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Rethinking Climate Justice in the Digital Age: Pathways to Resilient Health Systems for Marginalized Communities

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ABSTRACT

Climate change is not only an environmental challenge but a profound justice crisis, disproportionately affecting marginalized communities in low- and middle-income regions by intensifying social, economic, and health inequalities. In the digital age, rethinking climate justice requires integrating digital health innovations to strengthen health system resilience and equity. This study aims to reconceptualize climate justice in the digital age by examining the disproportionate health impacts of climate change on marginalized communities, evaluating the potential of digital innovations to strengthen resilient and equitable health systems, and proposing inclusive pathways that align digital transformation with human rights to safeguard vulnerable populations. The research employed a qualitative review and analytical approach, drawing on interdisciplinary literature from environmental sociology, climate policy, human rights law, and international development. It examined the intersection of environmental degradation, social exclusion, and health vulnerabilities, focusing on women, children, indigenous peoples, and ethnic minorities. Findings indicated that digital tools, including telemedicine and mobile health applications, enhanced healthcare access, system responsiveness, and equitable service delivery in climate-impacted regions. However, persistent barriers such as digital divides, weak infrastructure, and insufficiently inclusive governance limited their effectiveness. By bridging climate justice and digital health, the study offered actionable policy pathways and research directions to promote equitable health resilience amid escalating climate risks. These insights underscored the need for an integrated, rights-based, and intersectional framework that aligned digital transformation with climate justice, enabling inclusive policies and interventions that protected vulnerable populations and strengthened long-term health system adaptability.

Keywords: Climate Justice, Digital Health, Health Equity, Health System Resilience, Marginalized Communities, Climate Vulnerability

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1. INTRODUCTION

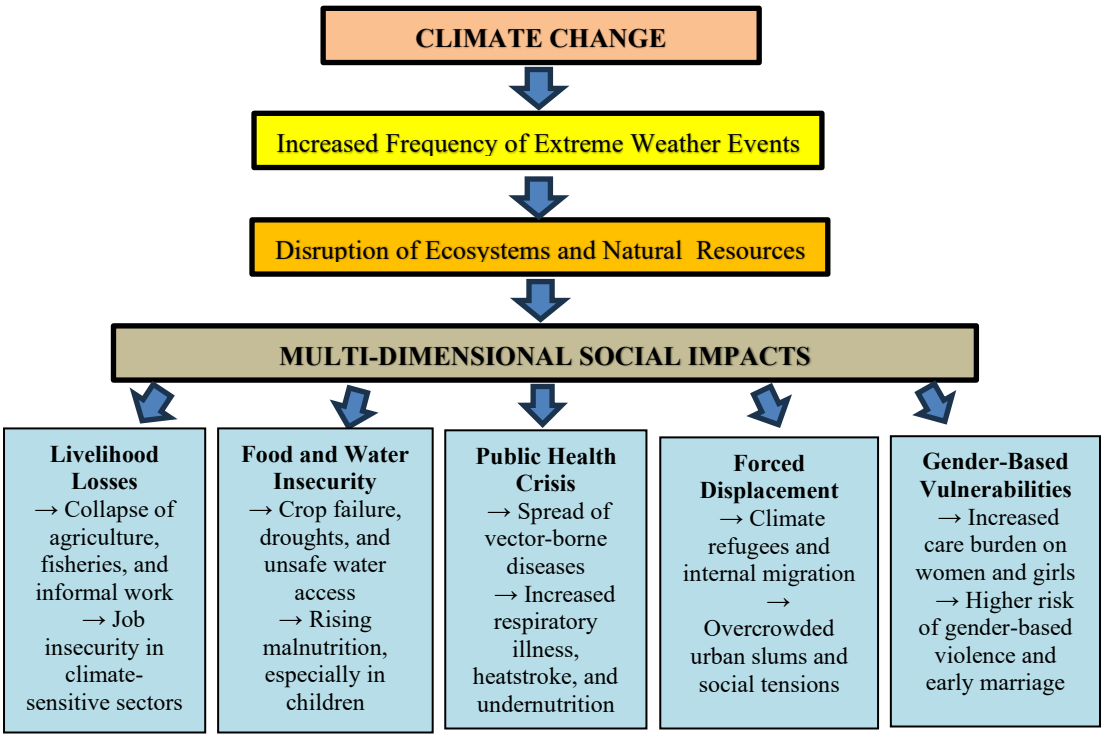
Climate change is not an equalizer, it is a magnifier of inequality. Its effects ripple through ecological, social, economic, and technological dimensions, creating a landscape where vulnerability is unevenly distributed and often amplified by systemic disparities. The repercussions of climate change

extend beyond ecological disruption, manifesting as a complex social phenomenon rooted in the interplay of societal structures, human actions, and power dynamics (Garcia et al., 2022; Islam, 2024). While its global impact is undeniable, the burden is disproportionately borne by those who are already socioeconomically, politically, and geographically marginalized. Communities with limited political representation, precarious livelihoods, and fragile health infrastructure face heightened exposure to climate hazards, which in turn exacerbate existing inequities (Putsoane et al., 2024; Smith et al., 2022). From rising sea levels and extreme weather events to prolonged droughts and food insecurity, climate-related disruptions threaten livelihoods (Rosinger, 2023) health, and survival, especially among indigenous populations, low-income groups, women, and children (Abdul-Razak et al., 2025; Uddin et al., 2021).

The repercussions of climate change are far-reaching and multifaceted, manifesting not only as environmental disturbances but also as profound social and economic disruptions (Islam, 2024). According to Hossain, (2025), in the digital age, the inequitable access to information, early-warning systems, and telemedicine amplifies the vulnerability of marginalized communities, limiting their capacity to anticipate, respond to, and recover from climate shocks. These further extend into the realm of education, where rising temperatures and extreme weather events can severely disrupt learning environments. Infrastructure damage to schools and diminished parental capacity to support education due to climate-related stressors directly jeopardize the educational prospects of future generations (Tammi & Martinez, 2025; Vergunst & Berry, 2022).

Healthcare systems, particularly those serving marginalized populations, face unprecedented stressors (Choe et al., 2023). Heatwaves, pollution-related illnesses, and the spread of vector-borne diseases strain under-resourced clinics and hospitals, revealing gaps in both physical infrastructure and digital health networks. According to Butzner & Cuffee (2021), the lack of access to electronic health records, telehealth consultations, and mobile health alerts prevents timely interventions, disproportionately affecting those in remote or underserved regions. Environmental shocks disproportionately impact marginalized communities, who often reside in high-risk areas with limited access to adaptive resources. Crop failures and water scarcity exacerbate food insecurity, while heat waves and pollution-related illnesses strain already inadequate healthcare systems (Rosinger, 2023). Beyond the physical toll, climate change fuels economic instability, heightens the risk of conflict over dwindling resources, and forces entire populations into migration, stripping individuals of their homes, cultural identities, and means of survival. Ultimately, climate change acts as a threat multiplier, deepening existing inequalities and exposing the urgent need for justice-centered climate responses. Figure 1, identifies these multidimensional implications of climate change. Figure 1 illustrates the cascade of environmental and social impacts triggered by climate change, disproportionately burdening marginalized communities. It highlights the interconnected nature of climate-induced challenges such as livelihood loss, health crises, displacement, and deepening inequality.

Figure 1
Multi-Dimensional Implications of Climate Change



Environmental justice, at its core, seeks to address these imbalances by ensuring that no group bears a disproportionate share of environmental harm (Kaklauskaite & Streimikiene, 2024; Obasa, 2025). According to Bhawra (2022) and Wanimbo & Wafumilena (2025), in the digital era, environmental justice must be reimagined to leverage technological tools, such as data analytics, digital health platforms, mobile warning systems, and climate monitoring networks, while simultaneously addressing digital inequities that can leave marginalized communities further behind. The intersection of climate vulnerability with pre-existing inequities, such as inadequate access to healthcare, education, housing, and political representation, creates a compounded crisis that demands urgent attention (Smith et al., 2022).

Emerging evidence suggests that integrating digital technologies into climate resilience strategies can enhance early-warning systems, improve health surveillance, and facilitate community-level adaptation (Ayadi et al., 2025; Barteit et al., 2023; Zhou et al., 2025). For example, wearables can track disease outbreaks during heatwaves (Koch et al., 2022), telemedicine can provide remote consultations for communities cut off by floods (Hossain, 2025), and data-driven planning can prioritize resource allocation for the most vulnerable (Le et al., 2023). However, these innovations are not panaceas; without deliberate inclusion policies, they risk widening the gap between digitally connected populations and those who are excluded from technological advancements.

This study aims to reconceptualize climate justice through a digital health lens by investigating how marginalized communities are disproportionately affected by climate change, assessing the capacity of digital innovations to foster resilient and equitable health systems, critically reviewing existing environmental and climate justice frameworks, and proposing equity-oriented pathways that align digital transformation with human rights to safeguard vulnerable populations and support sustainable adaptation. By reframing climate justice in the context of the digital age, this research underscores the necessity of integrating technological, social, and ecological solutions to protect the health and well-being of the most vulnerable populations.

2. METHOD

This study employs a qualitative systematic review and analytical approach to examine the intersection of climate change, environmental justice, social inequality, and health system resilience in the digital age. The methodology is designed to synthesize interdisciplinary literature while critically assessing how digital innovations can support marginalized communities in coping with climate-related health challenges. Data sources for this study include peer-reviewed journal articles indexed in Scopus, Web of Science, and PubMed, covering environmental science, public health, climate policy, digital health, development studies, and human rights law. In addition, reports and datasets from international organizations such as the World Bank, United Nations Development Program (UNDP), World Health Organization (WHO), Intergovernmental Panel on Climate Change (IPCC), and International Labour Organization (ILO) were included to provide policy-oriented and global perspectives. Case studies and field reports were also reviewed to highlight geographically and socio-economically vulnerable communities, including those in Sub-Saharan Africa, the Horn of Africa, Southeast Asia, and marginalized urban populations, with a particular emphasis on the role of digital interventions in enhancing health system resilience.

The selection of articles and reports was conducted in a structured and systematic manner, which can be conceptualized as an inverted prism (Helbach et al., 2023). During the identification stage, all potentially relevant literature from databases and organizational reports was collected, initially yielding approximately 1,257 articles and 238 reports. The screening stage applied specific inclusion criteria, including publications from 2013 to 2025, English language, and relevance to climate-health interactions, marginalized communities, and digital health interventions, resulting in 482 articles and 126 reports being retained. The eligibility stage involved a full-text review to ensure inclusion of empirical studies, reviews, and policy analyses, while excluding studies lacking empirical evidence or relevance to health, marginalized populations, or digital interventions. This process yielded a final dataset of 94 journal articles and 21 reports, including websites and books, totaling 115 sources for comprehensive analysis. Data extracted from these sources were synthesized thematically, focusing on health system resilience, digital interventions, and climate justice, while integrating perspectives from both the Global North and Global South to generate evidence-based policy recommendations aimed at strengthening the resilience of marginalized communities.

Data analysis was conducted using thematic and comparative approaches, enabling the identification of patterns, knowledge gaps, and best practices related to the impact of climate change on public health, as well as the effectiveness of digital technologies in supporting adaptation. Additionally, historical emissions data and international frameworks, including the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement, were reviewed to contextualize contemporary challenges and policy responses. This methodological framework ensures rigor, reproducibility, and

scientific relevance, while highlighting the critical interplay between climate justice, digital innovation, and health system resilience for the most vulnerable populations.

3. RESULTS AND DISCUSSION

3.1. The Global Divide in Climate Responsibility

According to Filonchyk et al. (2024), Naz et al. (2022), and Bhatti et al. (2024), characterizes climate change as a primarily anthropogenic phenomenon, driven by industrial emissions of greenhouse gases (GHGs) that disrupt global temperature level. These emissions have not only environmental consequences but also ripple effects across public health systems, particularly in regions lacking robust health infrastructure, making marginalized communities more susceptible to climate-induced health crises. Ullah et al. (2025) and Islam (2024) emphasize that these anthropogenic forces not only devastate the environment but also erode economic stability, particularly affecting marginalized communities. The unequal distribution of vulnerability highlights the intersection between climate change, socio-economic inequality, and health disparities, underlining the urgent need for justice-driven approaches that consider both environmental and digital dimensions of resilience. As a result, the call for climate justice arises, demanding rectification for those most vulnerable to the harmful impacts of climate change.

Climate justice has its roots in the broader concept of environmental justice, which historically sought to address the human rights violations and socio-economic harms stemming from environmental degradation (Hannigan, 2022). In the context of health systems, climate justice extends to ensuring equitable access to healthcare, preparedness for extreme weather events, and the deployment of digital tools for early-warning and telemedicine services in marginalized regions (Putsoane et al., 2024). In this context, the Global North must be held accountable for its historical role in damaging the environment, particularly through its production of GHG emissions that fueled economic growth at the expense of the Global South's living conditions. The 1992 UN Framework Convention on Climate Change (UNFCCC) established two key principles of climate justice (Lefstad & Paavola, 2024). The first, the "polluter pays" principle, assigns responsibility for GHG emissions to those who have historically contributed the most (Tan, 2023). The second, "common but differentiated responsibilities" (CBDR), distinguishes the obligations of the Global North and South based on their socio-economic development (Qiao-Franco, 2021), with the former being tasked with a greater share of reparative actions due to their historical role in climate change. Despite these distinctions, the UNFCCC emphasizes that all countries must contribute to both mitigating GHG emissions and adapting to the extreme weather events and other effects caused by climate change (Ciplet & Roberts, 2017; Wright et al., 2023). Importantly, adaptation strategies must incorporate the strengthening of resilient health systems, particularly through investments in digital health infrastructure that can enhance monitoring, response, and equitable delivery of care in vulnerable communities.

While the UNFCCC sets universal standards for climate justice, two opposing interpretations have emerged. The Global North predominantly frames climate justice through a neoliberal lens, which advocates for minimizing restrictions on the private sector to foster economic growth (Cairney et al., 2023; Kaklauskaite & Streimikiene, 2024). In this neoliberal interpretation, the rights of individuals are prioritized over collective social needs, which may constrain corporate innovation. Consequently, health system strengthening and community-level preparedness often receive limited attention, especially for marginalized populations who are disproportionately affected by climate-induced health shocks. Under this framework, states are encouraged to respond voluntarily to climate obligations, without facing penalties for non-compliance. Neoliberal climate justice also promotes the idea that states can secure mutual economic benefits through joint climate action, allowing them to accumulate capital for funding mitigation and adaptation efforts (Gifford & Sauls, 2024). This approach often aligns with private sector interests, particularly those in extractive industries, which can benefit from the economic opportunities created by climate action (Amorim-Maia et al., 2022; Hannigan, 2022).

However, neoliberalism has been heavily criticized for exacerbating the unequal distribution of resources and power between the Global North and South. Critics argue that an individual-driven approach to climate action stalls the collective transformation of socio-economic systems. Moreover, neoliberal climate justice is seen as unjust because it allows extractive activities in marginalized communities to serve the broader goal of economic growth, often at the expense of the welfare of these vulnerable populations (Bogert et al., 2022; Islam, 2024; Kashwan, 2021). This approach further risks undermining health equity, as communities most exposed to climate hazards often lack access to robust health systems, digital monitoring tools, and adaptive health interventions.

In response, activists from the Global South advocate for a 'transformative' approach to climate justice, one that emphasizes collective action to overhaul the current profit-driven and individualistic system (Kinol et al., 2023). Transformative climate justice explicitly integrates health system resilience, prioritizes marginalized communities, and leverages digital technologies to support equitable adaptation and rapid response to climate-induced health crises (Aziz & Anjum, 2024; Saxena & Joshi, 2024). Transformative justice has three central goals: to integrate diverse sectors, to align climate action with

human rights, and to decentralize climate governance (Newell et al., 2021). These activists argue that climate mitigation and adaptation efforts must be balanced and should prioritize the restoration of human rights, with a clear focus on reparations and self-reporting mechanisms from the private sector.

To achieve transformative climate justice, several researchers suggests four critical actions for states: first, the equitable distribution of climate finance and resources to help the Global South mitigate and adapt to climate change (Dafermos, 2025); second, the establishment of legal frameworks to hold extractive industries accountable for human rights violations in marginalized communities (Idemudia et al., 2022); third, the recognition of justice to address the historical and ongoing harm caused by resource extraction, particularly to indigenous peoples (Osborne et al., 2024); and fourth, the incorporation of intergenerational justice to safeguard future generations from the severe impacts of the climate crisis (Teodoro et al., 2023). In addition, these measures should be complemented by the integration of digital health infrastructure, telemedicine, and data-driven early-warning systems to build resilient health systems that can respond effectively to climate-induced health emergencies in marginalized populations.

Thus, addressing climate change requires a shift from neoliberal to transformative justice, emphasizing accountability, equitable resource distribution, and a collective approach to safeguarding vulnerable communities and future generations. Rethinking climate justice in the digital age also entails recognizing the pivotal role of technology and health system resilience in operationalizing these justice principles, ensuring that marginalized populations are not only recipients of reparative measures but also active participants in shaping adaptive and sustainable climate-health strategies.

3.2. Digital Innovations for Health Resilience in Vulnerable Communities

Climate change has exacerbated health inequalities worldwide, with the most severe impacts experienced by the most vulnerable communities, including women, children, persons with disabilities, and other marginalized groups. In this context, according to Argyroudis et al. (2022) and Saxena & Joshi (2024), digital innovations have emerged as crucial tools for strengthening health system resilience, enabling faster and more inclusive responses to the challenges posed by climate change. Digital technologies, including telemedicine, mobile health applications, and electronic health information systems, offer significant potential to reach hard-to-access populations and provide essential healthcare services during emergencies.

A systematic review by Ngcamu (2023) highlights how climate change disproportionately affects vulnerable populations in the Global South, with impacts further compounded by social, economic, and political inequalities. The study demonstrates that, despite efforts to implement adaptation mechanisms, many groups remain marginalized in decision-making processes and climate-related interventions. This underscores the urgent need for more inclusive and evidence-based approaches in designing health interventions that account for community vulnerability.

Meanwhile, a scoping review by Ansah et al. (2024) identified that health systems in various countries have begun integrating climate considerations into their policies and infrastructure. Investments in innovative technologies, early-warning systems, and capacity-building for healthcare workers form part of strategies to build more resilient health systems against climate-related risks. Nevertheless, challenges such as weak policy implementation and insufficient funding remain significant barriers to achieving these objectives.

In the context of digital innovation, technologies such as telepsychiatry and asynchronous consultations have proven effective in reducing carbon emissions while providing essential mental healthcare during climate crises. Research by Yellowlees (2022) demonstrates that the use of digital systems in mental health care not only reduces travel requirements but also improves service accessibility for individuals living in remote areas or affected by disasters. This is particularly relevant given the rising prevalence of climate-related mental health disorders, such as eco-anxiety and disaster-induced trauma.

However, to ensure that digital innovations genuinely enhance health resilience in vulnerable communities, context-sensitive approaches tailored to the specific needs of these groups are required. Badr et al. (2024), Lythreatis et al. (2022) and Petretto et al. (2024) emphasizes the importance of addressing digital divides and ensuring that developed technologies are accessible and usable by all segments of society, including those with physical, economic, or educational limitations. This includes training local healthcare workers, developing culturally and linguistically appropriate content, and providing infrastructure that supports technology use.

Moreover, integrating community perspectives into the design and implementation of digital interventions is essential. Community-based approaches can improve technology acceptance and effectiveness, ensuring that solutions genuinely meet the needs and expectations of end users. Djatmiko et al. (2025) said that collaboration among governments, the private sector, civil society organizations, and local communities is critical in creating an inclusive and sustainable digital health ecosystem.

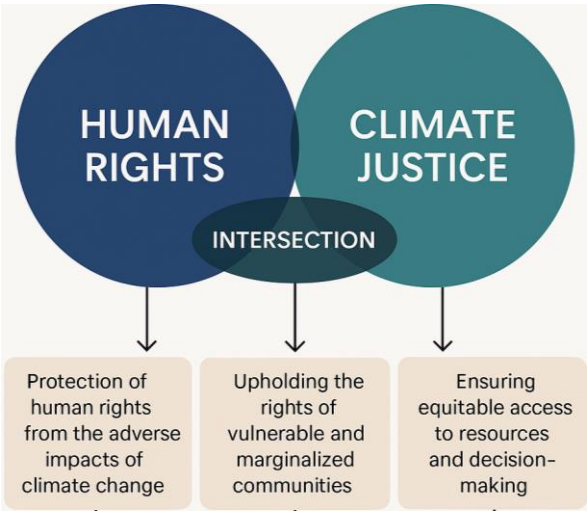
Overall, digital innovations hold substantial potential to strengthen health system resilience in addressing the challenges of climate change, particularly for the most vulnerable communities. However, realizing this potential requires strong commitments to bridging access gaps, ensuring contextual

relevance, and involving communities at every stage of technology development and implementation. With the right approach, digital technologies can serve as powerful tools for building health systems that are more equitable, inclusive, and resilient to the impacts of climate change.

3.3. The Intersection between Human Rights and Climate Justice

The intersection of human rights and climate justice (Figure 2) lies in understanding how climate change disproportionately affects vulnerable communities and exacerbates existing inequalities. Climate justice emphasizes that the impacts of climate change are not evenly distributed (Levy et al., 2024). In the digital age, these disparities are further magnified by unequal access to technology, information, and digital health resources, which are critical for climate adaptation and health resilience in marginalized communities (Rad, 2025). Marginalized and low-income communities, who are often the least responsible for climate change, bear the brunt of its effects (United Nations Development Programme, 2023). At the same time, human rights law stresses the importance of ensuring that all individuals have access to the basic rights they are entitled to, including the right to a healthy environment, the right to food, clean water, and the right to live in safety. Climate justice therefore, extends the concept of human rights to include the right to be protected from the negative impacts of climate change, the right to equitable access to health services, and the right to be compensated for the harm it causes (Islam, 2024). This approach recognizes that health systems must be resilient and adaptive, particularly in regions where marginalized populations face compounding climate and socio-economic risks. Figure 2 explains various aspects of human rights and climate justice that aim towards a common, more equitable future.

Figure 2
The Intersection of Human Rights and Climate Justice



To address the debate between individual and collective human rights in the context of climate justice, it is crucial to adopt an intersectional and multi-dimensional approach. Intersectionality, a concept introduced by feminist scholar Kimberly Crenshaw, highlights how multiple forms of injustice overlap and interact, revealing the inequalities inherent in power structures (Kassam et al., 2020; King-Mullins et al., 2023). Applying this lens in the digital age also incorporates disparities in access to technology, digital health literacy, and telemedicine, which influence the ability of marginalized communities to adapt to climate-induced health challenges. This approach has been integrated into climate discourse to shed light on the unique yet interconnected human rights violations experienced by marginalized groups due to systems that disproportionately benefit the privileged (A. Ghosh & Dutta, 2024). While these vulnerable groups may face overlapping injustices, the intersectional framework enables them to identify shared goals and work together to address the systemic issues causing these violations, thereby promoting systemic change (Kassam et al., 2020).

In the context of climate change, applying intersectionality allows us to recognize the distinct vulnerabilities that various human groups face, while also acknowledging the commonalities in their struggles (Amorim-Maia et al., 2022; Kassam et al., 2020). For instance, workers in climate-sensitive industries may lose their livelihoods due to the global transition to renewable energy, while youth and indigenous populations may face displacement or heightened health risks due to the intensification of extreme weather events, particularly if digital early-warning systems and adaptive healthcare measures are insufficiently deployed (Pinchoff et al., 2025; UNDP, 2025). These issues are not isolated but are interconnected within broader systems that include government decisions, economic priorities, and geographical factors. For example, the state's willingness to address the climate crisis can impact the vulnerability of these sectors, while geographic factors like proximity to oceans or deserts can further

exacerbate their exposure to extreme weather events such as storms and droughts. Digital health interventions, climate monitoring systems, and equitable resource allocation are therefore essential to mitigating these compounded risks.

By understanding these intersecting vulnerabilities, we can highlight the shared struggles of different sectors, including unequal exposure to climate risks and exclusion from resources like compensation or legal recourse. Moreover, applying intersectionality critiques the role of extractive industries in delaying collective climate action. The neoliberal emphasis on economic growth often prioritizes development over ecological integrity and human rights, reinforcing the unequal distribution of power and resources (Brankovic, 2023). This neoliberal model also perpetuates disparities in digital access and health infrastructure, leaving marginalized communities more vulnerable to climate-induced health crises. This creates a system where economically powerful sectors exploit vulnerable groups and the environment, exacerbating existing inequalities and hindering meaningful climate action.

In essence, an intersectional approach to climate justice emphasizes the need for a more inclusive, multi-dimensional, and technologically informed understanding of human rights, one that connects the environmental crisis with broader socio-economic, political, and digital equity issues. It calls for collective action to address these overlapping vulnerabilities, the integration of resilient health systems and digital health solutions, and policies that challenge systems perpetuating inequality and injustice, thereby ensuring that marginalized populations are not left behind in the climate adaptation and health resilience efforts of the 21st century.

3.4. Geographic and Socioeconomic Dimensions of Climate Vulnerability

Climate change is as much a social and economic issue as it is environmental, with the poorest and most geographically vulnerable communities facing the greatest risks (Tee Lewis et al., 2023). These risks are compounded by structural inequalities, limited access to healthcare, and insufficient digital infrastructure, which together hinder the ability of marginalized populations to anticipate, respond to, and recover from climate-related hazards. Limited resources and infrastructure deepen their exposure to climate impacts, creating a cycle of vulnerability. For instance, rural communities with poor connectivity may lack access to early-warning systems, telemedicine services, or digital health education, which increases susceptibility to climate-induced health crises. Similarly, informal urban settlements often experience heightened exposure to floods, heatwaves, and pollution, while simultaneously facing systemic barriers to healthcare, clean water, and essential services. The committee must consider these intersecting factors to ensure that state responses are equitable and effective (World Bank, 2025). The figure 3, gives an overview of these aspects.

Figure 3

Geographic and Socioeconomic Dimensions of Climate Vulnerability

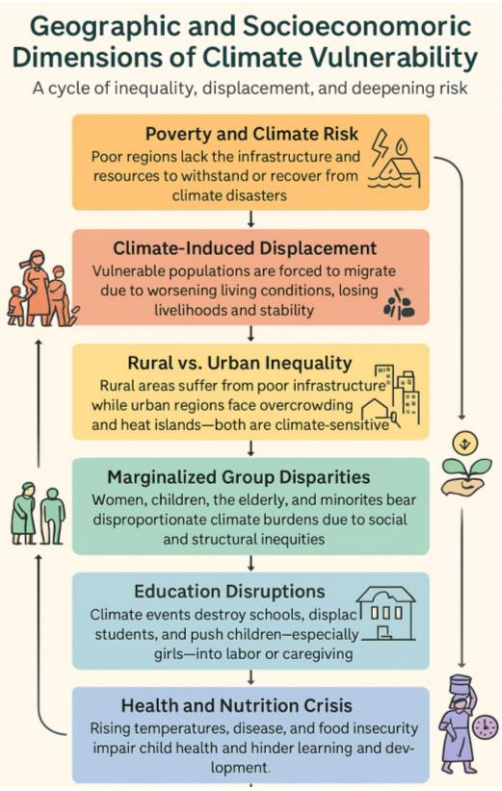


Figure 3 visually outlines the interconnected factors that heighten climate vulnerability, such as poverty, migration, rural-urban disparities, educational and health related implications, while also emphasizing the critical role of digital access, health system preparedness, and social protection mechanisms to mitigate the adverse impacts of climate change. This representation underscores the systemic and multifaceted nature of climate injustice, highlighting that resilience requires integrated solutions that address environmental, social, economic, and technological dimensions simultaneously.

By recognizing the geographic and socio-economic determinants of climate vulnerability, policymakers and stakeholders can prioritize interventions that strengthen local health systems, ensure equitable access to digital health tools, and create adaptive capacities for communities that are historically marginalized and disproportionately affected by climate shocks. In the context of the digital age, these interventions must leverage technology, data analytics, and remote healthcare solutions to bridge the gap between vulnerable populations and essential climate-health services, thereby operationalizing climate justice in practical, measurable ways.

3.5. Poverty as a Driver of Climate Vulnerability

Regions with low economic diversity, poor infrastructure, and high levels of environmental degradation, such as small island states, are particularly vulnerable to the adverse effects of climate change (UNDP, 2024; World Bank, 2024). These vulnerabilities are not only environmental but also deeply social and economic, as limited access to health services, poor sanitation, and insufficient digital connectivity exacerbate the risks faced by marginalized populations. The lack of resources will limit the ability to cope with the effects of climate change and people living in poverty will not have the financial resources to build resilient housing that can withstand extreme weather events, such as storms or floods. This inadequate infrastructure also impedes access to emergency healthcare and essential services during disasters, amplifying health risks and mortality rates. This also creates internal migration because in some locations it becomes uninhabitable.

By 2050, 216 million climate refugees will have been displaced in six world regions, with the top three being in sub-Saharan Africa (86 million), East Asia and the Pacific (49 million), and South Asia (40 million) (World Bank, 2021). The displacement of such large populations will not only create humanitarian crises but will also place enormous stress on public health systems, social services, and local economies in both origin and destination areas. What is more alarming is that according to the World bank reports only one-tenth of the world's greenhouse gases are emitted by the 74 lowest-income countries, however, they are the most affected (Wang & Lotfi, 2025). According to some studies of the World Bank Group, in the worst-case scenarios based on the assumptions on future impacts of the climate change, around 100.7 million people will be pushed into extreme poverty due to the effects of climate change by 2030 (Lavell et al., 2023). This stark disparity underscores the urgent need for justice-oriented climate interventions that target low-income communities and strengthen their resilience, including access to health systems, social protection programs, and climate-adaptive technologies.

In this new climate reality, low-income communities cannot afford climate insurance, and most of the time, if there is a government subsidy, it’s not enough to protect their hopes and livelihoods. Some regions, such as Sub-Saharan Africa, need substantial financing to support their economic development. Investing in adaptive measures, including climate-resilient infrastructure and digital health networks, would enable these countries to cope with climate hazards more effectively while promoting sustainable economic growth. By allowing them to address the challenges of climate change, their countries would be able to develop faster and more steadily. In addition, upfront investment in adaptation would not only save millions of lives but it will also be less costly than frequent disaster relief (Mitra et al., 2022). Nevertheless, there are studies (Belianska et al., 2022; Sibiya et al., 2023) shows that the investment required for adaptation in developing countries could range between 50 to 500 billion annually in 2050. Just for the African continent, the climate change adaptation costs are estimated at $50 billion per year by 2050 (Ghanem et al., 2024). Such investment should integrate health system strengthening, digital infrastructure for climate monitoring, and community-based adaptation programs to maximize effectiveness and equity.

However, this brings another issue to consider: the rising debt in developing countries. There is a vicious circle known as the “climate debt trap.” Developing countries do not have the resources to fight climate change without increasing sovereign debt (Dhar & Uz Zaman, 2025). This means that governments are forced to borrow money from creditors, including local institutions, other countries, and development banks, often at high interest rates, which in turn constrains their capacity to fund essential health and climate adaptation programs. The borrowed funds are invested in public goods and services, such as education, healthcare, energy systems, and climate change interventions. Debt accumulation becomes problematic when governments are unable to meet their repayment obligations, commonly referred to as “debt servicing.” Several factors, such as high interest rates, short repayment terms, and adverse national conditions like overlapping crises (e.g., a pandemic alongside natural disasters), can hinder a government’s ability to fulfill these obligations (Arner et al., 2022).

Additionally, as a country's vulnerability to climate change rises, so do its borrowing costs. Without effective adaptation measures, nations face growing exposure to the damaging impacts of climate change, increasing the need for more financial resources to mitigate risks and address the consequences of events like floods, droughts, and wildfires. This financial pressure not only limits the capacity to invest in resilient health systems but also threatens long-term economic stability, creating a feedback loop where climate vulnerability and poverty reinforce each other. The economic setbacks caused by climate change have already led to a $62 billion rise in debt costs for the Vulnerable 20 (V20) countries, a group particularly susceptible to climate-related effects, over the past decade. This climate-related debt premium is expected to more than double in the next 10 years (Leykun, 2024).

Moreover, the costs of servicing debt may exceed a government's ability to pay, especially when a significant portion of borrowing is in foreign currency and exchange rates fluctuate drastically. Developing countries often face considerably higher interest rates compared to wealthier nations like Germany or the United States, due to both real and perceived risks. Addressing these structural economic challenges is essential for ensuring that climate adaptation efforts, including investments in resilient health systems and digital solutions for vulnerable populations, are sustainable and do not exacerbate existing inequalities.

3.6. Economic Displacement and Migration

As the effects of climate change intensify, many individuals and families find themselves forced to relocate, often in search of more stable and secure environments (Crandon et al., 2022; Lawrance et al., 2022). This relocation is increasingly mediated by access to digital information, early-warning systems, and adaptive technologies, which can influence decisions about when and where to move, as well as the resources available for relocation. The disparity in economic resources significantly influences migration patterns. Wealthier individuals, who have access to financial capital and mobility, are generally able to move to areas with better infrastructure, where they can rebuild their lives more easily. In contrast, poorer populations are left with fewer options. The economic and technological constraints they face limit their ability to access safe housing, healthcare, and social support networks, leaving them more exposed to climate impacts in their current locations. This economic gap deepens existing inequalities in areas that receive these migrants, contributing to overcrowded and underfunded urban settlements, which themselves are vulnerable to climate-related disasters such as floods, heatwaves, and storms (Ansah et al., 2024a; Lv & Sarker, 2024).

For those who do migrate, the consequences of forced displacement are often severe. Migration under climate duress frequently results in both immediate and long-term health vulnerabilities, including limited access to medical care, exposure to communicable diseases, and psychosocial stress (Shibesh & Nagabhatla, 2025). Moving due to climate impacts frequently leads to further impoverishment, as many migrants are unable to secure stable housing or employment in their new locations. The lack of resources and limited access to basic services such as healthcare and education exacerbates their vulnerability (Ferreira et al., 2021). Digital exclusion further compounds these challenges, as many displaced individuals cannot leverage telehealth, online educational platforms, or digital aid coordination to mitigate the impacts of displacement (Asak, 2024). Furthermore, displaced individuals may encounter discrimination and exploitation, which heighten their challenges and undermine their ability to integrate into new communities. Migrants are often placed in precarious situations, where they face not only economic hardship but also social exclusion and, in some cases, exploitation (Shin et al., 2023). These intersecting vulnerabilities create a cycle of poverty, marginalization, and heightened exposure to climate risks, illustrating the critical need for justice-oriented migration and health policies.

Climate-induced migration is not only about physical displacement; it also has profound socio-economic implications. The movement of populations due to climate stress affects both public health planning and the equitable distribution of resources, as receiving communities often struggle to provide adequate medical, educational, and social services to new arrivals. Forced migration due to climate impacts often disrupts local economies, leaving communities without vital human capital. This can lead to long-term economic instability in both the areas people are fleeing and the regions that receive them. In some cases, the migration of young, skilled individuals exacerbates the "brain drain," further stalling development efforts in the regions that are already struggling to cope with environmental stresses (Aksel & Şenel, 2025; R. C. Ghosh & Orchiston, 2022). Addressing these dynamics requires integrated strategies that combine climate justice, social protection, and digital health solutions, ensuring that displaced populations have access to resilient health systems, equitable economic opportunities, and social inclusion mechanisms, thereby mitigating the long-term adverse effects of climate-induced migration.

3.7. Rural vs. Urban Vulnerability

Rural areas, heavily reliant on agriculture, are highly vulnerable to climate change due to limited access to services, infrastructure, and technologies. Extreme weather events like floods and droughts

devastate agricultural production, and the lack of critical infrastructure, such as irrigation and quality roads, hinders their ability to adapt. Recovery in rural areas is slow, increasing long-term vulnerability.

Urban areas, though more resilient with better services and support, face challenges like the "urban heat island" effect, where infrastructure traps heat, raising temperatures compared to surrounding rural areas. This exacerbates heatwaves. While rural areas also experience temperature rise, they are less affected by this effect but still need stronger infrastructure to cope with extreme weather. Urban regions struggle with increased surface runoff due to impervious surfaces (Das et al., 2025; Tchonkouang et al., 2024).

Climate change poses challenges to services, infrastructure, housing, livelihoods, and public health in both urban and rural areas. Urban areas contribute significantly to climate change, responsible for about 70% of global CO2 emissions, with transportation and buildings being major culprits (UNEP, 2024). Many cities are now adopting renewable energy, cleaner industrial practices, and emission-reduction measures.

3.8. Marginalized Groups

Certain marginalized groups, including women, children, the elderly, ethnic minorities, and people with disabilities, are disproportionately affected by climate change due to social, economic, and political factors. These vulnerabilities are further compounded in the digital age, where unequal access to information, technology, and digital health services limits adaptive capacity and emergency preparedness for climate-related events. Economic disparities in low-income areas make it difficult for residents to adapt. For example, in Hong Kong's "cage homes," overcrowded and substandard living conditions leave low-income families vulnerable to heat-related illnesses, especially during summer heatwaves (Chen & McFarlane, 2025) Limited access to cooling technologies, healthcare facilities, and real-time weather alerts exacerbates these risks, highlighting the need for integrated digital health interventions targeting these populations. A study showed that elderly residents in these conditions had higher risk of death due to heat (Yao et al., 2025). This demonstrates that climate impacts intersect with age, socio-economic status, and living conditions, underscoring the importance of targeted health policies and community support systems.

Racial disparities also heighten vulnerability, particularly among communities of color. In the U.S., Black and African American communities face greater risks, including a 34% higher likelihood of living in areas with rising childhood asthma rates and a 40% higher chance of residing in areas with extreme temperature-related deaths (Berberian et al., 2022). Such disparities are indicative of structural inequities, including limited access to healthcare, environmental hazards in residential areas, and lower resilience to climate shocks. Hispanic and Latino individuals are also overrepresented in industries vulnerable to extreme temperatures, such as construction and agriculture (Berberian et al., 2022). These occupational exposures increase health risks while reducing opportunities for climate-adaptive interventions, including digital health monitoring and occupational safety measures.

Globally, wealthier nations in North America and Europe contribute the most to greenhouse gas emissions, yet countries with minimal emissions are the ones most affected by climate change (Oreggioni et al., 2021). This inequity underscores the ethical imperative for climate justice policies that not only address emissions but also prioritize support for marginalized communities disproportionately bearing the burden of climate change. In the digital age, this includes leveraging technology to enhance early warning systems, telemedicine, remote health monitoring, and access to climate-resilient healthcare infrastructure, ensuring that vulnerable populations can adapt and thrive despite systemic disadvantages.

3.9. Disruptions to Education

Climate change has severely disrupted children's education across the globe. Each year, the education of over 40 million children has been interrupted due to climate-related disasters such as floods, hurricanes, and wildfires (UNICEF, 2023b). These disruptions are not only a threat to academic progress but also have long-term implications for health, social well-being, and economic mobility, particularly for marginalized populations with limited access to digital learning alternatives. These events have destroyed school infrastructure, displaced families, and forced children into temporary shelters, preventing them from continuing their education. The lack of continuity in education also undermines access to school-based health services, nutrition programs, and psychosocial support, further exacerbating the vulnerabilities of affected children.

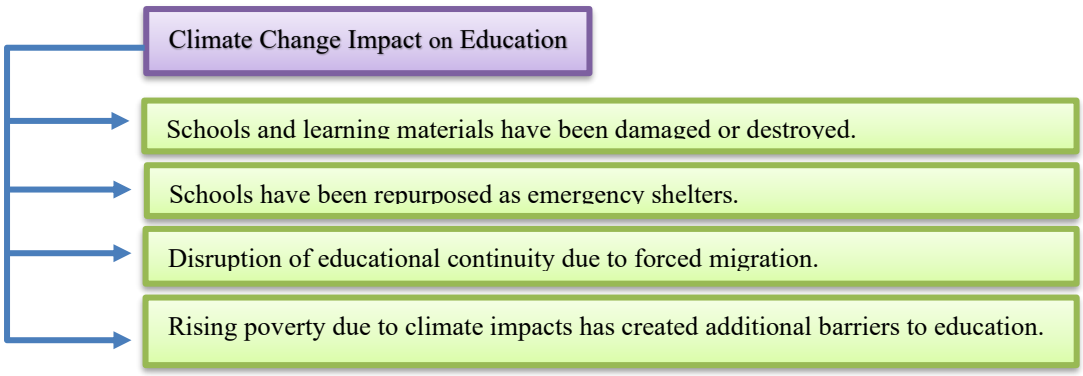
In regions repeatedly affected by such events, schools have remained closed for weeks or even months. Increasing heatwaves, projected to expose nearly 2.2 billion children by 2050, have also led to school closures (UNICEF, 2024). In addition, the digital divide compounds the problem, as children in low-income or remote areas often lack access to online learning platforms, internet connectivity, or devices, leaving them disproportionately disadvantaged compared to their peers in more resourced regions. Travel to school has become dangerous as roads and infrastructure have been damaged, making regular attendance difficult or impossible. Several key trends have emerged as discussed in figure 4.

Climate change disrupts education by damaging infrastructure, repurposing schools as shelters, and displacing families through forced migration. Moreover, these disruptions intersect with health vulnerabilities, as children lose access to school-based vaccination programs, health screenings, and mental health support. Additionally, rising poverty from climate impacts limits access to learning resources and opportunities. The cumulative effect of disrupted education, economic hardship, and limited digital access significantly undermines the resilience of communities, creating intergenerational cycles of vulnerability.

In the Horn of Africa, for instance, 2.7 million children in Kenya, Ethiopia, and Somalia have been unable to continue their education due to prolonged droughts (UNICEF, 2022). The subsequent El Niño phenomenon has caused widespread flooding in Somalia, displacing an estimated 400,000 children by early December. Approximately 876,000 children have been affected as schools have been damaged, destroyed, or converted into shelters (UNICEF, 2023a). These disruptions also strain local health systems, as displaced families often lose access to basic healthcare, clean water, and nutrition programs, further compounding the impact of climate change on child health and well-being.

Figure 4

Key Trends Impacting Education due to Climate Change



Moreover, economic hardships caused by climate change have forced many children to drop out of school to support their families. In communities dependent on agriculture or fishing, climate events have led to income loss, pushing children into labor or caregiving roles when parents have been displaced, fallen ill, or lost their livelihoods. This situation underscores the critical need for integrated approaches that combine climate adaptation, resilient health systems, and digital education platforms to ensure that marginalized children can continue learning and accessing essential services even amidst environmental shocks.

3.10. Health and Well-being Concerns

Climate change has significantly impacted children's health and well-being, directly affecting their ability to access and benefit from education. These impacts are amplified in marginalized communities, where limited healthcare infrastructure, poor sanitation, and unequal access to digital health resources exacerbate vulnerabilities. It has intensified a range of physical and mental health risks that have made it harder for children to attend school regularly or perform academically (Sheffield & Landrigan, 2011).

One of the most pressing concerns has been malnutrition (Adeyeye et al., 2023; Bossi et al., 2022), driven by climate-induced disruptions to food security (Agostoni et al., 2023). These disruptions are further compounded by economic constraints, displacement, and the lack of access to digital tools for nutrition monitoring or support programs, particularly in low-income regions. Events such as droughts and floods have reduced access to nutritious food, particularly in low-income and agriculturally dependent regions. The World Health Organization and the Intergovernmental Panel on Climate Change have identified undernutrition as the most serious health impact of climate change on children (WHO, 2023). Malnourished children experience weakened immune systems, increased susceptibility to illness, impaired cognitive development, and long-term health complications, all of which contribute to school absenteeism and reduced educational outcomes.

In Sub-Saharan Africa, especially in countries like Kenya, food production has been highly sensitive to changes in rainfall, temperature, and soil quality. Climate variability has already undermined food systems, with nearly 30% of children in Kenya aged one to five reported as stunted, an indicator of chronic undernutrition (Grace et al., 2012). The lack of adaptive agricultural technologies, combined with poor healthcare access, limits the ability of these communities to respond effectively to climate-induced nutritional crises.

Rising global temperatures and more frequent heatwaves have posed additional health threats. Young children have been particularly vulnerable to heat stress, dehydration, and heatstroke. Inadequate access to cooling systems, clean water, and health education further heightens these risks, particularly in informal settlements and rural areas. Air pollution and wildfire smoke, exacerbated by climate change, have worsened respiratory conditions like asthma, further increasing school absences.

Moreover, climate change has expanded the geographic range and seasonality of vector-borne diseases such as malaria, dengue, and Zika virus (Parums, 2023). Warmer temperatures, altered precipitation patterns, and insufficient vector control measures have created ideal conditions for disease vectors to thrive. As a result, children have faced a growing risk of infection, which, compounded by overburdened and under-resourced healthcare systems, has led to frequent illness and prolonged disruptions to their well-being and education. Integrating digital health solutions, such as telemedicine, disease surveillance apps, and remote health education, is therefore crucial to mitigating these health risks and ensuring that marginalized communities can maintain access to essential healthcare services amid climate challenges.

3.11. The Gendered Impact of Climate Change

Women and girls, particularly in low-income communities, face climate change in ways that are often more severe and complex than those faced by men or boys. These gendered vulnerabilities are amplified in the digital age, where unequal access to information, technology, and digital health services further limits adaptive capacity and resilience. Climate change disproportionately affects populations that rely heavily on natural resources for their livelihoods or those with limited ability to cope with natural disasters, such as droughts, landslides, floods, and hurricanes (Sorensen et al., 2018). These communities are often the most vulnerable to the impacts of climate change across all countries. Women commonly face higher risks and greater burdens from the impacts of climate change in situations of poverty, and the majority of the world's poor are women (Md et al., 2022). These risks include increased exposure to health hazards, reduced access to emergency care, and greater vulnerability to displacement, all of which intersect with systemic gender inequalities.

Traditional gender roles and social structures play a significant part in determining the educational opportunities and overall well-being of girls, especially in the aftermath of climate-related disasters. In many communities, girls are expected to take on caregiving responsibilities for younger siblings or elderly family members when climate disasters occur (de Carvalho, 2025). This responsibility not only interrupts their education but also affects their mental health and long-term social mobility. This often means girls must miss school or drop out entirely to fulfill these roles. In some cultures, the economic pressures caused by climate change also require girls to stay at home and help with domestic chores or work, further limiting their educational prospects (Nosheen et al., 2023). The lack of access to digital learning platforms or remote education exacerbates these educational disruptions, particularly in marginalized and rural communities.

Girls are also more vulnerable to gender-based violence in the aftermath of climate-related disasters. In overcrowded shelters or displaced persons camps, where resources are limited, women and girls are particularly at risk of exploitation, trafficking, and violence (Schuster et al., 2024; Ullah et al., 2024). These threats to safety and well-being further undermine their access to healthcare, nutrition, and mental health services, compounding the adverse effects of climate change on their overall development. This not only affects their safety but also their ability to access education and realize their long-term potential. In such situations, the compounded effects of violence and limited opportunities for education further restrict girls' future prospects (Thurston et al., 2021). In addition, the digital divide prevents many girls from accessing online support services, educational content, and community resources that could mitigate the impacts of these crises.

In regions where there is a strong preference for boys, families experiencing scarcity due to disasters are more likely to prioritize boys when distributing food and other resources. They may also take their daughters out of school, marry them off at a young age, or pull women from agricultural work to focus on household duties. These gendered coping mechanisms reinforce intergenerational cycles of vulnerability, limiting girls' opportunities to gain education, economic independence, and access to healthcare.

By understanding these gendered impacts and working to ensure that girls have the resources and support they need during and after climate disasters, including access to digital education, telehealth services, psychosocial support, and targeted climate adaptation programs, we can help to break the cycle of vulnerability and build a more equitable future for all. Integrating gender-sensitive approaches into climate justice frameworks is essential to ensure that health systems, social protections, and educational programs respond effectively to the unique needs of women and girls in marginalized communities.

3.12. Recommendations

The deepening climate crisis disproportionately affects the world's most marginalized communities, particularly women, children, ethnic minorities, indigenous populations, and climate-vulnerable urban poor. As climate change accelerates, so too does the urgency to address not only environmental

degradation but the systemic injustices it magnifies. True climate justice requires integrated, digital-inclusive, and intergenerationally responsible strategies, where the rights, futures, and well-being of children and unborn generations are safeguarded through immediate, inclusive, and equitable policy actions. Table 1 outlines strategic, multidimensional recommendations designed to redress these disparities and build long-term resilience in marginalized communities through a rights-based, justice-oriented, and digitally integrated framework.

Table 1
Multidimensional Aspects of Climate Change and Strategic Policy Recommendations

No	Multi-Dimensional Aspects of Climate Change	Policy Recommendations
1	Safeguard Education Amid Climate Disruptions for Equity and Resilience. Education is a fundamental human right and an indispensable tool for climate adaptation. Climate-induced disasters such as floods, heatwaves, and displacement continue to disrupt schooling for millions of children, reinforcing cycles of poverty, gender inequality, and social exclusion.	• Build climate- and digitally-resilient schools with disaster-proof infrastructure in vulnerable regions; • Ensure education continuity during climate crises using remote learning tools, mobile classrooms, and community learning hubs; • Integrate climate literacy, digital literacy, and sustainability education into curricula, focusing on local adaptation knowledge and disaster preparedness; • Provide targeted support for girls and marginalized children at risk of school dropouts during climate shocks.
2	Promote Health Equity for Children and Marginalized Communities. Climate change worsens health disparities, especially among low-income families, rural populations, and frontline communities. Children face heightened risks of undernutrition, vector-borne diseases, and psychological trauma, while health systems remain under-resourced and unprepared.	• Expand universal access to climate-resilient and digitally enabled healthcare; • Implement school-and community-based health monitoring systems to detect and respond to climate-related illnesses; • Fund nutrition programs, clean water, and mental health support in climate-vulnerable communities; • Strengthen early warning systems for disease outbreaks and climate-health emergencies.
3	Operationalize Transformative Climate Justice. Addressing environmental injustice requires systemic reform beyond market-driven neoliberalism.	• Enforce binding international accountability mechanisms for historical polluters based on “polluter pays” and CBDR principles; • Increase climate finance flows and technology transfers to marginalized communities with transparent, equitable allocation; • Institutionalize financial reparations and climate debt cancellation for low-income nations to invest in adaptation without unsustainable obligations; • Mainstream intersectionality into climate governance, recognizing overlapping social vulnerabilities.
4	Build Locally Tailored Resilience Infrastructure. Inadequate infrastructure amplifies climate impacts, particularly in slums, tribal areas, and rural environments. Justice-centered planning demands localized, inclusive investments reflecting the lived realities of affected communities.	• Prioritize community-led planning and implementation of climate-resilient infrastructure; • Invest in clean energy, water management, disaster-resistant housing, and adaptive educational and healthcare facilities; • Protect schools and health facilities from environmental hazards; • Promote ecosystem-based adaptation that strengthens both livelihoods and natural systems.
5	Enable a Just and Inclusive Energy Transition. Low-carbon transitions must equitably distribute benefits and avoid displacing risks onto marginalized populations.	• Create inclusive green job pathways with skills training for youth, women, and informal sector workers; • Guarantee labor protections, collective bargaining rights, and living wages in renewable energy sectors; • Engage indigenous and frontline communities in clean energy planning and ownership; • Ensure energy affordability and access as a core goal.

6	Protect Climate-Displaced Populations through Legal and Social Inclusion. Climate displacement threatens lives, particularly of women and children, who remain largely unprotected under international law.	• Establish an international legal framework to recognize and safeguard climate refugees; • Provide education, health, and psychosocial support to displaced children and youth; • Promote inclusive integration policies in host communities to prevent marginalization; • Support cross-border cooperation for climate migration planning.
7	Enhance Protection for Climate-Displaced Populations Repeated emphasis underscores the urgency of safeguarding migrants, especially children and women, from exploitation, educational disruption, and violence.	• Strengthen international recognition and legal protections for climate migrants; • Expand services, health, and psychosocial support for displaced populations; • Implement inclusive host-community integration to prevent social fragmentation; • Facilitate solidarity-based, rights-centered cross-border planning.
8	Address Gender and Intersectional Vulnerabilities in All Climate Action. Women and girls from indigenous, rural, and low-income backgrounds face compounded climate burdens, including gender-based violence, early marriage, and educational exclusion.	• Embed gender-responsive, youth-focused, and intersectional planning in national climate strategies; • Expand legal protections and social safety nets for women and children; • Create safe spaces and leadership platforms for girls and youth to influence climate policy; • Mandate inclusive participation of indigenous leaders, youth activists, and grassroots communities in governance.

By centering the needs, rights, and leadership of marginalized communities, particularly women, children, and climate-exposed populations, climate policy can advance toward a more inclusive, humane, and sustainable future. These recommendations, grounded in justice, human rights, and digital innovation, provide a roadmap not only for resilience but for reimagining climate action as a vehicle for structural equity and collective empowerment.

3.13. Pathways to Resilient Health Systems for Marginalized Communities

Building resilient health systems in the context of climate change requires a comprehensive, justice-centered approach that integrates climate adaptation, digital innovation, and equity-focused policies. This study demonstrates that climate change exacerbates pre-existing social inequalities, with marginalized communities, particularly in the Global South, bearing the heaviest burden. Women, children, ethnic minorities, indigenous populations, and the urban poor are disproportionately affected due to layered socio-economic disadvantages and institutional neglect. These compounded vulnerabilities often manifest in the form of educational disruption, gender-based violence, malnutrition, and the loss of livelihoods in disaster-prone regions.

The findings presented in Sections 3.1 to 3.11 reinforce the urgent need for targeted interventions that address the multidimensional impacts of climate change. Systemic inequities and power dynamics further compound these challenges, as the Global North continues to benefit from industrialization while contributing most significantly to greenhouse gas emissions (Fuhr, 2021). Neoliberal approaches to climate justice frequently fall short, as they prioritize voluntary corporate actions over structural reform, often neglecting the needs of the most vulnerable populations. Geographic vulnerability adds another layer of complexity, particularly in regions with fragile ecosystems and limited economic diversity, such as small island states and parts of Sub-Saharan Africa. These areas face a dual crisis of climate adaptation and mounting sovereign debt, while the climate-induced displacement crisis is projected to affect over 200 million people by 2050 (World Bank, 2024).

Equitable climate finance and targeted investment are essential pathways to address these challenges. Resources should prioritize climate-resilient health infrastructure, including hospitals, clinics, water and sanitation systems, and sustainable energy solutions, ensuring continuous access to care even during extreme climate events. Digital health technologies, such as telemedicine, mobile health applications, and early-warning systems, are crucial tools for improving service delivery in remote and underserved communities, enabling timely interventions, disease surveillance, and continuity of care.

Integrating an intersectional lens is critical to understanding how overlapping factors such as age, gender, economic status, and geography create multidimensional vulnerabilities (Chisty et al., 2021). Intersectionality helps policymakers and practitioners recognize the complex, interwoven nature of risks, allowing the design of equitable, context-specific, and localized strategies. For instance, digital health interventions can be tailored to reach women, children, and indigenous populations who face unique barriers to accessing care, while community-based adaptation programs can enhance local resilience by leveraging local knowledge and resources.

Proactive adaptation strategies should include strengthening health system capacity to mitigate climate-sensitive risks, including malnutrition, heat stress, vector-borne diseases, and mental health stressors (Hossain, 2025; Shibesh & Nagabhatla, 2025). Predictive modeling, climate-informed epidemiological surveillance, and early-warning mechanisms can improve preparedness, while education and community engagement programs promote health literacy, preventive behaviors, and access to digital services.

Gender-sensitive and inclusive policies are also crucial. Women and girls, particularly in marginalized communities, experience disproportionate impacts of climate change (Sidun & Gibbons, 2024). Health programs must address reproductive health needs, psychosocial support, protection from gender-based violence, and access to digital platforms for remote care and education. These approaches help maintain continuity in healthcare, nutrition, and education services during and after climate crises, reducing the long-term vulnerabilities of marginalized populations.

Multisectoral collaboration is essential to operationalize these strategies effectively (Sutarsa et al., 2024). Linking health, education, social protection, agriculture, and technology sectors ensures that climate adaptation measures address the interconnected social, economic, and environmental determinants of health. Community-driven approaches enhance sustainability, allowing local populations to participate in decision-making, monitoring, and implementation of resilience initiatives. Community-based early-warning systems, locally managed health centers, and digital platforms for reporting climate and health risks empower residents to respond proactively and equitably to climate hazards.

In conclusion, pathways to resilient health systems for marginalized communities must combine justice-oriented, intersectional, and technology-enabled strategies that address the multidimensional vulnerabilities imposed by climate change. By integrating equitable investment, proactive adaptation, gender-sensitive policies, digital innovation, and community engagement, health systems can better protect marginalized populations, promote human rights, and ensure long-term resilience in the face of accelerating climate impacts. This framework emphasizes the need to rethink climate justice in the digital age, ensuring that future health interventions are inclusive, localized, and sustainable.

4. CONCLUSION

Climate change is not just an environmental threat; it represents a profound justice crisis that magnifies pre-existing social, economic, and health inequalities across the globe. Marginalized communities, particularly in the Global South, face disproportionate risks due to intersecting vulnerabilities related to poverty, gender, geography, and systemic exclusion. These compounded vulnerabilities manifest in diverse forms, including disrupted education, gender-based violence, malnutrition, health inequities, economic displacement, and limited access to essential services. Addressing these injustices requires moving beyond market-driven models to embrace a rights-based, intersectional framework that prioritizes equity, accountability, and the leadership of those most affected.

Investing in climate-resilient infrastructure, health systems, and digital solutions is essential for building adaptive capacity. Hospitals, clinics, schools, water and sanitation systems, and sustainable energy solutions must be designed to withstand climate-related shocks. Digital health technologies, telemedicine, early-warning systems, and mobile health platforms can enhance access to care, improve disease surveillance, and ensure continuity of services for remote or underserved populations. Protecting climate-displaced populations, ensuring inclusive education, and strengthening social protections are integral to promoting resilience and breaking intergenerational cycles of vulnerability.

A just and equitable energy transition, combined with intersectional health and social policies, is critical for reducing emissions while safeguarding the livelihoods and rights of marginalized communities. Gender-sensitive, culturally appropriate interventions and community-driven approaches enhance sustainability and effectiveness. By integrating equity, digital innovation, and community participation into climate adaptation strategies, policy interventions can be locally relevant, socially just, and responsive to the multidimensional vulnerabilities highlighted in this study.

This study contributes a novel perspective by bridging digital health and climate justice, offering policy pathways and research directions for promoting equitable health resilience in an era of environmental uncertainty. Climate justice is not peripheral; it is central to achieving sustainable and inclusive development. By prioritizing investments in resilient infrastructure, digital solutions, education, and healthcare, and by empowering the voices and leadership of those most affected, we can build adaptive systems that protect marginalized communities and promote long-term equity and resilience in the digital age.

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