of the successful examples of the implementation of climate policies are:

*Renewable Energy Transition:* Germany's Energiewende policy has resulted in a significant shift towards renewable energy sources, reducing carbon emissions (Böhringer et al. 2017).

*Hurricane Katrina Resilience:* New Orleans' post-Hurricane Katrina recovery plan involved strengthening infrastructure, flood defenses, and emergency management systems (Gall et al. 2011).

*Forest Landscape Restoration:* The Bonn Challenge has led to commitments by governments to restore degraded forest landscapes, contributing to climate mitigation and resilience (Griscom et al. 2017).

However, challenges exist in effectively implementing and enforcing climate and resilience policies at the local and national levels (Eisenack et al. 2014). Adequate funding for climate mitigation and adaptation remains a challenge, particularly in developing countries (Bierbaum et al. 2013). Equity and Social Justice is again

a big challenge to combat when it comes to the crisis of climatic change. Vulnerable communities often face unequal access to resources and face disparities in climate impacts. Ensuring equitable policies is a challenge (Adger 2003). Integrating climate adaptation and resilience into existing policies and sectors can be complex and requires effective governance (Eriksen et al. 2011).

## 18.8 Mainstreaming Climate Resilience and Vulnerability Considerations into National Policies

Mainstreaming climate resilience and vulnerability considerations into national policies is a crucial step in addressing the impacts of climate change and reducing vulnerabilities. This involves integrating climate adaptation and resilience into a wide range of policy areas, from agriculture and water resources to urban planning and health. Some of the plans that can be included to have synergy among climate change, climate resilience, and vulnerability are:

*Climate Adaptation in National Plans:* National governments are increasingly incorporating climate adaptation into their overarching development and environmental policies. For example, many countries have developed National Adaptation Plans (NAPs) to outline their strategies for addressing climate impacts (UNFCCC 2015).

*Sector-Specific Integration:* Climate resilience is integrated into various sectors. In agriculture, policies may focus on drought-resistant crops and water management. In urban planning, policies can include climate-resilient infrastructure and land-use planning (Dazé et al. 2017; Setiadi et al. 2020).

*Legal Frameworks:* Many countries have established legal frameworks that mandate climate change adaptation and resilience measures. These frameworks can set requirements for impact assessments and risk reduction (Lyster et al. 2017).

*Capacity Building:* Building capacity at the national and local levels is essential for mainstreaming resilience. This includes training policymakers, practitioners, and local communities in climate resilience strategies (Dow et al. 2019).

*Monitoring and Evaluation:* Effective policies include mechanisms for monitoring and evaluating climate adaptation efforts to ensure progress and accountability (Ford et al. 2018).

Cross-sectoral approaches involve collaboration and integration across various policy areas to address complex challenges related to climate resilience and vulnerability. Key points include:

*Synergy and Co-benefits:* Cross-sectoral approaches aim to identify synergies and co-benefits between different policy areas. For instance, promoting green infrastructure in urban planning not only enhances resilience but also provides environmental and social benefits (Bulkeley and Betsill 2013).

*Reducing Trade-offs:* Policies that span sectors help reduce trade-offs, ensuring that actions taken in one area do not inadvertently harm another. For example, land-use planning can consider both agriculture and flood risk management (Tompkins and Adger 2005).

*Interagency Cooperation:* Effective cross-sectoral approaches require cooperation and coordination among different government agencies, as well as with non-governmental organizations, communities, and the private sector (Cash et al. 2003).

*Integrated Risk Assessment:* Cross-sectoral policies often rely on integrated risk assessments to identify vulnerabilities across different sectors. This helps in developing comprehensive strategies for resilience (Preston et al. 2011).

*Community Engagement:* Community involvement is a key aspect of cross-sectoral approaches. Engaging communities in decision-making ensures that policies are contextually appropriate and responsive to local needs (Eriksen et al. 2011).

## 18.9 Emerging Trends in Climate Research and Policy

*Interdisciplinary Approaches:* Climate research is increasingly emphasizing interdisciplinary collaboration, bringing together natural and social sciences to understand complex climate-resilience issues (Turner et al. 2015).

*Adaptation Finance:* Emerging trends in policy include greater attention to climate adaptation finance, such as innovative financing mechanisms, insurance solutions, and climate bonds (Hedger et al. 2016).

*Nature-Based Solutions:* Policies and research are focusing on nature-based solutions, which involve using ecosystems (e.g., wetlands, forests) to enhance resilience and reduce vulnerability (Ruckelshaus et al. 2018).

*Urban Resilience:* Urban areas are a growing focus of climate research and policy, with an emphasis on sustainable and resilient urban planning, green infrastructure, and equitable climate adaptation (Rosenzweig et al. 2018).

*Youth and Stakeholder Engagement:* Climate research and policy increasingly involve youth and stakeholders, recognizing their crucial role in advocacy, decision-making, and innovation (Reckien et al. 2018).

## 18.10 Key Findings and Insights

Climate change is exacerbating vulnerabilities across the world, with a disproportionate impact on marginalized communities and regions (IPCC 2014). The increased frequency and intensity of extreme weather events, such as hurricanes, droughts, and floods, are amplifying vulnerabilities in both developed and developing countries (Eriksen et al. 2011). It affects ecosystems, economies, and societies through intricate and often nonlinear interactions (Hallegatte et al. 2016).

These interactions make it challenging to predict and address vulnerabilities comprehensively. It also affects various economic sectors, including agriculture, water resources, health, and urban infrastructure (IPCC 2014). The interconnectedness of these sectors necessitates a cross-sectoral approach to policy development and implementation (Bierbaum et al. 2013). Climate change exacerbates existing inequities, disproportionately impacting vulnerable populations, such as the poor, women, and indigenous communities (Adger 2003). Equity considerations are central to building climate resilience (Ford et al. 2018). Both adaptation and mitigation strategies are essential. Mitigation measures reduce greenhouse gas emissions to limit the extent of climate change, while adaptation strategies enhance resilience to the changes that are already underway (IPCC 2014).

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