Poverty and Climate Change

Reducing the Vulnerability of the Poor through Adaptation

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Acronyms and Abbreviations

GDP	Gross domestic product
GEF	Global Environment Facility
GHG	Greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
LDCs	Least developed countries
LEG	Least Developed Countries Expert Group
MDGs	Millennium Development Goals
NAPA	National Adaptation Programme of Action
PRS	Poverty Reduction Strategies
PRSP	Poverty Reduction Strategy Paper
RCOF	Regional Climate Outlook Forum
UNFCCC	United Nations Framework Convention on Climate Change
VARG	Vulnerability and Adaptation Resource Group

Foreword

Climate change is a serious risk to poverty reduction and threatens to undo decades of development efforts. As the Johannesburg Declaration on Sustainable Development states, "the adverse effects of climate change are already evident, natural disasters are more frequent and more devastating and developing countries more vulnerable." While climate change is a global phenomenon, its negative impacts are more severely felt by poor people and poor countries. They are more vulnerable because of their high dependence on natural resources, and their limited capacity to cope with climate variability and extremes.

Experience suggests that the best way to address climate change impacts on the poor is by integrating adaptation responses into development planning. This is fundamental to achieve the Millennium Development Goals, including the over-arching goal of halving extreme poverty by 2015, and sustaining progress beyond 2015.

The objective of this document is to contribute to a global dialogue on how to mainstream and integrate adaptation to climate change into poverty reduction efforts. We hope this will move the discussion further towards action.

While this joint paper focuses on adaptation to climate change in relation to poverty, we understand that adaptation has to go hand in hand with mitigation of climate change by limiting greenhouse gases in the atmosphere. We also reaffirm that industrialized countries should take the lead in combating climate change and its adverse effects.

We share a commitment to assisting and working with poor people, partner governments, civil societies, and the private sector in coping with the vulnerability of the poor to climate change. We resolve to ensure that our own institutions support this commitment.

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Executive Summary

Poverty Reduction – the Challenge of the 21st Century

Despite international efforts, poverty has become more widespread in many countries in the last decade, making poverty reduction the core challenge for development in the 21st century. In the Millennium Declaration, 189 nations have resolved to halve extreme poverty by 2015 and all agencies involved in this paper are committed to contribute to this aim. However, climate change is a serious risk to poverty reduction and threatens to undo decades of development efforts.

This paper focuses on the impacts of climate change on poverty reduction efforts in the context of sustaining progress towards the Millennium Development Goals and beyond. It discusses ways of mainstreaming and integrating adaptation to climate change into poverty reduction and sustainable development efforts.

The chief messages emerging from this paper are:

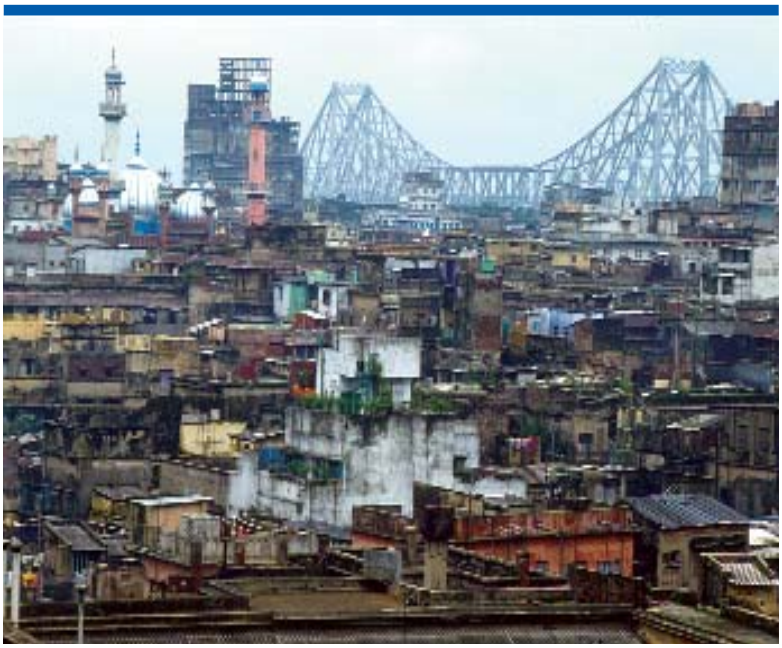
- Climate change is happening and will increasingly affect the poor.
- Adaptation is necessary and there is a need to integrate responses to climate change and adaptation measures into strategies for poverty reduction to ensure sustainable development.

This decision to focus on adaptation is deliberate and is taken with the understanding that adaptation cannot replace mitigation efforts. The magnitude and rate of climate change will strongly depend on efforts to reduce greenhouse gas (GHG) concentrations in the atmosphere. The higher the concentrations of GHGs, the higher the likelihood of irreversible and grave damage to human and biological systems. Therefore, adaptation is only one part of the solution. Mitigation of climate change by limiting greenhouse gas concentrations in the atmosphere is the indispensable other part.

Climate Change is Happening and Will Increasingly Affect the Poor

Today, it is widely agreed by the scientific community that climate change is already a reality. The Intergovernmental Panel on Climate Change (IPCC) has concluded that human activities are altering our climate system and will continue to do so. Over the past century, surface temperatures have increased and associated impacts on physical and biological systems are increasingly being observed. Science tells us that climate change will bring about gradual changes, such as sea level rise, and shifts of climatic zones due to increased temperatures and changes in precipitation patterns. Also, climate change is very likely to increase the frequency and magnitude of extreme weather events such as droughts, floods, and storms. While there is uncertainty in the projections with regard to the exact magnitude, rate, and regional patterns of climate change, its consequences will change the fate of many generations to come and particularly impact on the poor if no appropriate measures are taken.

The impacts of climate change, and the vulnerability of poor communities to climate change, vary greatly, but generally, climate change is superimposed on existing vulnerabilities. Climate change will further reduce access to drinking water, negatively affect the health of poor people, and will pose a real threat to food security in many countries in Africa, Asia, and Latin America. In some areas where livelihood choices are limited, decreasing crop yields threaten famines, or where loss of landmass in coastal areas is anticipated, migration might be the only solution. The macroeconomic costs of the impacts of climate change are highly uncertain, but very likely have the potential to threaten development in many countries.



Therefore, the task ahead is to increase the adaptive capacity of affected poor communities and countries.

Part 1 of this document examines how climate change is likely to affect the existing vulnerability of poor people to climate related impacts. According to the Third Assessment Report of the IPCC, developing countries are expected to suffer the most from the negative impacts of climate change. This is due to the economic importance of climate-sensitive sectors (for example, agriculture and fisheries) for these countries, and to their limited human, institutional, and financial capacity to anticipate and respond to the direct and indirect effects of climate change. In general, the vulnerability is highest for least developed countries in the tropical and subtropical areas. Hence, the countries with the fewest resources are likely to bear the greatest burden of climate change in terms of loss of life and relative effect on investment and the economy.

Many sectors providing basic livelihood services to the poor in developing countries are not able to cope even with today's climate variability and stresses. Over 96% of disaster-related deaths in recent years have taken place in developing countries. Often, extreme weather events set back the development process for decades. With fishing grounds depleting, and droughts, floods, and storms destroying entire annual harvests in affected areas, the El Niño phenomenon serves as a prime example of how climatic variability already affects vulnerable countries and people today. In many developing countries, climate change already increases stresses from climate variability and extremes and will do so increasingly in the future.

Adaptation is Necessary

In the view of the participating agencies, adaptation to climate change is a priority for ensuring the long-term effectiveness of our investment in poverty eradication and sustainable development.

Part 2 examines lessons learned in reducing poverty while strengthening the capacity of those living in poverty to adapt to climate change. The findings support a conclusion of the IPCC that adaptation measures, if pursued in the sustainable development framework, can diminish the damage from future climate change and climate variability.

Through the decisions of the United Nations Framework Convention on Climate Change (UNFCCC), work has been initiated to develop the adaptive capacity of poor people and the poorer countries (Least Developed Countries) to cope with the impacts of climate change. Yet, a stronger focus must be placed on poverty reduction and sustainable development. We believe that the development and environment community must ensure that adaptation is not treated as a standalone issue, but in the context of poverty reduction and the Millennium Development Goals (MDGs).

Many examples show that addressing poverty implies also preparing for climate variability and extremes. While climate change is only one of the many factors influencing poverty, immediate action should be taken to adapt to climate change impacts. We argue that many possible interventions have already been identified, and prompt action can be taken today.

Our combined experience suggests that the best way to address climate change impacts on the poor is by integrating adaptation measures into sustainable development and poverty reduction strategies. Only such a comprehensive approach, which provides options for poor people to reduce their vulnerability to current and future risks, will contribute towards achieving the MDGs and ensure that sustainable progress is made beyond 2015.

Strengthening Adaptation Efforts

Many adaptation mechanisms will be strengthened by making progress in areas such as good governance, human resources, institutional structures, public finance, and natural resource management. Such progress builds the resilience of countries, communities, and households to all types of shocks, including climate change impacts. Strategies to cope with current climate variability provide a good starting point for addressing adaptation needs in the context of poverty reduction. Learning from experience will help to prevent the underachievement of sustainable development efforts and avoid maladaptation.

Progress will require:

Improved governance, including an active civil society and open, transparent, and accountable policy and decision making processes, which can have a critical bearing on the way in which policies and institutions respond to the impact of climatic factors on the poor.

First steps towards mainstreaming climate issues into all national, sub-national, and sectoral planning processes, such as Poverty Reduction Strategies (PRS) or national strategies for sustainable development.

Encouraging a ministry with a broad mandate, such as planning or finance, to be fully involved in mainstreaming adaptation, especially in countries where major climate impacts are expected.

Combining approaches at the government and institutional level with bottom-up approaches rooted in regional, national, and local knowledge.

Empowerment of communities so that they can participate in assessments and feed in their knowledge to provide useful climate-poverty information. They will also need full access to climate relevant information systems.

Vulnerability assessments that fully address the different shades and causes of poverty.

Access to good quality information about the impacts of climate change. This is key for effective poverty reduction strategies. Early warning systems and information distribution systems help to anticipate and prevent disasters.

Integration of impacts into macroeconomic projections. The rate and pattern of economic growth is a critical element of poverty eradication, and climatic factors can have a powerful bearing on both. Integration will prevent climate change diverting limited resources into disaster relief and recovery activities and away from long-term development priorities. The national budget process should be the key process to identify climate change risks and to incorporate risk management so as to provide sufficient flexibility in the face of uncertainty.

Increasing the resilience of livelihoods and infrastructure as a key component of an effective poverty reduction strategy. Similarly, effective adaptation strategies should build upon, and sustain, existing livelihoods and thus take into account existing knowledge and coping strategies of the poor. Traditional risk sharing mechanisms, such as asset pooling and kinship, could be complemented by micro-insurance approaches, and infrastructure design and investment, both for private and public use, should take into account the potential impacts of climate change.

Next Steps

Part 3 makes specific recommendations for action in the areas of:

- Development agency and donor activities.
- Governments in developing countries.
- Strengthening information and assessments.
- Engagement of the UNFCCC process.
- Ensuring synergies with other multilateral agreements.
- Funding adaptation.

Development and environment agencies need to ensure that their efforts support the mainstreaming of climate issues into general sustainable development. This requires a sector-wide examination of existing programs as well as: a close look at existing disaster reduction and preparedness programs to make maximum use of their ability to assess and reduce current vulnerabilities; the development of tools and methodologies for planning in the face of risk; training and awareness raising of senior management and staff; and the improvement of institutional processes to address the vulnerability of the poor in development programs. Furthermore, checks must be built in to avoid any development activity that undermines the capacity of the poor to cope with climate variability and change.

The UN Conventions on Climate, Biodiversity, and Desertification all provide opportunities for sustainable development and implementation of measures should be integrated in poverty reduction strategies. However, many developing countries are stretched by the need to service all these international processes, leaving little time for them to engage in domestic implementation and determining national environmental priorities. This conflict can be reduced by, for example, maximizing synergies in reporting and other requirements and by integrating implementation measures into general development strategies.

Reducing the vulnerability of those most at risk from the impacts of climate change and the process of mainstreaming adaptation into poverty reduction will require, in many cases, substantial external financial resources. These resources would need to be provided through a number of channels, which would include: bilateral, multilateral, and non-governmental development assistance; the new funds created by the UNFCCC; and the Global Environment Facility (GEF) as the financial mechanism of the UNFCCC.

Development assistance should aim to reorient current practices and remove barriers to "no regrets" adaptation interventions through the integration of climate risk management in development programs. This would also help to mainstream adaptation in national development planning and budgetary processes. Additional resources are required to assess and address climate risks in projects supported by development assistance, where climate-safe development implies extra costs over and above business-as-usual. Funding by the GEF and the new climate change funds further supports interventions that help to prepare for climate change adaptation, and help demonstrate adaptation interventions. The nature and scope of this latter support is dependent on the evolving guidance from the UNFCCC, but we do have to act now.

PART 1: Climate Change and the Poor

Currently over 1 billion people – two thirds of them women – live in extreme poverty on less than US$1 a day. This figure rises to 2.8 billion if a standard of US$2 a day is used (OECD 2001).

Climate change will compound existing poverty. Its adverse impacts will be most striking in the developing nations because of their geographical and climatic conditions, their high dependence on natural resources, and their limited capacity to adapt to a changing climate. Within these countries, the poorest, who have the least resources and the least capacity to adapt, are the most vulnerable (IPCC 2001a). Projected changes in the incidence, frequency, intensity, and duration of climate extremes (for example, heat waves, heavy precipitation, and drought), as well as more gradual changes in the average climate, will notably threaten their livelihoods – further increasing inequities between the developing and developed worlds. Climate change is therefore a serious threat to poverty eradication. However, current development strategies tend to overlook climate change risks.

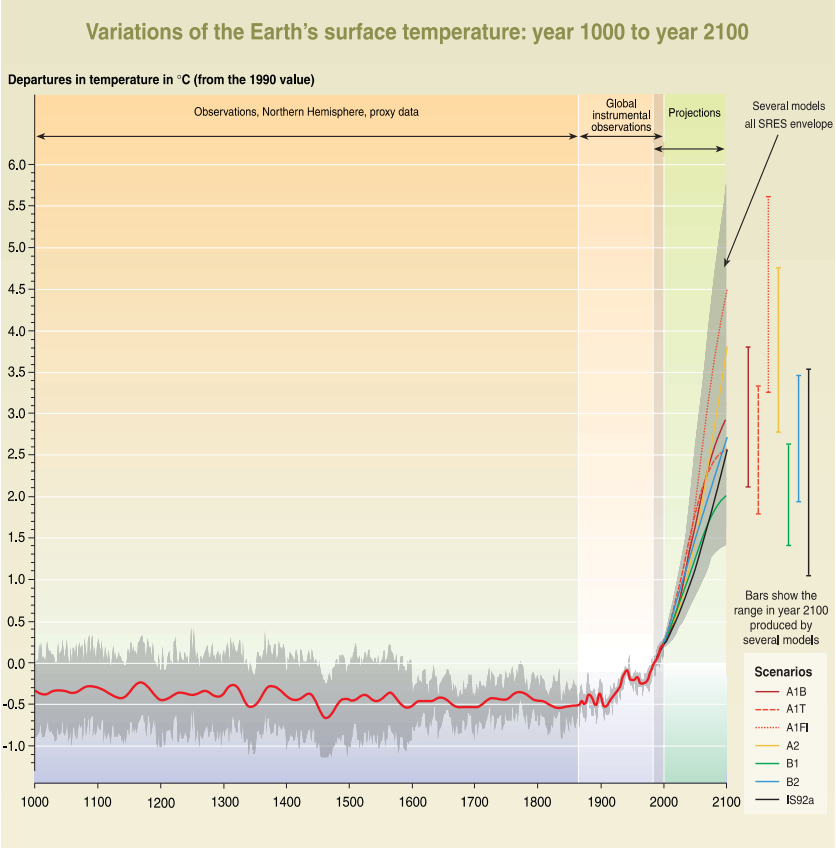
An approach that uses both mitigation and adaptation is needed. Current commitments to mitigate climate change by limiting the emissions of greenhouse gases (GHGs) will not, even if implemented, stabilize the atmospheric concentrations of these gases[1]. Developing adaptive capacity to minimize the damage to livelihoods from climate change is a necessary strategy to complement climate change mitigation efforts.

Climate change adaptation – all those responses to climatic conditions that reduce vulnerability – is therefore an integral and urgent part of overall poverty reduction strategies. Adaptation should not be approached as a separate activity, isolated from other environmental and socioeconomic concerns that also impact on the development opportunities of the poor. A comprehensive approach is needed that takes into account potential synergistic and antagonistic effects between local and global environmental changes as well as socioeconomic factors.

1.1 Climate Change is a Reality

Today, it is widely agreed by the scientific community that climate change is already a reality. The rate and duration of warming observed during the twentieth century are unprecedented in the past thousand years. Increases in maximum temperatures, numbers of hot days, and the heat index have been observed over nearly all lands during the second half of the twentieth century. Collective evidence suggests that the observed warming over the past fifty years can be mostly attributed to human activities. The warming trend in the global average

Figure 1
Variations in the Earth´s Surface Temperature, 1000–2100.
Source: IPCC 2001 a.



surface temperature is expected to continue, with increases projected to be in the range of 1.4 to 5.8 °C by 2100 in comparison to 1990 (IPCC 2001a).

There is increasing observational evidence that regional changes in climate have contributed to various changes in physical and biological systems in many parts of the world (IPCC 2001a; 2001b). These include the shrinkage of glaciers, thawing of permafrost, changes in rainfall frequency and intensity, shifts in the growing season, early flowering of trees and emergence of insects, and shifts in the distribution ranges of plants and animals in response to changes in climatic conditions.

On the regional level, climate change is superimposed on the existing climatic conditions and manifests itself through:

- Changes in average climatic conditions. For example, some regions may become drier or wetter on average (IPCC 2001a).
- Changes in climate variability. For example, rainfall events may become more erratic in some regions.
- Changes in the frequency and magnitude of extreme events (IPCC 2001a; 2001b).
- Changes in sea levels, which are projected to rise by between 0.09 and 0.88 meters by 2100 relative to 1990 (IPCC 2001a).

Table 1
Impacts of Climate Change, Vulnerability, and Adaptive Capacity
Source: Adapted from IPCC 2001 b.

Region	Likely Regional Impacts of Climate Change	Vulnerability and Adaptive Capacity
Africa	Increase in droughts, floods, and other extreme events would add to stress on water resources, food security, human health, and infrastructure, constraining development. Changes in rainfall and intensified land use would exacerbate the desertification process (particularly in the Western Sahel and Northern and Southern Africa). Grain yields are projected to decrease, diminishing food security, particularly in small food-importing countries. Sea level rise would affect coastal settlements, flooding and coastal erosion, especially along the eastern Southern African coast. Major rivers are highly sensitive to climate variations and may experience decreases in run-off and water availability, affecting agriculture and hydropower systems, which may increase cross-boundary tensions. Increase in frequency of some extreme events in some places.	Adaptive capacity is low due to low GDP per capita, widespread poverty (the number of poor grew over the 1990s), inequitable land distribution, and low education levels. There is also an absence of social safety nets, in particular after harvest failures. Individual coping strategies for desertification are already strained, leading to deepening poverty. Dependence on rain-fed agriculture is high. More than one quarter of the population lives within 100 kilometers of the coast and most of Africa's largest cities are along coasts vulnerable to sea level rise, coastal erosion, and extreme events. Climate change has to be recognized as a major concern with respect to food security, water resources, natural resources productivity and biodiversity, human health, desertification, and coastal zones. Adaptive capacity will depend on the degree of civil order, political openness, and sound economic management.
Asia	Extreme events have increased in temperate Asia, including floods, droughts, forest fires, and tropical cyclones. Thermal and water stress, flood, drought, sea level rise, and tropical cyclones would diminish food security in countries of arid, tropical, and temperate Asia. Agriculture would expand and increase in productivity in northern areas. Reduced soil moisture in the summer may increase land degradation and desertification. Sea level rise and an increase in intensity of tropical cyclones would displace tens of millions of people in low-lying coastal areas of temperate and tropical Asia.	Adaptive capacity varies between countries depending on social structure, culture, economic capacity, and level of environmental degradation. Areas of concern include water and agriculture sectors, water resources, food security, biodiversity conservation and natural resource management, coastal zone management, and infrastructure. Capacity is increasing in some parts of Asia, for example the success of early warning systems for extreme weather events in Bangladesh, but is still constrained due to poor resource bases, inequalities in income, weak institutions, and limited technology.

Region	Likely Regional Impacts of Climate Change	Vulnerability and Adaptive Capacity
Latin America	Loss and retreat of glaciers would adversely impact runoff and water supply in areas where snowmelt is an important water resource. Floods and droughts would increase in frequency, and lead to poorer water quality in some areas. Increases in the intensity of tropical cyclones would change the risks to life, property, and ecosystems from heavy rain, flooding, storm surges, and wind damages. Coastal human settlements, productive activities, infrastructure, and mangrove ecosystems would be negatively affected by sea level rise.	Some social indicators have improved over the 1990s including adult literacy, life expectancy, and access to safe water. However, other factors such as high infant mortality, low secondary school enrolment, and high-income inequality contribute to limiting adaptive capacity. Areas of particular concern are agriculture, fisheries, water resource management, infrastructure, and health.
Small Island States	The projected sea level rise of 5 millimeters per year for the next 100 years would cause enhanced soil erosion, loss of land, poverty, dislocation of people, increased risk from storm surges, reduced resilience of coastal ecosystems, saltwater intrusion into freshwater resources, and high resource costs to respond to and adapt to changes. Coral reefs would be negatively affected by bleaching and by reduced calcification rates due to higher CO_2 levels; mangrove, sea grass bed, and other coastal ecosystems and the associated biodiversity would be adversely affected by rising temperatures and accelerated sea level rise.	Adaptive capacity of human systems is generally low in small island states, and vulnerability high; small island states are likely to be among the countries most seriously impacted by climate change. Areas of concern are food security, water resources, agriculture, biodiversity and coastal management, and tourism. Islands with very limited water supplies are highly vulnerable to the impacts of climate change on the water balance. Declines in coastal ecosystems would negatively impact reef fish and threaten reef fisheries, those who earn their livelihoods from reef fisheries, and those who rely on the fisheries as a significant food source. Limited arable land and soil salinization make agriculture of small islands, both for domestic food production and cash crop exports, highly vulnerable to climate change. Tourism, an important source of income and foreign exchange for many islands, would face severe disruption from climate change and sea level rise.

1.2 Developing Countries Will Be Particularly Affected

The impacts of climate change vary across geographical regions (IPCC 2001b). (See Table 1).

Some of the anticipated impacts of climate change are positive (see IPCC 2001b). For example, water-scarce regions such as parts of Southeast Asia may benefit from increased water availability. However, developing countries are likely to suffer most from the negative impacts of climate change (IPCC 2001b). This is due to the economic importance of climate-sensitive sectors (for example, agriculture and fisheries) for these countries, and to their limited human, institutional, and financial capacity to anticipate and respond to the direct and indirect effects of climate change. In general, the vulnerability is highest for least developed countries (LDCs) in the tropical and subtropical areas. Hence, the countries with the fewest resources are likely to bear the greatest burden of climate change in terms of loss of life and relative effect on investment and the economy (IPCC 2001b).

1.3 Adaptation is a Necessity

The extent and scope of regional climate change impacts depend on the degree of mitigation. While the urgency and scale of adaptation efforts required will be lower if aggressive mitigation is undertaken early on, some degree of adaptation is inevitable[2].

Reductions in emissions of greenhouse gases would delay and reduce damages caused by climate change (IPCC 2001c). Essentially, the lower the future stabilization level of atmospheric greenhouse gas concentration, the less would be the likely damage[3]. The UNFCCC states that: "the parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof." (Article 3.1 of the UNFCCC).

Even if greenhouse gas emissions were curbed immediately, the global average temperature would still continue to rise due to the slow response of the Earth's atmosphere system to past emissions. This suggests that any future levels of greenhouse gas concentration, once stabilized, will be above current levels.

1.4 Existing Vulnerability to Climate Variability

'Three years ago it was a very bad year. The flood washed away all of our crops, and there was a lot of hunger around here, to the point that many people actually died of hunger,' Benin 1994.

(Narayan et al. 2000)

Climate change is a very emotional subject for the Philippines because the issue is viewed not only as causing additional economic burdens, but as a critical factor that would determine its survival as a nation. Many of its people are in coastal areas and at risk from the impacts of extreme climatic events, sea level rise and degradation of marine ecosystems. The effects of climate change on agriculture, forestry and water resources will further encumber a country already reeling from a host of socio-economic and environmental problems.

(Philippines 1999)

Recent catastrophes … have shown that the poor are much more likely to be adversely affected than the non-poor. Because of the inadequate construction, poor people's dwellings are particularly vulnerable; and when affected have insufficient savings to address the emergencies.

(Nicaragua 2001)

Before addressing climate change adaptation in the context of development, it is important to recognize that today's climate already influences economic opportunities and development prospects. Poor countries and people tend to be particularly vulnerable to deviations from average climatic conditions and climatic extremes (OFDA/CRED; UNDP 2003b).

Climate and climate variability are therefore important elements of the complex web of factors influencing people's livelihoods. When comparing data on natural hazards in developing and developed countries, the loss of life and the number of people affected tend to be considerably larger in developing country regions for natural disasters of comparable magnitude. Damages in relation to GDP are usually also higher.

Bangladesh is a prime example of a country that is particularly vulnerable to today's climate. With a low-lying coastline, high population density, and an economy highly dependent on agriculture, the lives and livelihoods of people are threatened by frequent cyclones and the associated effects, such as saltwater intrusion, that render agricultural lands unproductive. Between 1974 and 1998, the country experienced seven major floods (Matin 1998). In 1998, about 68 percent of the country's geographical area was flooded, affecting more than 30 million people and causing 918 fatalities (Choudhury 1998). Economic losses were estimated at US$3.3 billion, equivalent to 8 percent of the country's GDP (Choudhury et al. 1999).

The impact of climate variability on countries is also well illustrated by the environmental and socioeconomic damages associated with El Niño. El Niño is a natural recurring climatic phenomenon associated with fluctuations in the atmospheric pressure and sea surface temperatures in the tropical Pacific Ocean. It affects the climate on a global scale, with the impacts concentrated in the tropical and subtropical regions. The shift in sea surface temperature is known to affect marine productivity. On land, El Niño is associated with floods and droughts in Latin America, Asia, and Africa, as well as changes in extreme events and the distribution of vector-borne diseases (IPCC 2001b). El Niño has caused loss of life, destroyed livelihoods, and affected national economies. For Ecuador, the overall costs of direct damages to agriculture, livestock and fishing associated with the 1997–98 El Niño constituted 4.7 % of its agricultural GDP. Loss of harvest and rising unemployment of agricultural workers led to an increase in the incidence of poverty by 10 percentage points in the affected municipalities (Vos et al. 1999).

Between 1970 and 1999 about 3.76 billion people were affected by natural disasters in Asia, explained in a large part by Asia's high population density in hazard prone areas. Africa had the second highest number of people affected by natural disasters, largely due to frequent occurrence and the long-term effects of droughts and the importance of the agricultural sector. For the regions of Latin America and the Caribbean, floods had the highest cumulative cost, followed by windstorms, earthquakes, and droughts (Charveriat 2000).

1.5 Already Stressed Coping Capacities

All societies and economies have developed mechanisms to cope with climate extremes and other natural hazards, which they face occasionally. Trade, migration, or precautionary storage of food are examples of strategies to cope with adverse climatic conditions.

This capacity to cope with climate variability and extreme weather events in itself is highly dependent on the level of economic development. In general, livelihood sources of the poor are usually narrower and more climate-sensitive than those of the non-poor. Extreme weather events, which would cause limited damage and few casualties in a developed country, often cause extensive damage and substantial loss of life in a developing country. Poor people are particularly vulnerable to deviations from average climatic conditions such as prolonged drought and to natural disasters such as floods. In periods of stress they may be forced to sell off their physical assets such as land, bicycles, and farming implements, thereby undermining the sustainability of their livelihoods over the longer term.

Among the poor, vulnerability varies, since some groups are more lacking in the financial, social, and political means of securing alternative livelihoods less exposed to risk than others. Women for example may be constrained by social and cultural structures that place them in inferior social positions, limiting their access to income, education, public voice, and survival mechanisms. In addition, the coping capacities of the poor are often

already strained due to a number of trends including HIV/AIDS, increasing population densities, and detrimental forces associated with globalization. Climate change will add to these trends and increase vulnerabilities.

1.6 Climate Change Compounding Existing Risks and Vulnerabilities

Traditional coping mechanisms are backward-looking, based on historical experience and observations. In the face of changing patterns of climate variability, and significant deviations from historical experience, their effectiveness may be significantly reduced. For example, in Tanzania, high rainfall due to the 1998 El Niño was followed by a two-year period of erratic rainfall. This climatic shock caused some of the poorer farmers to give up maize farming and opt instead to sell their labor at farms in other, more productive areas. The resulting dependence on physical working capacity as their sole endowment increased vulnerability, since malnutrition and disease can reduce their capacities for manual labor.

Since the mid-1970s El Niño events have become more frequent, persistent and intense than the opposite cool phase (IPCC 2001a). Whether this is already the result of climate change is the subject of ongoing scientific debate. However, such deviations from normal climatic conditions and previous experience illustrate the additional strain climate change is likely to exert on the poor, if no appropriate adaptation measures are taken. The poor will need to devote more of their already limited resources to coping with adverse climatic conditions.

Climate change may thus force drastic changes to livelihood strategies. Where economic diversification is low, income opportunities and hence options for developing alternative livelihoods in response to climatic changes may be limited. In some cases migration, which is an important coping strategy for poor people, might be the only solution, but will potentially cause social disruption.

The impacts of climate change on the poor will be context-specific, reflecting factors such as geographic location; economic, social, and cultural characteristics; prioritization and concerns of individuals, households, and social groups; as well as institutional and political constraints. The following points illustrate the impacts of climate change on poor people's livelihoods.

Ecosystem Goods and Services

The degree of local environmental degradation will influence the vulnerability of an ecosystem to climate change. Habitat fragmentation is already a leading cause of biodiversity loss and changes in temperature and moisture regimes further limit habitats necessary for the survival of species. Degradation of forested mountain slopes in conjunction with intensified rainfall may increase erosion and loss of fertile soil and affect the quality of watersheds. Climate change is likely to lead to changes in species distribution and abundance, and increase the risk of extinction and loss of biodiversity (IPCC 2001b).

Since some ecosystems are highly sensitive, even small changes can have large effects. Minor increases in water temperature can, for example, damage coral reefs, exacerbating other stresses such as pollution and over-fishing and thereby cause a reduction in fish stocks, jeopardizing fish- and tourism-dependent livelihoods.

Poor people are often directly dependent on goods and services from ecosystems, either as a primary or supplementary source of food, fodder, building materials, and fuel. This makes them highly vulnerable to ecosystem degradation. While local economic and social conditions drive poor people into marginal areas and force them to exploit natural resources to support their livelihoods, climate change further erodes the quality of the natural resource base, thereby reinforcing conditions of poverty.

Changes in ecosystem composition and provision of goods and services may also have wider economic effects. Essential ecosystem services include breaking down wastes and pollutants, purifying water, and maintaining soil fertility. Climate change will alter the quality and functioning of ecosystems, reducing their capacity to perform their role as important life support systems. This will have important impacts on key economic sectors such as agriculture, water supply, and others.

Water

Water scarcity is already a major problem for the world's poor. The number of people impacted by water scarcity is projected to increase from about 1.7 billion people today to around 5 billion people by 2025, independent of climate change (IPCC 2001b). Climate change is projected to further reduce water availability in many water scarce regions, particularly in the subtropics, due to increased frequency of droughts, increased evaporation, and changes in rainfall patterns and run-off.

Precipitation is expected to increase in equatorial, middle, and high latitude regions (IPCC 2001b), which tend to suffer less from water scarcity. As rainfall events are expected to become more intense, the incidence of floods may increase, jeopardizing human settlements and infrastructure.

Increases in temperature and changes in precipitation are projected to accelerate the retreat and loss of glaciers (IPCC 2001a; 2001b). Associated changes in the timing of streamflow will have downstream effects for agriculture. The melting of glaciers has become a serious concern in the Himalayan region, because of the growing risk of glacial lake out-burst floods (UNEP/ICIMOD 2002; Bhutan 2000).

Agriculture and Food Security

Agriculture is the most important sector for most least developed countries as the impact of agricultural growth on poverty reduction tends to exceed the impact of growth in other sectors (ODI 2002). Food security is a function of several interacting factors, including food production as well as food purchasing power. Climate change could worsen the prevalence of hunger through direct negative effects on production and indirect impacts on purchasing powers.

Land degradation, price shocks, and population growth are already a major concern for sustaining agricultural productivity. Changes in temperature, precipitation, and climatic extremes will add to the stress on agricultural resources in many developing country regions and reduce the quality of land areas for agricultural production. This will be particularly serious for areas where droughts and land degradation, including desertification, are already severe. As access to productive land is important for reducing rural poverty, the impacts of climate change on the productivity of land will further constrain efforts to combat rural poverty.

Low-lying coastal communities will have to deal with sea level rise and the impact of climate change on marine resources. Sea level rise may lead to salinization and render agriculture areas unproductive. In areas where fish constitute a significant source of protein for poor people, declining and migration of fish stocks due to climate change and associated changes in the marine environment will further need to

be considered in their impact on the local food security.

The impact of climate change on food supply varies significantly by region. In general, crop yields are projected to decrease in most tropical and subtropical regions due to changes in temperature and rainfall (IPCC 2001b). Consequently, there is a real risk that climate change will worsen food security and exacerbate hunger in some developing-country regions. In the short term, however, the greater impact on food security could come from the projected increases and severity of extreme weather events rather than from gradual changes in the climate (FAO 2002).

The impact of climate change on food security will be a major concern for Africa. In conjunction with the previously discussed changes in water supply, the production losses for Sub-Saharan countries could be substantial as the length of suitable growing periods decreases. Livestock activities and crop yields for many countries in Asia and Latin America are also projected to decrease.

Health

The potential impacts of climate change on human health would increase vulnerability and reduce opportunities by interfering with education and the ability to work. While any attempt at predicting and gauging the impact of climate change on human health is a complicated task, it is likely that climate change will have both direct and indirect adverse effects on human health.

A direct effect is an increase in temperature-related illnesses and deaths. Prolonged intense heat waves coupled with humidity may increase mortality and morbidity rates, particularly among the urban poor and the elderly. Another direct effect will be increased death and injury from extreme weather events such as flooding, landslides, and storms – over 96 percent of disaster-related deaths in recent years have taken place in developing countries (World Bank 2001).

Changes in temperature and rainfall may change the geographic range of vector-borne diseases such as malaria and dengue fever, exposing new populations to these diseases (see Box 1). Young children as well as pregnant women and their unborn children are especially vulnerable to malaria. Malaria contributes to perinatal mortality, low birth weight,

and maternal anemia (WHO 2002). The frequency and severity of malaria epidemics in East Africa already appear to have increased in correspondence with the increased frequency, magnitude, and persistence of the El Niño phenomenon over the past 20 to 30 years (McMichael et al. 1996).

Box 1

Climate Change Impacts on Malaria

Modeling based on IPCC (2001b) scenarios suggests that temperature rise by 2100 could lead to significant increases in potential breeding grounds for malaria in parts of Brazil, Southern Africa, and the Horn of Africa. In a few areas – such as parts of Namibia and the West African Sahel – malaria risk may fall due to excessive heat. In Africa, cities that currently are not at risk of malaria because of their high altitudes, such as Nairobi and Harare, may be newly at risk if the range in which the mosquito can live and breed increases.

Source: Gallup and Sachs 2000.

The net effect of climate change on malaria infections is still uncertain, and the impacts will vary

from region to region. Nevertheless, the close link of the occurrence of malaria and other vector-borne diseases with climatic parameters and the potential changes in the distribution ranges of such diseases warrant responsive health institutions, precautionary action, and monitoring.

Climate change–induced droughts, flooding and other extreme weather events degrade and reduce potable water supplies and increase water-associated diseases such as cholera and diarrhea, particularly in areas with inadequate sanitary infrastructures. Inadequate access to safe drinking water and sanitation, combined with poor hygiene practices, are major causes of ill health and life-threatening disease in developing countries. At present, these diseases already kill an estimated 2.213 million people per year in developing countries, of which about 90 percent are children under the age of five (Prüss et al. 2002). Women are particularly exposed to water-associated diseases through their traditional chores of washing and water collection.

Involuntary Displacement, Migration, and Conflicts

The direct and indirect effects of climate change and their interaction with other vulnerabilities and environmental exposures may lead to mass migrations, as crucial resources become degraded and livelihoods are threatened.

Loss of land mass in coastal areas due to sea level rise is, for example, likely to lead to greater permanent or semi-permanent displacement of populations, which may have considerable economic and political ramifications. Areas most vulnerable to sea level rise lie in the tropics: the west coast of Africa; the north and eastern coast of South America; South and Southeast Asia; and small island states in the Caribbean, Pacific and Indian Oceans (IPCC 2001a). Of the world's 19 mega-cities (those with over 10 million people), 16 are on coastlines and all but 4 are in the developing world. The poor living in Asian mega-cities are particularly at risk, as sea level rise compounds subsidence caused by excessive groundwater extraction in Manila, Bangkok, Shanghai, Dhaka, and Jakarta.

To this should be added the risk for potential conflicts, including social unrest, political instability, and wars over decreasing water or other natural resources and possible mass migration due to, for example, land loss or degradation and extreme weather events. Such conflicts may have considerable costs both in macroeconomic terms and in human suffering.

Economy-Wide Effects

Climate change is expected to have effects on the overall economy of poor countries, thus hampering potential for economic growth. In addition, poor adaptation (see glossary) will increase the impacts of extreme events, increasing the costs of rehabilitation and diverting funds from longer-term development purposes.

Current extreme weather events are already taking their toll on developing countries' economies, leading to loss of human and economic capital. Regions where climate change exacerbates climatic extremes and which have limited adaptive capacity will be further constrained in their development prospects due to additional loss of life, private assets, reduced productivity of important economic sectors, and destruction of infrastructure [4].

This is particularly true for small countries and countries with low economic diversity, where the impact of climatic extremes cannot be well absorbed by economic activity in other regions or sectors (Box 2).

Box 2

Impacts of Climate Change on Small Island States: The Pacific

The Pacific Islands are becoming increasingly vulnerable to extreme weather events as growing urbanization and squatter settlements, degradation of coastal ecosystems, and rapidly developing infrastructure on coastal areas intensify the islands' natural exposure to climate events. In the 1990s alone, the cost of cyclones and typhoons exceeded US$800 million, while the 1997 drought cost upwards of US$175 million even before nutrition-related deficiencies were taken into account. During the 1997–98 drought in Fiji US$18 million in food and water rations had to be distributed.

Source: IPCC 2001b; IFRC-RCS 2002; World Bank 2000.

Even though both people and systems appear to be generally more vulnerable to sudden disruptive changes than gradual ones, long-term climate change can be just as harmful. Changes in average climatic conditions, as well as extremes, and loss of productive areas due to sea level rise, have both been highlighted in their projected impacts on the agricultural sector. Countries where tourism represents a major source of income may be affected by a decrease in revenues due to the effects of both gradual climatic changes and extreme weather events. Such events are likely to alter the attractiveness of certain holiday destinations, for example coral reef mortality is expected to reduce income opportunities for local populations in some regions. All these factors can affect GDP, balance of payments, level of indebtedness, state of public finances, and may divert investments from important development objectives.

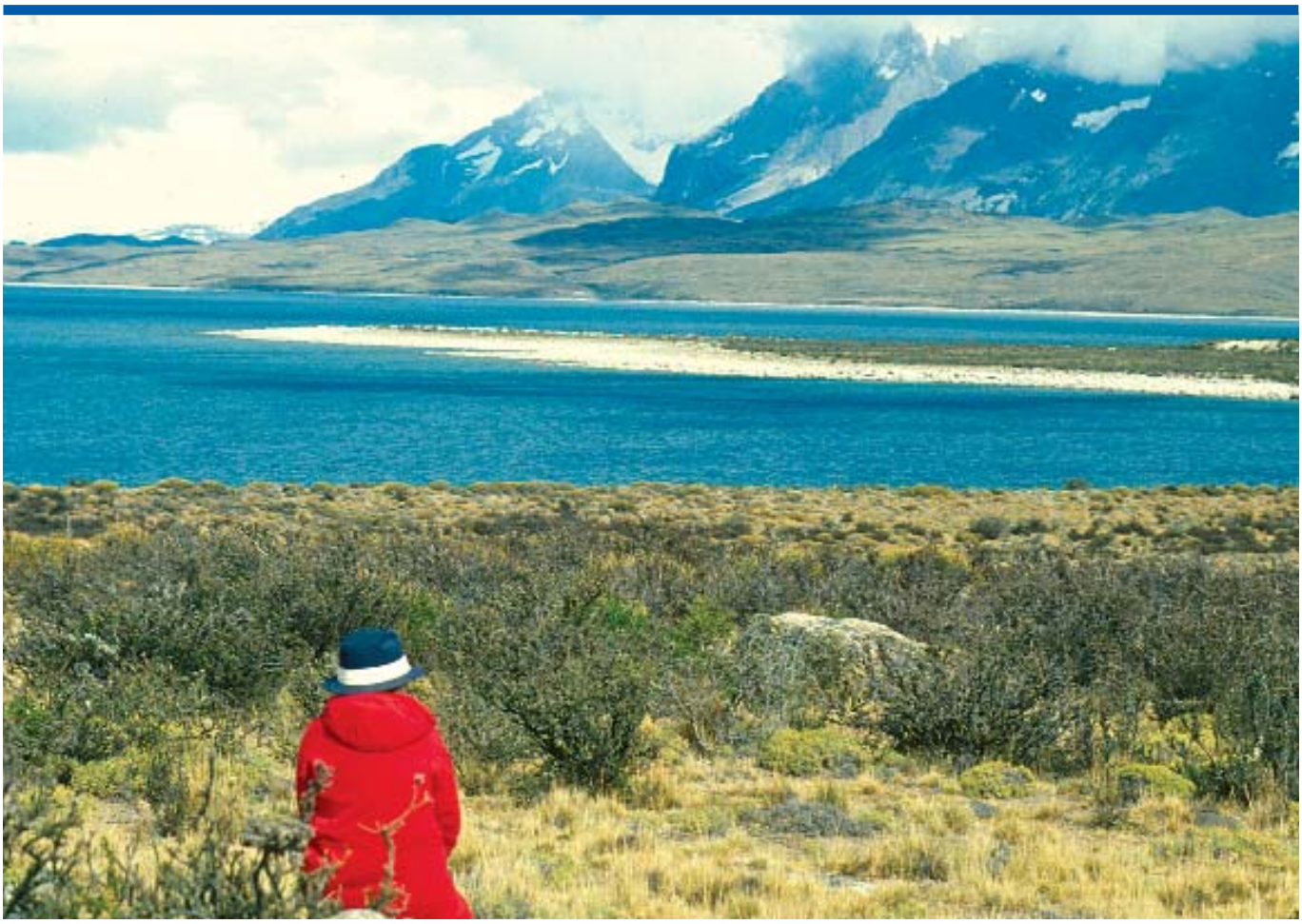
1.7 Implications for Poverty Eradication

Part 1 has so far illustrated that even though climate change is a global threat, it is also very much a problem for development, since poorer countries, having the least adaptive capacity and hence the most vulnerable populations, are expected to suffer the greatest adverse effects. This is because many of the world's poor are found in geographically vulnerable places, and live under vulnerable environmental, socioeconomic, institutional, and political conditions.

Climate change provides an additional threat that adds to, interacts with, and can reinforce existing risks, placing additional strains on the livelihoods and coping strategies of the poor. In 2000, leaders of 189 nations agreed on the Millennium Declaration that outlined eight fundamental goals. Climate change challenges the achievement of the

Table 2
Potential Impacts of Climate Change on the Millennium Development Goals

Millennium Development Goals: Climate Change as a Cross-Cutting Issue	
Millennium Development Goal	**Examples of Links with Climate Change**
Eradicate extreme poverty and hunger (**Goal 1**)	● Climate change is projected to reduce poor people's livelihood assets, for example, health, access to water, homes, and infrastructure. ● Climate change is expected to alter the path and rate of economic growth due to changes in natural systems and resources, infrastructure, and labor productivity. A reduction in economic growth directly impacts poverty through reduced income opportunities. ● Climate change is projected to alter regional food security. In particular in Africa, food security is expected to worsen.
Health related goals: ● Combat major diseases ● Reduce infant mortality ● Improve maternal health (**Goals 4, 5 & 6**)	● Direct effects of climate change include increases in heat-related mortality and illness associated with heat waves (which may be balanced by less winter cold-related deaths in some regions). ● Climate change may increase the prevalence of some vector-borne diseases (for example malaria and dengue fever), and vulnerability to water, food, or person-to-person borne diseases (for example cholera and dysentery). ● Children and pregnant women are particularly susceptible to vector and water-borne diseases. Anemia – resulting from malaria – is responsible for a quarter of maternal mortality. ● Climate change will likely result in declining quantity and quality of drinking water, which is a prerequisite for good health, and exacerbate malnutrition – an important source of ill health among children – by reducing natural resource productivity and threatening food security, particularly in Sub-Saharan Africa.
Achieve universal primary education (**Goal 2**)	● Links to climate change are less direct, but loss of livelihood assets (social, natural, physical, human, and financial capital) may reduce opportunities for full-time education in numerous ways. Natural disasters and drought reduce children's available time (which may be diverted to household tasks), while displacement and migration can reduce access to education opportunities.
Promote gender equality and empower women (**Goal 3**)	● Climate change is expected to exacerbate current gender inequalities. Depletion of natural resources and decreasing agricultural productivity may place additional burdens on women's health and reduce time available to participate in decision making processes and income generating activities. ● Climate related disasters have been found to impact more severely on female-headed households, particularly where they have fewer assets to start with.
Ensure environmental sustainability (**Goal 7**)	● Climate change will alter the quality and productivity of natural resources and ecosystems, some of which may be irreversibly damaged, and these changes may also decrease biological diversity and compound existing environmental degradation.
Global partnerships	● Global climate change is a global issue and response requires global cooperation, especially to help developing countries to adapt to the adverse impacts of climate change.



Millennium Development Goals (MDGs) and related national poverty eradication and sustainable development objectives. Unless concrete and urgent steps are undertaken to reduce vulnerability and enhance adaptive capacity of poor people, and unless these actions are integrated in national strategies for poverty eradication and sustainable development, it may be difficult to meet some MDGs by 2015 (Table 2).

Strategies to strengthen capacity to cope with current climate variability and extremes and to adapt to expected future climatic conditions are mutually supportive and will have immediate benefits. They will also help identify and take advantage of the positive impacts of climate change.

There is much experience to date of coping with climate variability and disasters from which useful lessons for adaptation can be drawn. Ensuring that the poor are able to adapt to current and imminent climate variability is the first step. The task ahead for the development community is to enhance the adaptive capacity of the poor and poor countries and to help to implement specific actions for addressing climate change impacts. With this in mind, Part 2 discusses lessons learned from past experience with coping with climate variability.

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Review

Investigating Vulnerability, Adaptation, and Resilience: A Comprehensive Review within the Context of Climate Change

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Abstract: This review seeks to enhance the understanding of the critical concepts of vulnerability, adaptation, and resilience within the context of global environmental challenges, with a particular focus on climate change. Climate change is characterized by rising global temperatures and an increase in extreme weather events, making the comprehension and addressing of these concepts crucial for effective adaptation strategies. Despite widespread recognition of the interconnectedness of vulnerability, adaptation, and resilience, there remains a gap in a comprehensive understanding of how these concepts interrelate. Through synthesizing existing literature, this review provides a detailed examination of their definitions and the interrelationships among vulnerability, adaptation, resilience, and climate-related disasters. Additionally, it explores the impact of climate change on future disaster risk reduction efforts by analyzing the nexus between climate change adaptation and disaster risk reduction. Key findings highlight the necessity of incorporating social, institutional, economic, and environmental factors into adaptation planning and call for innovative approaches to boost adaptive capacity and resilience. This review not only furthers the discourse in research, policy, and practice in this vital area but also offers strategic insights for developing more resilient and adaptive societies amidst the challenges posed by climate change.

Keywords: vulnerability; adaptation; resilience; climate change; disaster risk reduction

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1. Introduction

Climate change has intensified extreme weather events, leading to an increase and normalization of climate-related natural disasters globally. These events have had a devastating impact on human lives and pose a significant threat worldwide. Climate change-related disaster extreme events, whether they are created by nature or by humans, make adaptation challenging and result in catastrophic property losses and the paralysis of income and livelihoods [1]. Unfortunately, additional natural catastrophes caused by climate change, such as floods, heat waves, droughts, and other multi-hazard situations, have been impacting many countries and regions around the world.

The impacts of climate change are vast and already significantly affecting various sectors, including national income, economic growth, agriculture, industry, and tourism, as well as human health, labor productivity, energy demand, and even political stability and migration patterns. Particularly in developing countries, vulnerable populations striving for sustainable development face additional threats from increased temperatures, unpredictable extreme weather events, and shifts in precipitation patterns [2]. Climate change influences people's lives both directly and indirectly by disrupting the environmental and social determinants of health [3]. It poses comprehensive challenges to public health, manifested through rising global temperatures [4], more frequent and intense heatwaves [4,5], increased incidents of injuries and deaths due to extreme heat and wildfires [3,6], alongside a decrease in cold-related mortality [7]. Moreover, climate change escalates the risks of floods and droughts [8], facilitates the spread of infectious diseases, alters the distribution

and severity of disaster risks, and increases malnutrition [4,9]. Beyond physical health, extreme weather events are also a significant source of acute mental health issues, including anxiety, depression, and post-traumatic stress disorder [10,11], especially for children who experience the cumulative effects of exposure to disasters [12]. The ongoing loss of livelihoods, displacement, disruption of social cohesion, and the overarching uncertainty brought about by climate change can lead to long-term mental health disorders, highlighting the need for comprehensive strategies to address both the immediate and extended impacts of climate change on human well-being [13].

These events have significant adverse effects on society as they intensify natural environmental processes and result in catastrophes. While natural disasters can strike anywhere, their impacts can be mitigated, even if the events themselves are unavoidable [14]. The extent to which climate change affects different regions depends largely on the vulnerability of their natural ecosystems and infrastructure to climate-related changes and extreme weather events, as well as their capacity to respond and adapt to new environmental conditions [15].

In recent decades, the rapid acceleration of climate change has highlighted the critical need for a comprehensive understanding of and effective responses to its complex impacts. Addressing vulnerability, adaptation, resilience, and the growing frequency of climate-related disasters has become increasingly important. Central to this challenge are the concepts of vulnerability, adaptation, resilience, and the significant challenges posed by the more frequent climate-related disasters to societies worldwide. Although various definitions and conceptual frameworks for resilience exist, particularly in the context of disasters, a universally accepted definition of catastrophe resilience remains elusive. However, these definitions commonly emphasize three core elements: disaster resilience, adaptive capability/adaptation, and vulnerability. Resilience and vulnerability are key concepts across numerous scientific disciplines [16,17] and have gained prominence in efforts to minimize disaster risks. Some scholars consider resilience as a concept integrated within a framework of vulnerability [18,19]. According to Klein and Thomalla [20], resilience influences adaptive capacity. Furthermore, several studies have identified resilience as a component of adaptive ability [21], underscoring its importance in managing and mitigating the impacts of climate change and disasters.

Regardless of the focus on vulnerability, resilience, or adaptation in specific research, the field of disaster research has significantly addressed their interconnectedness. The frequent, high-risk, and abrupt nature of hazards associated with climate change demands policies and processes that are not only more rigorous and refined but also resilient and adaptive. This requires a deep understanding of how vulnerability, resilience, and adaptation are interlinked and grounded in a comprehensive risk analysis. Such analysis is essential to evaluate our experiences, responses, and actions, enabling the development and enhancement of prevention and response strategies. These strategies are crucial for adapting to climate change and preparing for future catastrophic events.

In this context, this review seeks to critically analyze the existing body of literature on vulnerability, adaptation, resilience, and climate crises. This review used a variety of academic databases, including Web of Science and Google Scholar, and used keyword combination searches to ensure that a wide range of literature resources were obtained. After an initial screening, we assessed the quality and relevance of the selected literature, paying particular attention to the definition and understanding of concepts such as vulnerability, adaptability, and resilience. This review strives to deepen the understanding of how these concepts are interconnected and their significance for efforts to adapt to climate change. By synthesizing and evaluating a wide array of studies, inductive and comprehensive analysis methods were used to organize and summarize the extracted data and present the results of the literature review in the form of text descriptions, charts, and tables, clearly demonstrating the differences in different kinds of literature. Definitions and relationships of vulnerability, adaptation, resilience, and the climate crisis are provided. Our goal is to shed light on the intricate dynamics between these concepts while identifying new trends,

pinpointing gaps, and suggesting directions for future research. This comprehensive examination of the literature provides a detailed exploration of the definitions and relationships between vulnerability, adaptation, resilience, and climate-related disasters. The aim of this review is to enhance collective comprehension of the complex challenges presented by climate change, thereby supporting the development of evidence-based policies and interventions aimed at bolstering societal resilience against climate-induced disasters and uncertainties. Furthermore, we explore the impact of climate change on future disaster risk reduction efforts by delving into the interplay between climate change adaptation and disaster risk management.

2. Overview of the Concepts of Vulnerability, Adaptation, and Resilience

2.1. Vulnerability

Birkmann [22] explores the evolution of the concept of vulnerability, initially defined narrowly to focus solely on the inherent characteristics of natural hazards and their associated risks. This perspective gradually shifted towards a more human-centered view, emphasizing the potential for harm to individuals. The definition was further expanded to encompass sensitivity and the capacity for adaptation. Thus, exposure and adaptability are considered separate yet integral aspects of vulnerability. Consequently, the widely recognized definition of vulnerability now embraces a multidimensional approach, incorporating institutional, economic, social, and physical dimensions.

Dow [23] posits that individuals, communities, ecosystems, and technological entities all exhibit vulnerability. This vulnerability is defined and assessed based on its capacity to respond to specific hazards, such as floods, earthquakes, or droughts, acknowledging that this capacity varies greatly. While few may consider themselves invulnerable, others may perceive them as such. Vulnerability can be described through three key factors: exposure, capability, and potential for recovery. The human-centered approach to vulnerability, according to this framework, focuses on the ability of individuals or groups to anticipate, cope with, manage, and recover from the impact of natural hazards [24]. Therefore, strategies aimed at reducing vulnerability typically involve decreasing exposure, enhancing coping mechanisms, improving recovery potential, and strengthening damage mitigation efforts to minimize adverse effects. Pelling [25] identifies three critical components of vulnerability: exposure, resistance (the capacity to withstand negative impacts), and resilience (the ability to adapt and recover). The concept emphasizes the ability of people or communities to predict, manage, resist, and recuperate from environmental hazards. Factors such as age, gender, race/ethnicity, social standing, physical and mental health, educational level, and religious beliefs all contribute to defining vulnerability [26]. Therefore, standard and recommended responses to vulnerability typically involve reducing exposure, enhancing coping abilities, boosting recovery capacity, and fortifying damage control measures to minimize adverse effects. Turner et al. [27] define vulnerability as "the extent to which a system, subsystem, or component of a system is susceptible to damage when subjected to hazards".

Vulnerability is exposure to stressors and unforeseen circumstances, as well as the difficulty of coping with them [28]. Hence, vulnerability has two facets: an internal component of defenselessness, which denotes an inability to cope without suffering losses, and an external aspect of the dangers, shocks, and pressures to which an individual or household is exposed. The state of a particular region in terms of risk, exposure, readiness, prevention, and reaction qualities to a certain natural hazard is known as vulnerability. It assesses this group of elements' capacity to survive an event with physical features [29]. The link between vulnerability and resilience is the subject of disaster risk [30].

Vulnerability has been defined from a sociological perspective as the flaws in social structures when they are paired with outside influences that lead to disasters. The genesis of disasters lies in the very nature of the social system [31]. According to this theory, disasters are a blatant illustration of underlying social vulnerability, or more specifically, a flaw in the social system or structure. The mechanism by which disasters originate is

their source or cause. They should not be viewed as outside factors influencing the social system, like how an appearance disaster goes beyond how the danger affects the victims' various lifestyles. Instead, disasters have their roots in the flaws of the social structure that have revealed themselves, depending on the dynamics of that system. This claim puts forth the sociological stance that the primary cause of disasters is the social system's "underlying" fragility or weakness. As a result, a natural disaster—like a flood—occurring in two separate towns might have very different effects and implications. One group may experience societal devastation, while the other may not. The distinguishing characteristic will be the inherent strengths of each community's vulnerability (or resilience and fragility).

Vulnerability is the danger that could be brought about by several people, things, activities, or projects that are put at risk. This risk can be brought on by natural, technological, social, purposeful, or complex dangers, and it may result in a disaster. Vulnerability is a social construct since decision-making processes primarily consider social, economic, political, and cultural aspects. For instance, vulnerability can be divided into six groups based on social origin and external threats/causes: 1. Total vulnerability: resulting from a lack of planning or readiness to deal with the possibility of a disaster; 2. Economic vulnerability: resulting from a shortage of suitable jobs; 3. Technological or technical vulnerability: resulting from technological dangers; 4. Persistent vulnerability: a lack of adaptation in modernization; 5. The susceptibility to delinquency: brought on by dishonesty, carelessness, and other wrongdoing; 6. New vulnerabilities: brought on by environmental changes [32].

Vulnerability is a result of the inability to access resources and a lack of coping skills, and these two factors are indicated by four indicators: "poverty, marginalization, and access to resources; resource dependence and diversity; inequality and marginalization; and the sufficiency of institutional structures to enhance resilience". The extent to which governmental institutions and "market structures" exist in impacted communities, as well as how easily or difficult it is for them to adjust to and cope with disasters, all play a significant role in how vulnerable they are. This perspective is comparable to sociological thought, which sees agents' behavior—not vulnerability—as the product of social systems [33].

In the field of climate change, vulnerability has a complex relationship with this occurring climate change; for example, it is wide-ranging and involves many factors [34]. Ford views climate change as a stimulus that may cause damage to the system and vulnerability as the risk of exposure. Therefore, vulnerability is highly dependent on the nature of the stimulus, including its intensity, frequency, spatial distribution, duration, and impact on exposure [35].

Vulnerability describes the study of climate change and its related fields of natural hazards and disaster management, ecology, public health, poverty and development, secure livelihoods and famine, sustainability science, and land change [36]. Related research on vulnerability seeks to determine where, how, and why human systems are affected by climate change [37].

Vulnerability assessment is a commonly used tool to represent the potential for damage to human and ecological value systems in response to global climate change [21]. Vulnerability depends on estimates of potential climate change and adaptive responses, and the degree of vulnerability is determined by the adverse consequences that remain after the adaptation process has occurred [38]. Climate-related vulnerability assessments consider various factors, including the characteristics of the vulnerable system, the type and number of stressors, their root causes, their impact on the system, and the time frame of the assessment [39].

Moss et al. [40] identified three dimensions of vulnerability to climate change. The first is the physical environment dimension, which accounts for hazards caused by climate, referring to the climatic conditions in a region and the biophysical effects of climate change, such as changes in agricultural productivity or the distribution vectors of diseases. The second is the socioeconomic dimension, which refers to a region's ability to recover from extreme events and adapt to long-term changes. The third dimension, external aid, refers

to the extent to which a region has access to assistance as it attempts to adapt to change. This aid may come from allies and trading partners, diaspora communities in other regions, and international arrangements.

2.2. Adaptive Capacity and Adaptation

Adaptive capacity does not only refer to the static capacity of the system to prevent disturbances but also encompasses the mobilization of various resources of the system to respond to changes in the external environment [41]. Adaptive change occurs over several stages that integrate collective subjectivity and coordinated behaviors over time and space (preparation, reaction, recovery, and transformation) [42].

As the effects of climate change on social and natural systems continue to worsen, it has been widely acknowledged that human societies must adapt to the changing climate [43]. Adaptation is often the result of the interaction of climate and other factors. Adaptation to changes depends not only on climatic stimuli but also on respecting other non-climatic conditions, sometimes called intervening conditions, which help to influence the sensitivity of the system and its property adjustments. For example, a series of droughts may have similar effects on crops. Two regions may have different yields but different economic and institutional arrangements. The two regions are likely to have very different effects on farmers, and therefore adaptive responses in both the short and long term are significantly different [44]. Hazards and vulnerability need to be considered when examining how climate change affects catastrophe risk [45]. Adaptation takes place in response to rapid changes in technology, globalization processes, and demographic, cultural, environmental, and economic changes [46].

Some researchers view resilience as an aspect of adaptive capacity [47], while others see adaptive capacity as a component of resilience [21,48]. Adaptation is the act of managing a system's resilience, with adaptability being the ability of individuals within a system to influence that resilience [49]. This concept highlights human abilities to manage resilience within social-ecological systems. Generally, adaptation is defined as the process, action, or capacity of an individual or system to modify its inherent genetic or behavioral characteristics to better cope with change, often through social learning. To reduce future catastrophes, community resilience must incorporate "passive and active aspects" that bring together adversity recovery (pre-element) and environmental adjustments [50]. To respond to unpredictable disturbances, adaptation entails the avoidance of risks and the exploitation of advantageous possibilities, which includes reducing negative impacts and maximizing their potential opportunities [51]. Since adaptive capacity is "location and context specific", it is strongly route-dependent [52]. This comprehensive approach to vulnerability and resilience contends that knowledge of physical change alone does not shield society from the risk of climate change, and governments, communities, and organizations may learn a lot from it. Human institutions can play a vital role in minimizing the adverse effects of climate change and seizing the opportunities it presents. In particular, the role of adaptation is crucial for assessing the potential impacts of climate change [44]. Also, the forecast may not offer what one might expect given the non-linear findings of natural hazard causation from the point of climate change. Even if one is fully aware of a particular natural hazard's features, adaptation may still fail owing to a lack of resources, paired pressures from other hazards, such as technical dangers, deteriorating social connections, a lack of institutions, etc. Likewise, infrastructures influence individual adaptability because they determine a system's access to resources. Information has always been an important part of developing strategy. In climate change scenarios, a better understanding of the nature of weather hazards and changes enables systems to study, analyze, plan, and implement adaptation measures. Systems are better able to formulate strategies, thus increasing their ability to adapt [34]. It is also crucial to remember that social approval in its traditional sense will not exist. A society will automatically adapt if there is a lack of political will and motivation [53]. Hazards, exposure, resilience, and adaptive capacity continue to be influenced by similar amounts of risk as well as the type of social risk components as their

configurations change. This is because the adaptability of the system is not fixed and will change with time, region, and society. The economic situation of a country or group is one of the decisive factors affecting adaptive capacity, such that rich countries are better able to withstand the costs of climate change impacts and risks than poorer countries [34].

2.3. Resilience

The term "resilience" was first used by Holling to refer to "a measure of the persistence of a system" and "its ability to absorb changes and disturbances and still preserve the same relationship between populations or state variables" [54]. As more countries acknowledge that not all threats or disasters can be prevented and that they cannot eliminate all risks, resilience has become increasingly important recently [55]. Instead, nations must learn to adapt to risks and manage them in ways that have the least detrimental effects on people and other systems. Resilience is a term used in the world of disaster management to describe the capacity to cope under difficult conditions in the face of great hardship. To maintain some relevance in the disaster sector, its philosophical foundations must be established in the body of catastrophe knowledge.

According to Bruneau et al. [48], the term "resilience" is frequently used across several academic fields; these fields define "elasticity" as "the ability of a material or system to restore equilibrium after displacement" [56]. Some scholars contend that resilience "should entail initial loss of function and subsequent recovery, followed by quick restoration of important functions" from a psychological point of view [57]. Notwithstanding the effects of the traumatic incident, resilient individuals or communities can recover to a state that restores "basic functioning". This method views resilience as a quality that is be-stowed upon the impacted subjects, whether they be resilient individuals, resilient groups, or resilient communities. Those who are resilient can be described as unstoppable, buoyant, persistent, and flexible: those who recover from trauma exposure [58].

According to the majority of resilience researchers, resilience is defined as the capability of a social system's to "bounce back" from adversity [59]. This word suggests the capacity to adjust to normal or anticipated levels of stress to account for unexpected shocks and needs. This idea can be viewed as a strategy in the context of hazards that includes both pre-event and post-event actions intended to stop damage and loss caused by hazards as well as to react to and lessen the effects of disasters.

It is believed that social systems' capacity to deal with and recover from disasters is influenced by both innate elements that help them absorb the effects of disasters and recover from them and post-event adaptation processes that support social systems' capacity to reorganize, change, and learn in response to threats [19]. Recovery is defined by Fisher et al. [60] as "returning and/or recovering to a level of normal functioning as rapidly and efficiently as possible".

When considering natural catastrophes, resilience is a crucial concept commonly defined as the ability to withstand and bounce back from losses resulting from disasters [30]. Although vulnerability and resilience are distinct concepts, Engle [61] points out that they are connected through adaptive capability. As the idea has been used in so many different contexts, there is not a single definition that is universally recognized. From a cross-domain viewpoint, some scholars offer an interpretive study of resilience, identifying three levels of description for each resilience domain [62]. Some scholars consider the population's capacity to lower risk, prevent loss, and recover from social disturbance with little to no disruption, as well as their inner fortitude and capacity for adaptability in the face of environmental shocks and disruptive occurrences [18,63,64].

Although there is not one widely accepted definition of resilience, there are at least three that can be used to describe it [65]: response to perturbations, self-organization, and learning and adaptability are the first three. Building and developing resilience in the context of climate change is an important but complex social process [66]. When it comes to urban climate adaptation, a resilience-based approach encourages practitioners to consider innovation and change to help recover from possible or unpredictable stresses

and shocks. For complex social-ecological systems that are dynamic and face high levels of uncertainty, resilience as a strategic approach offers many advantages over traditional system management [49]. As the conceptualization of resilience becomes more advanced, resilience shifts from being more outcome-oriented to being more process-oriented. The goal of disaster risk management is to reduce the number of fatalities and livelihood for post-disaster and disaster victims while ensuring that the community or system returns to normal as quickly as feasible. While it would be illogical to portray this negatively, it should be possible to make the case that resilience is connected to people's capability to go beyond the bare necessities of survival [67]. The Climate-Related Hazards Community Resilience Framework (CDCRF) in the context of climate change focuses on climate change-related hazards such as coastal hazards such as floods and hurricanes [68]. Although the hazard framework can be applied to different geographical areas regardless of the types of hazards they face, conceptualizing resilience to a specific hazard or set of hazards limits its applicability to regions where these hazards exist. For example, as climate change continues, poorer areas may be more severely affected than other areas. Therefore, enhancing the regional ability to withstand climate change disturbances and enhancing the long-term stability of the economy, society, and environment, that is, building sustainable resilience in response to climate change, is the key to human prosperity and social development [69].

3. Exploring the Relationships between Vulnerability, Adaptation, and Resilience

Although vulnerability and resilience are distinct concepts, Engle [61] argues that they are linked by adaptive capacity and that resilience is frequently viewed as a positive aspect of resilience, with vulnerability and adaptive capacity serving as the concept of disaster. In a vulnerability framework, Gallopin [70] merges the elements of resilience and adaptation capacity into responsiveness; resilience is a subset of responsiveness, which is itself a subset of sensitivity, exposure, and responsiveness.

The processes underlying exposure, sensitivity, and adaptive ability are frequently interconnected and intrinsically intertwined at various dimensions [71]. The ability to adapt varies with scale and location, with country, community, social group, and individual differences, as well as with time.

According to Lucini, Zhou et al., and Nelson, these are connected ideas rather than being diametrically opposed [30,41,59]. They both effectively convey the key elements of how people proactively react to forces of change, the two concepts are not opposites; rather, they are connected, exhibiting features of systems or victims that may be at risk. Resilience and vulnerability are opposite extremes of a continuum, demonstrating susceptibility to unfavorable or benign consequences when exposed to high-risk contexts [72]. In other words, while vulnerability indicates unfavorable results after adversity, resilience represents positive results. The distinctions between vulnerability and resilience, as well as other related notions like adaptability and adaptive capacity, are sometimes hazy despite being extensively explored [19,21,70].

In the context of climate change, vulnerability is viewed as a consequence of a community's exposure to climate change and its capacity for adaptation (i.e., how the community transforms itself to cope with those conditions) [35,73]. This notion of vulnerability includes two elements: exposure to risks and capacity for adaptation. Ford and Smit view resilience and adaptive capacity as a subset of vulnerability when resilience is considered as a term that is somewhat comparable to adaptive capacity [35].

The IPCC links the ideas of adaptation, vulnerability, and resilience with the social goals of equity, health, and well-being, as outlined in the Paris Agreement. The concept of vulnerability offers a unique perspective into the effects of climate change on diverse communities, people, and ecosystems, particularly considering factors such as racial, gender, and wealth inequality. Resilience, being a broad term, encompasses both outcomes and processes. It involves maintaining necessary functions and having the potential to transform. If implemented effectively, resilience efforts will support the creation of a

climate-resilient society, advance the objectives of sustainable development, and address social objectives of equity, well-being, and ecosystem health [74].

Hence, disaster resilience should encompass not only the capacity to "bounce back" or "move on" following a disaster [75], but also the capacity to proactively rebuild and adjust oneself to handle future disasters more effectively. Restoring internal balance is only one aspect of community resilience, but it must also facilitate growth. Therefore, being disaster-resilient entails proactively rebuilding and adjusting to better handle future calamities. Community resilience encompasses the power to rebound from a catastrophe as well as the ability to restore homeostasis. In other words, the process of developing resilience following a disaster must include the social change that occurs as the impacted society adjusts to its new environment.

Lei et al. [51] conceptualize the relationship between vulnerability, adaptation, and resilience in terms of disaster risk. Adaptation is the proactive change of one's structure and function to adapt to environmental changes or associated hazards. In contrast to resilience, which is typically a proactive response to a crisis, adaptation is typically a proactive move in the event of a disaster that is predicted to reduce any potential risks or negative effects beforehand. To enable the transformation of transient resilient reactions into durable strategies, adaptation typically denotes a long-term process. Systems have an inherent vulnerability that makes them susceptible to the negative effects of hazards and enhances readiness for prospective dangers. Resilience is the capacity to withstand, take in, adapt to, and recover from the consequences of risks quickly and effectively. This capacity is typically a reactive response to continuous dangers. Contrarily, adaptation is generally proactive behavior in reaction to impending dangers to reduce any risks or adverse effects. Long-term adaptation (LTA) and short-term adaptation (STA) are two more divisions of the adaptation process (LTA).

Based on these prior conceptualizations, the concepts of resilience, vulnerability, resilience, and adaptive capacity were originally interrelated rather than mutually inclusive (Figure 1). Resilience includes the response and recovery when a disaster occurs, and the ability to quickly return to a normal state or even develop from a disaster; adaptation refers to adaptability and sustainability, the process by which individuals and groups proactively respond to changes through continuous learning; exposure and sensitivity is a factor that characterizes vulnerability, including multidimensional exposures and sensitivities, the ability to anticipate risks, and manage and bear negative consequences.

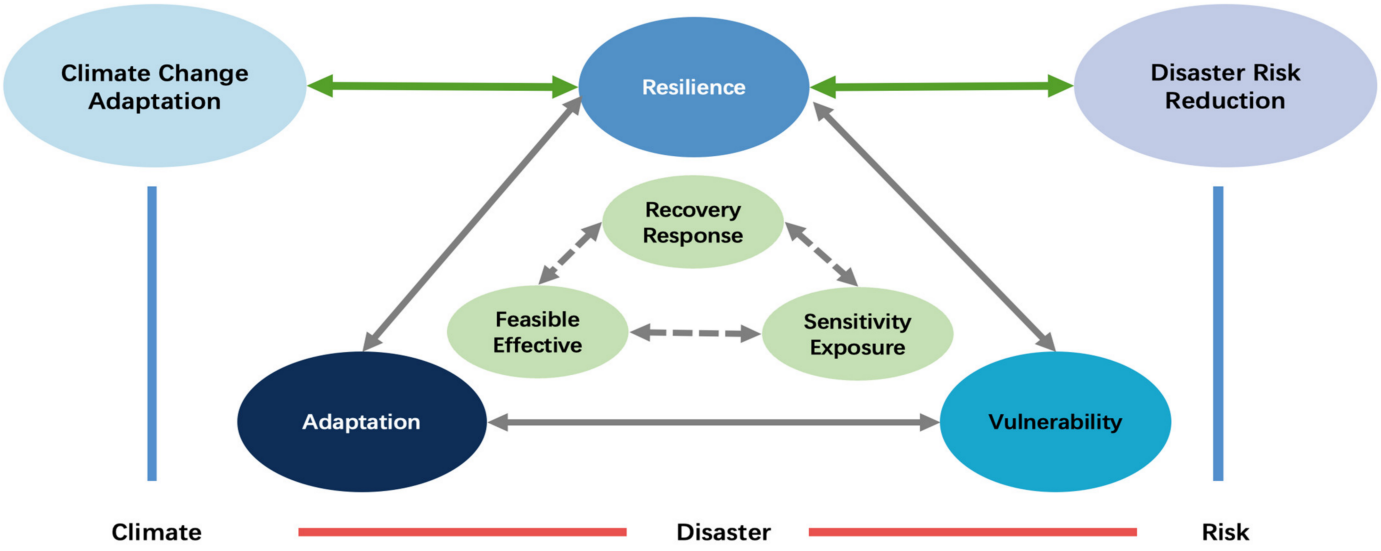

Figure 1. Links between vulnerability, adaptation, and resilience.

4. Climate Change and Climate-Related Disaster

4.1. Climate Change

One of today's most significant global challenges is climate change, posing numerous ecological, environmental, social, and economic threats to human survival and development. The changing global climate emerges as a new global threat that plagues modern society [76]. Both human activities and natural environmental changes contribute significantly to global climate change, with human-induced greenhouse gas emissions being the primary driver of global warming [77,78]. Global warming has led to adverse effects such as melting glaciers, rising sea levels, and an increase in extreme weather events, including heatwaves, droughts, intense tropical storms, and heavy precipitation [79]. According to the 2022 IPCC report, anthropogenic climate change, including more frequent and severe extreme events, has caused widespread damage to nature and human systems, surpassing the normal rate of climate variability. Vulnerable populations and systems seem to be disproportionately affected across various sectors and geographical regions. Extreme weather and climate events are on the rise, exceeding the capacity of both natural and human systems to adapt and resulting in irreversible consequences [74]. The United Nations Framework Convention on Climate Change (UN-FCCC) defines climate change as "climate change that is directly or indirectly attributable to human activities, which alters the composition of the global atmosphere and is in addition to the natural rate of climate variability observed over comparable periods" [80]. This definition is in line with and expands upon that definition.

Climate change is a complicated and enduring threat that is both a natural occurrence and a danger brought on by human-caused emissions of greenhouse gases. According to the IPCC [81], a discernible change in the status of the climate is called climate change, for instance, through statistical analyses of its mean values and/or variability, and that lasts for a long time, typically decades or more. A new notion of climate change, distinguished into "anthropogenic climate change" and "natural climatic variability", has been developed by the UNFCCC. Science investigates all climate change without considering the sources of change, but the international policy process solely considers anthropogenic climate change. This is the major distinction between the IPCC and UNFCCC definitions. While the Earth has endured significant changes long before human existence, both the IPCC and UNFCCC agree that human impacts on climate are likely to push the planet into a state that has never been experienced before [45].

Unquestionably, humanity is confronting a climate emergency, which is already here. As the number of climate-related calamities rises, the unbearable amount of human suffering, which is already immense, is escalating quickly [82]. Many scientists are quite concerned since it happened faster than they had anticipated. In other words, our society needs to undergo a significant historical shift in response to the current global climate emergency [83]. Political and scientific issues related to climate change are complex [84]. The dangers associated with climate change are both complex and enduring. Oceans are warming more slowly than land areas. On a continental, regional, and ocean basin scale, numerous additional long-term shifts in the climate have also been noted [85]. Across the world, areas impacted by drought have expanded since the 1970s, and over the past 50 years, the frequency of some extreme weather occurrences has increased relative to their intensity. Heat waves and heavy rains have also become more common [86].

Climate change is expected to cause precipitation to rise in intensity in many parts of the world. Already, the most vulnerable and impoverished nations have suffered from climate change [87]. More moisture can be stored in warmer air, which suggests that precipitation would probably increase in both amount and intensity. Widespread flooding is one possible outcome of this increase in precipitation [45]. Climate change-related sea level rise exacerbates the effects of other natural disasters and presents considerable problems to coastal regions. Coastal floods, erosion, and storm surges pose significant threats to low-lying communities, causing the most harm [88]. Predictions suggest that global warming will lead to an increase in extreme weather patterns, including greater dry

periods, intense downpours, violent hurricanes, more frequent flooding events, and more frequent and catastrophic wildfires [86].

Also, as the sea level rises, coastal flooding will get worse. Also, it is expected that storm and tropical cyclone-related floods will get worse in the upcoming years, leading to an increase in storm surges and flooding incidents. The most catastrophic coastal flooding, which poses a hazard to human life, is predicted to occur in tropical locations, including island nations in the Pacific and some areas of the United States [89]. Longer droughts in tropical and subtropical areas have been observed, as have more frequent intense rainfall events over most land areas and stronger tropical cyclones in the North Atlantic. These changes are anticipated to have widespread repercussions in the form of floods and droughts [90].

4.2. Climate-Related Disasters

Hazards must be considered when analyzing the impact of climatic emergencies on disaster risk, including both their effects and non-effects. Throughout human and planetary history, the Earth's climate has changed due to various hazards. This includes long-term trends, shifts in baseline and condition, variability, and cycles [45]. Several interconnected phenomena, such as general warming trends, modifications to precipitation patterns, sea level rise, and changes in rapidity, may contribute to these changes.

For instance, rapid Arctic warming may increase the risk of zigzagging and obstruction in Northern Hemisphere summer rapids, resulting in disasters including heat waves, floods, and droughts. What is certain is that in the face of a system of growing uncertainty and frequent disasters, climate change is worsening the impact on human hazards, livelihoods, communities, and infrastructure. It is also eroding the resilience of livelihoods [91]. There was a record-breaking heat wave in Siberia in the Arctic Circle, the Atlantic hurricane season cost more than $46 billion in damages, and deadly floods and landslides in Southeast Asia caused the displacement of over 12 million people. The year 2020 is one of the hottest on record. To stop the current cycle of fatal climate degradation and stop the melting of the Arctic, every effort must be taken to reduce emissions and enhance the removal of carbon from the atmosphere. Due to persistently increasing emissions, self-reinforcing climate feedback loops, and impending tipping points, scientists are already discovering [92]. There is mounting evidence that climate change has a terrible effect on people's lives and constitutes a serious threat to the entire world. Even infrastructure management systems may suffer from the effects of climate change, including relocations, population shifts, and financial losses [93]. Climate change does make some risks worse, which in turn makes some calamities worse [45]. According to the emergency events database (EM-DAT), there were 387 natural disasters and catastrophes in the world in 2022 that claimed 30,704 lives, affected 185 million people, and resulted in economic damages of about $223.8 billion. Over 16,000 people were killed by heat waves in Europe, while 88.9 million people in Africa were afflicted by droughts. In the Americas, Hurricane Ian caused $100 billion in damage [94]. Natural disasters are also happening more frequently; in fact, the number of natural disasters in 2022 (387) is higher than the average for the previous 20 years when compared to the data from 2002 to 2021 (370) (Figure 2).

Although there is significant year-to-year variation in drought, present trends point to a potential increase of more than 30% over the 30 years from 2001 to 2030 [95]. Extreme weather occurrences occur more frequently each year and are expected to roughly quadruple between 2001 and 2030 based on present patterns. The expected effects of climate change on catastrophe risk include both vulnerability and the hazard component. Climate change alters average weather patterns over the long term and increases the frequency and severity of extreme weather events. Since local environmental circumstances are changing so quickly, climate change makes people more vulnerable.

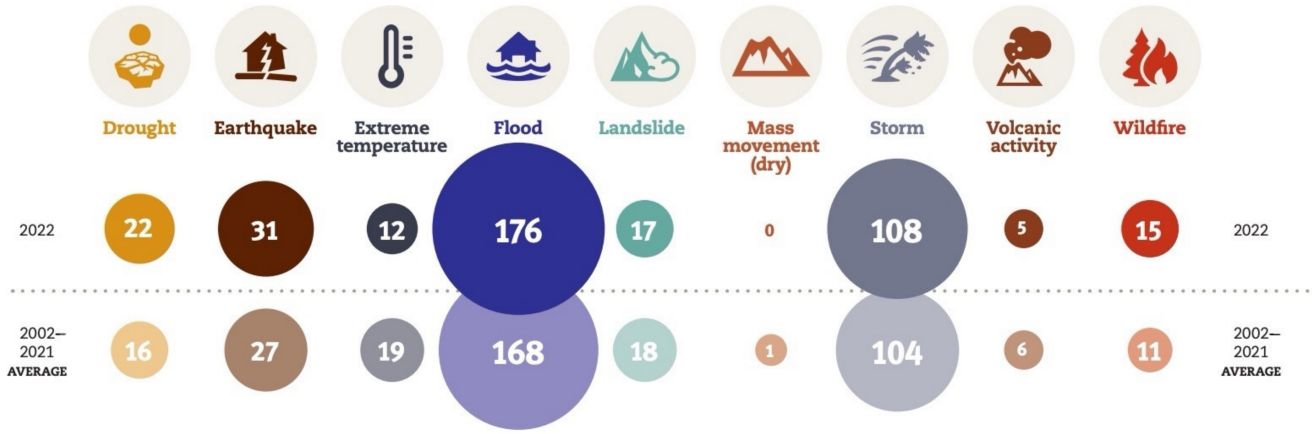

Figure 2. Occurrence by disaster type: 2022 compared to the 2002–2021 annual average from Ref [94].

Formerly rare occurrences of tragedies and calamities are becoming commonplace. The degree to which the natural resources and ecosystem services that people depend on are susceptible to climate change determines how vulnerable people are to it [96]. Regrettably, the poor in low-income countries, which make little contribution to the buildup of greenhouse gases, suffer disproportionately from these disasters. It might even be claimed that catastrophic events can be damaging for developing nations with weaker resistance to disasters [85,97]. This condition is most extreme among the poorest people.

One factor contributing to the danger of disaster is climate change [45]. As a result, instead of directly impacting disaster capabilities, climate change affects hazard parameters, sometimes making hazards worse and other times mitigating them. For instance, July 2019 set a record for warmth on a global scale. According to NASA data on global warming, between 2001 and 2018, there were 17 of the 18 warmest years ever recorded in the previous 136 years [98]. Global emissions are rising instead of declining, having significant cumulative effects on the climate system, the natural world, and the ecosystems that make up the world's food chain [83]. The overall number of deaths in 2022 was 30,704; among the types of deaths affected by disasters in 2022, the top three are disasters related to climate change, namely extreme temperatures, floods, and droughts. Among them, the number of deaths caused by extreme temperatures will reach 16,416 in 2022, which is twice the average annual rate from 2002 to 2021. Secondly, the number of deaths affected by floods will reach 7954 in 2022, and the number of deaths caused by drought will reach 2601 (Figure 3). Due to the enormous reduction in societal resilience and the ability to adapt to future crises, these concurrent and sequential effects are pushing society to its breaking point [82].

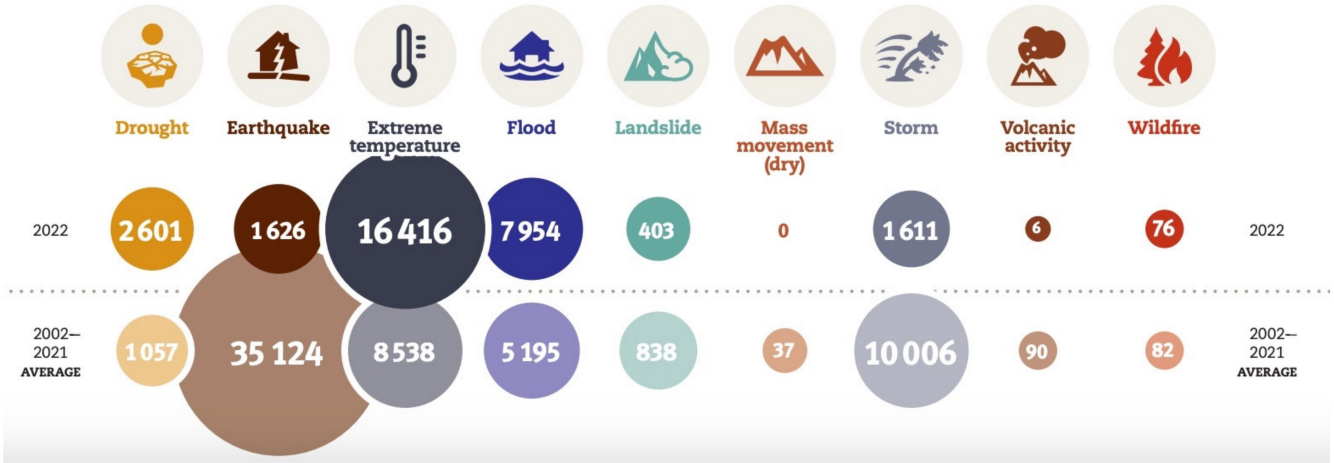

Figure 3. Number of deaths by disaster type: 2022 compared to the 2002–2021 annual average from Ref [94].

A disaster is a sudden, unfavorable, catastrophic event that harms people, plants, and animals significantly. The majority of catastrophes, or more precisely, the risks that cause them, cannot be prevented, but their impacts can be lessened. Proposals to lessen the effects of catastrophes are not brand new. The annual spike in climate disasters shows that, if things continue as they are, we are currently facing a serious climate crisis and global catastrophe. Moreover, humanity is on the verge of having the chance to fundamentally alter life as we know it on Earth [82].

5. Exploring Climate Change's Impact on the Future of Disaster Risk Reduction

5.1. Climate Change Adaptation (CCA) and Disaster Risk Reduction (DRR)

Within the broader context of sustainable development, DRR is defined as "the systematic creation and deployment of policies to reduce the impacts of methods and practices that minimize vulnerability, risks, and the incidence of disasters on society as a whole" [99]. Socioeconomic conditions, environmental factors, and the availability of knowledge and technology shape the capacity for adaptation and mitigation. However, there is significantly less information on the costs and effectiveness of adaptation strategies compared to mitigation efforts [86].

Recent climate disruptions have tested, and sometimes exceeded, our ability to cope. Without efforts to reduce exposure and enhance coping mechanisms, the rapid changes caused by climate change will increase the vulnerability of many areas. Adaptive capacity refers to the ability to adjust to minimize negative impacts and maximize any positive outcomes from climate change. Good adaptation involves managing and reducing the risks associated with climate change. It is a comprehensive concept that encompasses actions by private sector companies, public institutions like governments, and individuals and communities. Successful adaptation reduces vulnerability by improving and strengthening current coping strategies and resources, implementing specific measures to address climate change vulnerabilities, and integrating these efforts into broader policy frameworks [100].

The national development plan, which encompasses the formulation of budgets, plans, laws, and budgetary allocations, serves as the perfect platform for integrating disaster risk reduction (DRR) and climate change adaptation (CCA) into the development process. This framework also allows for the establishment of specific initiatives aimed at disaster risk prevention and management strategies [101].

Mercer highlights the differences between DRR and climate change adaptation (CCA) (Table 1). CCA is defined as the process of reducing the adverse effects of climate change while seizing opportunities to find innovative solutions [90]. Unlike DRR, which focuses on existing and historical risks to develop strategies based on past and present conditions, CCA looks towards the future, acknowledging uncertainties and emerging threats. Thus, independent of past mitigation efforts, there is a need for more adaptation measures at regional and local levels to mitigate the adverse impacts and variability of projected climate change. However, as the severity of impacts is likely to increase over time, adaptation alone may not be sufficient to address all expected effects of climate change, especially in the long term. While there are numerous adaptation strategies available, a broader range of options than currently available is necessary to reduce vulnerability to climate change [86].

Table 1. Summary of differences between DRR and CCA.

DRR	CCA
Relevant to all hazard types	Relevant to climate-related hazards
Most concerned with the present	Most concerned with the future
Historical perspective	Future perspective

Table 1. *Cont.*

DRR	CCA
Traditional/indigenous knowledge at community level is a basis for resilience	Traditional/indigenous knowledge at community level may be insufficient for resilience against types and scales of risk yet to be experienced.
Traditional focus on vulnerability reduction	Traditional focus on physical exposure
Community-based process stemming from experience	Community-based process stemming from policy agenda
Practical application at local level	Theoretical application at local level
Political and widespread recognition often quite weak	Political and widespread recognition increasingly strong

Source: Adapted from Mercer [90].

5.2. Community Disaster Resilience as a Means for Disaster Risk Reduction

The concept and practice of disaster risk reduction include making systematic attempts to identify and mitigate the causes of disasters [102]. All levels of society are subject to governance, a process involving the state, non-state actors, and the private sector. It contains a set of tools, such as institutions, methods, and processes, as well as the ability of individuals to rule using these tools. Consensus-driven, participatory, effective, efficient, fair, transparent, and accountable are all characteristics of good governance.

All parts of the DRR system must take governance issues into account. DRR itself should be considered as bolstering control over the full system of political, economic, and administrative management. DRR is a method for identifying the causes of catastrophes and preparing for their effects. DRR is cross-cutting and cross-disciplinary. Interventions to reduce the risk of disaster must therefore also be planned to increase overall development process governance [99].

Disaster governance is a significant road to attaining DRR procedures and outcomes since governance is a fundamental factor in achieving DRR and bad governance is a key potential generator of catastrophe risk [103]. By carrying out its governance, which includes creating an environment that supports disaster risk reduction, a dedicated government empowers people who are at risk to fulfill their obligation to protect against the effects of catastrophes. The institutional structure (policies, laws, goals), resources, and activities make up the enabling environment. A crucial step in political governance is the creation of institutional frameworks.

Severe weather conditions converge with localized poverty, ineffective government, and deteriorated infrastructure. Extreme phenomena such as droughts, floods, fires, and storms disproportionately impact poorer communities, as disasters often result from the convergence of these factors. Poverty prohibits people from adequately preparing for catastrophes, and disasters frequently entail environmental components that are challenging to address. Effectively managing climate change remains a critical challenge [104]. As a result, the influence of climate change on disaster risk is more in terms of hazards than vulnerability, modifying the parameters of hazards, sometimes escalating risks and other times reducing them.

As disasters occur with increasing frequency, the concept of building community resilience as a strategy for reducing risk, recovery, and rebuilding after catastrophes has become a more prominent consideration [56]. The global dialogue on DRR has gained momentum, defined as "the concept and practice of minimizing disaster risks through systematic efforts to analyze and manage the causes of hazards. This includes reducing exposure to hazards, decreasing the vulnerability of people and property, wisely managing land and the environment, and enhancing preparedness for adverse events" [102].

Disaster risk reduction focuses on reducing or eliminating the likelihood and impact of hazards, with the goal of "handling" these hazards in a way that minimizes their effects on

society. This approach is central to disaster management [105]. Sharifi and Yamagata [106] suggested that incorporating resilience thinking can help transition from short- to long-term planning. This is particularly relevant because disaster risk management often prioritizes short- and medium-term strategies.

Activities for reducing the risk of disasters can involve analyzing the risk from past occurrences or being proactive [105]. Relocation plans, insurance programs, updates to building codes, retention systems, detection systems, educational initiatives, and behavior change are a few examples of disaster risk reduction measures, It is well acknowledged that catastrophe risk reduction is an essential component of disaster management and that it affects all areas of the disaster management community.

There are more opportunities for humans to increase disaster resilience and decrease vulnerability so that disaster risk can be reduced regardless of climate change, and this means that understanding how climate change affects disaster risk cannot disentangle disaster risk from community disaster resilience. As a result, disaster risk reduction, climate change, and community disaster resilience are completely interconnected.

6. Conclusions

Although vulnerability, adaptation, and resilience are distinct concepts, they are closely interrelated and intrinsically linked. In the context of climate change, understanding the role of these three elements, particularly in disaster risk reduction, requires a comprehensive and in-depth understanding of their intrinsic linkages. Supporting a long-term perspective by integrating climate change into disaster risk reduction will further contribute to addressing vulnerability processes and recovery processes in the long term [45].

This review synthesizes the existing literature to provide an in-depth exploration of the definitions and interrelationships of vulnerability, adaptation, resilience, and climate disasters. Additionally, it provides an overview of the development of climate change, from climate change to the current climate crisis. Finally, the impact of climate change on future disaster risk reduction efforts is explored by describing and analyzing the relationship between climate change adaptation and disaster risk reduction.

Firstly, vulnerability assessments are essential for identifying the most at-risk populations, regions, and ecosystems and for understanding the underlying drivers of vulnerability. The expected effects of climate change on disaster risk include vulnerability as well as hazard factors. Climate change makes people more vulnerable by rapidly changing local environmental conditions, which makes it difficult for local environmental knowledge to keep up and makes it less useful for things like managing pests and local food and water resources. Policymakers and practitioners can create tailored adaptation and resilient strategies that address the underlying causes of vulnerability and improve adaptive capacity by having a thorough grasp of vulnerability.

Secondly, adaptation is critical to building resilience and reducing vulnerability to the impacts of climate change. Additionally, it helps communities obtain a greater awareness of the hazards associated with natural disasters, enabling early risk identification, interventions to improve adaptive capacity, and the encouragement of a culture of independence, reciprocal assistance, and community networks [107]. To successfully decrease risk, respond to and recover from disasters, and share the economic, financial, and social costs, governments must do more to involve local communities. To make communities resilient, residents and organizations can contribute their capabilities by working with local governments without being overbearing and impeding their creativity, flexibility, and efficiency [108]. However, disaster risk management usually places a premium on short- and medium-term planning, as noted by Sharifi and Yamagata [105], who suggest that adding resilience thinking can help move the focus to long-term planning. It is important to further refine the vulnerability, adaptation, and resilience framework and explore innovative approaches to climate change adaptation that prioritize equity, social justice, and sustainability.

Thirdly, resilience-building measures are critical to enhancing the ability of communities, ecosystems, and infrastructure to withstand and recover from climate-related disasters and stresses. To successfully reduce risk, communities must prioritize their plans and initiatives within the framework of regional expertise and resources. Community resilience focuses on common hazards and offers local agencies, groups, and organizations a framework to anticipate and address their own challenges [108]. Resilience-based approaches emphasize the importance of integrating social, institutional, economic, and environmental factors into adaptation planning and implementation. This review emphasized the importance of integrating the concepts of vulnerability, adaptation, and resilience into climate change and disaster risk reduction policies and practices. By utilizing a framework that considers the complex interactions between social, economic, and environmental factors, stakeholders can develop more effective and equitable adaptation strategies that increase resilience, lessen sensitivity to climate change, and improve ecosystems' and populations' capacity to adapt and prosper.

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