Vulnerability and Resilience: Assessing Climate Change Impacts on Urban Slums and Informal Settlements

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DOI: https://dx.doi.org/10.47772/IJRISS.2025.90300194

Received: 07 March 2025; Accepted: 11 March 2025; Published: 07 April 2025

ABSTRACT

The escalating consequences of climate change on urban slums present a critical area of study due to their disproportionate vulnerability to extreme weather events. This scoping review synthesizes global research on the multifaceted impacts of climate change on informal settlements, emphasizing socioeconomic factors that amplify risks, such as poor housing quality, low socioeconomic position, inadequate urban planning, and limited access to essential infrastructure. By evaluating adaptation strategies and policy recommendations from selected high and moder-ate-quality studies, this paper highlights the urgent need for comprehensive, community-focused climate adaptation and mitigation efforts. The objective representation of these findings under-scores the importance of inclusive policy formulations and resource distribution to enhance the resilience of low-income communities against climate change.

Keywords: climate change, urban slums, socioeconomic vulnerability, environmental justice.

INTRODUCTION

In 2018, revelations from the United Nations underscored the disparate impact of climate change across the globe, with a spotlight on the grave consequences of a 2°C increase in global temperatures or a rise in sea levels by 50 cm (Thomas et al., 2018; Rasmussen et al., 2018). These changes have disproportionately affected communities with lower socioeconomic statuses, manifesting in varied adverse outcomes including escalated food prices, deteriorated health conditions, and an increased susceptibility to catastrophic events like floods, disproportionately impacting impoverished communities and the broader populace (World Bank, 2020). Amidst the backdrop of the COVID-19 pandemic, the World Bank projected a stark rise in global extreme poverty in 2020, marking the first uptick in over two decades. The pandemic exacerbated the detrimental impacts of ongoing conflicts and climate change, further impeding poverty reduction efforts. The interplay between the pandemic and poverty unveiled a grim reality, with COVID-19 severely disrupting economies, employment, and social systems, thus elevating poverty levels (Patel et al., 2020; Whitehead et al., 2021). The pandemic's economic fallout is feared to plunge an additional 88 to 115 million people into extreme poverty, with potential figures reaching up to 150 million by 2021.

This escalating crisis draws our focus to the plight of low-income or impoverished communities, which are increasingly vulnerable to climate change. These communities, often situated in high-risk zones for climate-related disasters and burdened by limited access to crucial resources and infrastructure, find themselves on the frontline of climate adversity (Abbass et al., 2022; Giri et al., 2021; Thomas et al., 2019). It underscores the imperative to delve into and address the unique vulnerabilities and challenges faced by these communities, advocating for inclusive and equitable climate adaptation and mitigation efforts (Archer et al., 2014).

The study at hand embarks on a comprehensive examination of the intricate dynamics between low-income communities and climate change. It aims to unravel the distinct hardships these communities endure and to

spotlight effective strategies to mitigate the adverse effects of climate change. Highlighting the disproportionate vulnerability and risks these communities face, the study calls for a concerted push towards environmental and climate justice, advocating for equitable policy formulations and resource distribution (Kemarau and Eboy, 2023; Mendez, 2020). With urban areas and slums being magnets for individuals seeking better economic, educational, and healthcare opportunities, the intertwining of urbanization and climate change poses significant health risks, such as increased disease burdens (Caminade et al., 2019; Rosenzweig et al., 2011). The plight of over one billion people living in slum conditions, characterized by inadequate access to clean water, sanitation, and secure housing, is exacerbated in these settings, further complicating the challenges of climate change (United Nations, 2020). This scoping review seeks to forge a nuanced understanding of the relationship between climate change and low-income communities within urban landscapes. It aims to synthesize existing literature, explore the global impacts of climate change on these communities, and assess adaptation strategies tailored to their specific contexts. By addressing key research questions and evaluating recommendations for future research and policy, this study endeavors to illuminate paths towards more inclusive and effective responses to the challenges posed by climate change, ultimately contributing to the resilience and sustainability of low-income communities in the face of environmental changes.

METHODOLOGY

For this scoping review, we have structured a set of research questions and objectives focused on understanding the impact of climate change on vulnerability in informal settlements. To facilitate this exploration, we initially select articles from databases like SCOPUS, ScienceDirect, and Web of Science, using specific keywords (Table 2), focusing on peer-reviewed sources indexed by Scopus and Web of Science, and covering publications from 2000 to 2024. Employing sophisticated search strategies, the authors integrated phrase searching with Boolean logic (OR, AND) for optimal keyword amalgamation, contrasting with manual methods like selection, backward and forward tracking. An initial search yielded 91 articles, from which high-impact studies on climate change effects on urban slums and informal settlements were meticulously chosen (Figure 1).

The study's time frame, from 2005 to 2023, was selected based on Okoli and Schabram's (2010) recommendation, capturing a period rich in relevant research and methodological advancements in Systematic Literature Reviews (SLR) highlighted by Dixon Wood et al., (2005), Petticrew and Roberts (2006), and Whitemore and Knaf (2005). The focus on English-language articles, advised by Linares-Espinos et al., (2018), streamlined the review by avoiding language barriers and ensuring efficiency. The qualitative analysis followed Petticrew and Roberts' (2006) approach, assessing articles for quality based on five criteria defined by Hong et al., (2018), with only those of moderate to high quality included Table 1.

Table 1: Question to Assessing Article for Quality Based on Five Criteria.

Criteria for Inclusion
Does the article primarily focus on the effects of climate change on residents of slums or informal settlements?
Is the study context within urban areas?
Are the factors that intensify the impact of climate change on slums or informal settlements explicitly identified?
Does the article detail specific impacts of climate change on slum and informal settlement areas?
Are recommendations for adaptations to mitigate the effects of climate change provided?

Author assessed articles using a three-option criterion (yes, no, can't tell), categorizing them into high quality (four or five criteria met), moderate quality (three criteria met), or low quality (one or two criteria met). Out of the evaluated articles, 31 were deemed to meet the high or moderate quality standards for inclusion. Despite six

articles requiring further discussion, two were included for their unique contributions: one for its North American context and another for its insights into climate change effects on Nepal's slum residents. The selection and data extraction from these 31 articles were collaboratively executed by the authors, with the co-authors advising during data finalization.

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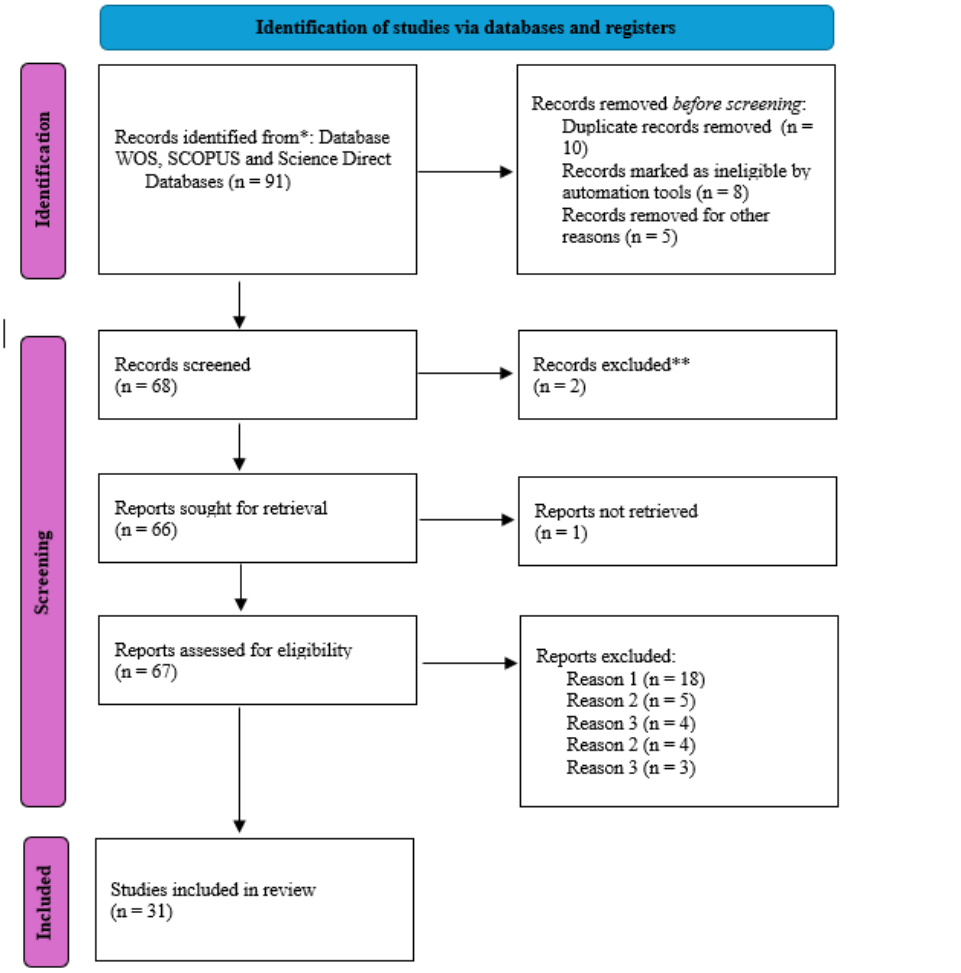

Figure 1: Flow Chart Methodology

RESULTS AND DISCUSSION

Result and discussion including specific impact climate change on slum and informal population, ssocioeconomic factors contributing amplify risks the impact of climate change on slum / informal population, adaptation strategies and recommendations and future research directions.

Specific Impact Climate Change on Slum and Informal Population.

The collection of studies presents a global perspective on the multifaceted impacts of climate change, especially on informal settlements and vulnerable populations. These impacts are categorized primarily by the type of climate exposure—extreme temperature, flooding, sea level rise, and general climate change effects—each

carrying distinct and significant consequences (Table 2). Studies by Rana et al., (2022) in Lahore, Pakistan, and Wilby et al., (2021) in Ghana, among others, highlight the severe vulnerability of informal settlements to extreme temperatures. These communities face a range of adverse outcomes, from heatwaves leading to indoor heat exposure-related deaths to a variety of health-related problems including respiratory issues, hypertension, and heat rashes. For instance, Rana et al., (2022) noted that 84% of people in Lahore's informal settlements live in conditions that are highly susceptible to heatwaves, significantly increasing mortality rates due to indoor heat exposure. Similarly, Zhao et al., (2021) address the global impact of lost work hours due to extreme temperatures, emphasizing the economic strain on low-income populations.

Table 2: Impact of Climate Change on Informal and Slum Populations

Authors	Study Areas	Specific Impact
Extreme Temperature		
Rana et al., (2022)	Pakistan	Informal settlement vulnerability to heatwaves, significant indoor heat exposure-related deaths.
Zhao et al., (2021)	World	Lost work hours.
Wilby et al., (2021)	Ghana	Health issues including respiratory problems and heat rashes.
Vellingiri et al., (2020)	India	Disease incidence related to heat.
Teare et al., (2020)	South Africa	Health impacts when mean heat index exceeds 35°C.
Flood		
Haque et al., (2021)	Bangladesh	Food shortages, house damage.
Parikh et al., (2020)	South Africa	Income impact, housing damage, access to services.
Contreras et al., (2018)	Peru	Mental health challenges, domestic violence.
Siyongwana et al., (2015)	South Africa	Financial losses, property damage, access to basic services impacted.
Sea Level and Flooding		
Porio (2014)	Philippines	Disruption to essential services, increased living costs.
Sariffudin et al., (2016)	Indonesia	Property damage.
General Impact Climate Change		
Dante et al., (2023)	Ghana.	Diseases related to flood, drought, dry spells.
Anderson et al., (2023)	Kenya	Air pollution, health status, water quality, droughts, heatwave.
Kayaga et al., (2021)	Ghana	Vulnerabilities to fecal contamination during flooding, water, and electricity shortages during extreme heat.
Giri et al., (2021)	Nepal	Water quality deterioration, health issues related to flooding.

Flooding, as discussed by Haque et al., (2021) in Dhaka, Bangladesh, and Parikh et al. (2020) in Durban, South Africa, among others, leads to immediate physical damages such as food shortages and house damage, alongside

longer-term socioeconomic effects like income loss and impaired access to basic services. The mental health impacts, as noted by Contreras et al., (2018) in Lima, Peru, underline the broader, often overlooked, consequences of such climate events. Porio (2014) in Manila, Philippines, and Sariffudin et al., (2016) in Semarang, Indonesia, offer insights into the repercussions of sea level rise and flooding, from the disruption of essential services to property damage. These effects underscore the compound nature of climate threats, where physical, economic, and social vulnerabilities intertwine. The broader impacts of climate change, as explored by Dante et al., (2023) in Greater Accra, Ghana, Anderson et al., (2023) in Nairobi, Kenya, and others, illustrate the complex interplay between various climate-induced weather events and health outcomes. These studies reveal the direct and indirect connections between climate change and the increased incidence of diseases, water quality deterioration, and socioeconomic disruptions.

For example, Kayaga et al., (2021) in Ghana highlighted the vulnerability of areas to fecal contamination during flooding and severe shortages of water and electricity during extreme heat. These studies collectively emphasize the urgent need for comprehensive strategies to mitigate the impacts of climate change on the world's most vulnerable populations. The specific impacts identified—ranging from health-related issues and economic hardships to the loss of critical services and infrastructure damage—call for targeted interventions that address both the immediate and long-term challenges posed by climate change.

Socioeconomic Factors Contributing Amplify risks the impact of climate change to Slum / Informal Population

The synthesis of research across various informal settlements worldwide reveals a nuanced understanding of how climate-related risks are amplified by specific vulnerabilities. These vulnerabilities, categorized under four primary themes namely housing quality, socioeconomic position, urban planning, and access to basic infrastructure offer a comprehensive lens through which the challenges and necessary interventions can be examined (Table 3). Housing quality emerges as a pivotal concern. Studies such as Wilby et al., (2021) in Ghana, Vellingiri et al. (2020) in Ahmedabad, India, and Roy et al., (2018) in Dar es Salaam, Tanzania, underscore the perilous nature of inadequate housing. These structures, often built without compliance with any construction standards, inadequately protect residents from extreme weather, thereby exacerbating their vulnerability. This is a recurrent theme across continents, as seen in Egondi et al., (2015) in Nairobi, Kenya, and Adelekan (2012) in Ibadan, Nigeria, illustrating the global pervasiveness of this issue.

Socioeconomic position is closely linked to climate vulnerability. The collective research, including Zhao et al., (2021)'s global analysis and Vellingiri et al., (2020)'s work in India, reveals how poverty and limited education amplify risks associated with climate change. This pattern is echoed in diverse settings, from Teare et al., (2020) in South Africa to Haque et al., (2021) in Bangladesh, highlighting the critical role socioeconomic factors play in shaping vulnerability across the globe.

Table 3: Key Factor amplify risks the impact of climate change to Slum / Informal Population

Theme	Key Factor	Studies
Housing Quality	Poor quality of housing, constructions not adhering to building codes, densely packed areas with minimal vegetation.	Wilby et al., 2021; Vellingiri et al., 2020; Roy et al., 2018; Egondi et al., 2015; Adelekan, 2012; Corburn et al., 2017; Sverdlik et al., 2011; Pasquini et al., 2020
Social Economic position	Low income and education levels.	Zhao et al., 2021; Vellingiri et al., 2020; Teare et al., 2020; Park et al., 2018; Madrigano et al., 2015; Egondi et al., 2015; Haque et al., 2021; Khan et al., 2014; Porio, 2014; Douglas et al., 2008; Dante et al., 2023; Kayaga et al., 2021; Giri et al., 2021; Wilk et al., 2018; Bambrick et al., 2015; Toan et al., 2014

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume IX Issue III March 2025

Urban Planning and population density	High density of population, unplanned urbanization, congestion.	Haque et al., 2021; Egondi et al., 2015; Tran et al., 2013; Giri et al., 2021
Access to infrastructure	Lack of access to essential services such as water supply, sanitation, poor waste management, blocked drainage systems.	Wilby et al., 2021; Parikh et al., 2020; Anderson et al., 2023; Waters and Adger, 2017; Pandey et al., 2017; Douglas et al., 2008; Sariffudin et al., 2016; Wilk et al., 2018; Siyongwana et al., 2015

Urban planning and population density are identified as critical factors that exacerbate vulnerability to climate impacts. The work of Haque et al., (2021) in Dhaka, Bangladesh, and Tran et al., (2013) in Ahmedabad, India, points to the challenges posed by high population density and unplanned urbanization. These studies, along with insights from Egondi et al. (2015) in Nairobi, Kenya, and Giri et al., (2021) in Kathmandu, Nepal, emphasize the urgent need for thoughtful urban development strategies to mitigate climate risks. Access to basic infrastructure, or the lack thereof, significantly contributes to the increased vulnerability of informal settlements to climate hazards. The findings of Wilby et al., (2021) in Ghana and Anderson et al., (2023) in Nairobi, Kenya, along with Parikh et al., (2020) in Durban, South Africa, and Waters and Adger (2017) in Kampala, Uganda, illustrate how inadequate water supply, sanitation, and ineffective waste management can magnify the impacts of climate change.

In the realm of climate change research, especially concerning vulnerable populations in informal and slum areas, studies often reveal a complex web of interrelated factors that compound the risks and impacts experienced by these communities (Figure 2). Wilby et al., (2021) and Vellingiri et al., (2020) provide insights into the quality of housing. Their research goes beyond merely noting the poor quality of dwellings; they delve into the implications of this for heat stress during extreme temperature events. Substandard housing often lacks the infrastructure necessary to mitigate the harsh effects of climate change, making adaptation more difficult. Roy et al., (2018) and Egondi et al., (2015) also touch upon housing quality, but they emphasize the lack of adherence to building codes, which often leads to structures that are unable to withstand climate stresses such as flooding and heatwaves, thereby increasing the vulnerability of their inhabitants.

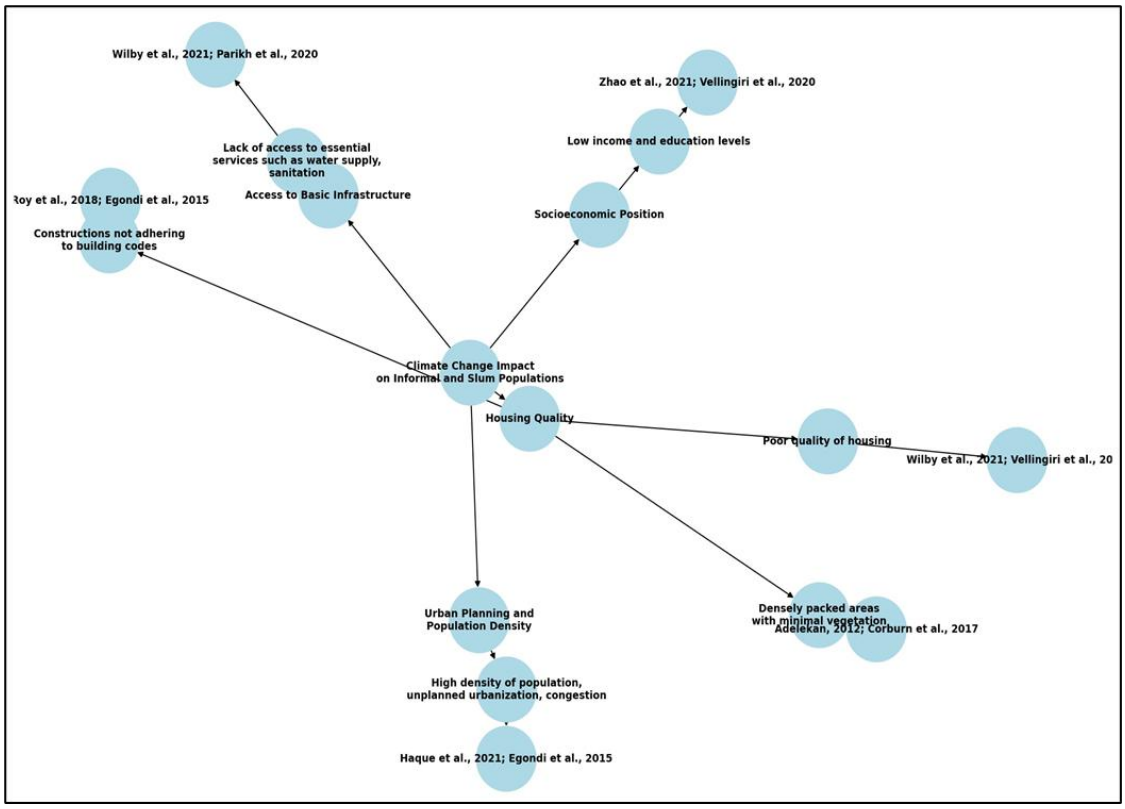

Figure 2: Multiple Factor imply risk impact to slum and informal population at urban.

The socioeconomic position, addressed by Zhao et al., (2021) and Vellingiri et al., (2020), highlights how low income and education levels can reduce the capacity of individuals and communities to respond to climate threats. Limited financial resources and a lack of knowledge about climate adaptation strategies can prevent communities from effectively preparing for and responding to environmental changes. Regarding access to basic infrastructure, Wilby et al., (2021) and Parikh et al., (2020) show that the lack of essential services like clean water and adequate sanitation can exacerbate the impacts of climate change. Inadequate infrastructure can lead to health crises during heatwaves or flooding when clean water is most needed and can hinder the recovery process following climate-induced disasters.

Pasquini et al., (2020) and Corburn et al., (2017) discuss how the density of housing and minimal vegetation in slums can create urban heat islands and reduce the ability of these areas to cope with extreme temperatures. Vegetation is not merely an aesthetic or ecological concern; it plays a critical role in cooling urban environments and improving air quality, which is vital during climate events. Lastly, Haque et al., (2021) and Egondi et al., (2015) consider the challenges arising from urban planning and population density. They point to the problems of high population density, unplanned urbanization, and congestion, which can impede evacuation during disasters, limit access to emergency services, and increase exposure to environmental hazards. Each of these studies, by examining more than a single dimension of vulnerability, underscores the complexity of climate change impacts. The interplay between physical, economic, social, and infrastructural factors demands comprehensive solutions.

Adaptation strategies and recommendations

In the context of addressing climate change, researchers across the globe have conducted extensive studies to understand its impacts and propose viable adaptation and mitigation strategies. These strategies range from urban greening initiatives to infrastructural modifications, emphasizing the diverse approaches needed to combat climate change effectively (Table 4).

Table 4: Adaptation and Recommendations in impact of climate change on informal / slum population and effectiveness Evaluation

Authors	Adaptation / Recommendation	Climate Exposure	Effectiveness Evaluation
Roy et al., (2018); Egondi et al., (2015); Rana et al. (2022), Lahore, Pakistan	Urban Greening and Awareness	Extreme Temperature	Moderate - Requires long-term investment and maintenance but improves urban microclimate and health benefits.
Zhao et al., (2021)	Shifting Working Hours	Extreme Temperature	High - Immediate effect in reducing heat exposure for workers but limited to employment sectors with flexible working conditions.
Wilby et al., (2021), Vellingiri et al., (2020), Tran et al., (2013)	Home and Infrastructure Modifications	Extreme Temperature	High - Reduces indoor heat and enhances thermal comfort, but costly for low-income households.
Anderson et al., (2023), Kayaga et al. (2021), Wilk et al., (2018)	Awareness, Education, and Community Engagement	Extreme Temperature, Flooding	Moderate - Improves public preparedness and knowledge but requires continuous efforts and incentives for behavior change.
Pasquini et al. (2020), Park et al.,(2018), Porio (2014)	Governmental Warning and Policy	Extreme Temperature, Flooding	High - Effective in disaster preparedness and early response, but implementation

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume IX Issue III March 2025

			varies depending on governance capacity.
Haque et al. (2021), Khan et al., (2014), Parikh et al., (2020)	Water Management and Sanitation	Flooding	High - Reduces waterborne diseases and enhances resilience, but infrastructure costs can be a limitation in informal settlements.
Contreras et al. (2018), Siyongwana et al., (2015)	Public Healthcare and Local Health Outreach	Flooding	Moderate - Increases access to healthcare but limited by healthcare infrastructure and funding.
Douglas et al. (2008), Waters and Adger (2017), Porio (2014)	Relocation and Evacuation Preparedness	Flooding	Low to High - Highly effective in high-risk areas but often faces resistance due to social and economic ties to current locations.
Dante et al., (2023), Corburn et al. (2017), Sariffudin et al., (2016)	Housing and Community Infrastructure	General	High - Strengthens resilience, improves living conditions, but requires significant investment and long-term planning.
Bambrick et al., (2015), Toan et al., (2014)	Enhanced Hygiene and Access to Clean Water	General	High - Directly reduces disease risk, but sustainability depends on infrastructure investment and community maintenance.
Sverdlik et al., (2011)	Specialized Assistance for Low-Income Groups	General	Moderate - Supports vulnerable populations but often limited in scale and financial resources.

Roy et al., (2018) in Dar es Salaam, Tanzania, and Egondi et al., (2015) in Nairobi, Kenya, focus on urban greening and raising public awareness about the risks associated with extreme temperatures. Rana et al., (2022) in Lahore, Pakistan, also emphasize awareness and suggest practical measures such as staying hydrated and wearing light clothes. Zhao et al., (2021), covering global perspectives, suggest shifting working hours to cooler times of the day to mitigate the impact of extreme temperatures. Wilby et al. (2021) in Ghana and Vellingiri et al. (2020) in Ahmedabad, India, propose modifications to homes, such as ceiling insulation and sustainable roofing solutions, aiming to enhance thermal comfort.

Studies such as Pasquini et al., (2020) in Dar es Salaam, Tanzania, and Park et al. (2018) across 53 countries, highlight the importance of governmental warning channels and policies to effectively communicate risks and manage the public's response to extreme temperatures and flooding. In the face of flooding, Haque et al., (2021) in Dhaka, Bangladesh, and Parikh et al., (2020) in Durban, South Africa, recommend elevating household furniture and improving infrastructure provisions, including drainage systems and waste management, to enhance community living conditions. Contreras et al., (2018) in Lima, Peru, and Siyongwana et al., (2015) in Missionvale, South Africa, emphasize the role of the public healthcare system and the construction of robust houses and enhanced drainage systems to withstand flood damage.

Dante et al., (2023) in Greater Accra, Ghana, Anderson et al., (2023) in Nairobi, Kenya, and Wilk et al., (2018) in Kota, India, propose a range of measures addressing flooding, drought, and extreme temperatures. These include government-provided infrastructure, garbage collection, water saving awareness, and enhancing the infrastructure system to mitigate flood risks while also preparing for heatwaves through urban landscaping. Adelekan (2012) in Ibadan, Nigeria, suggests adaptation measures for wind storms, including roof retrofitting. Corburn et al. (2017) across Asia, Africa, and Latin America, and Waters and Adger (2017) in Kampala, Uganda, advocate for enhanced flood management and the option to relocate to safer areas within cities.

Bambrick et al., (2015) in Shashemene, Ethiopia, and Toan et al., (2014) in Hanoi, Vietnam, focus on improving hygiene, access to clean water, and understanding the health impacts related to climate change, highlighting the need for immunization and better health practices. The critical importance of adaptable, community-focused strategies that address specific climate exposures. Urban slums are particularly vulnerable to climate-related hazards such as extreme temperatures and flooding, necessitating diverse adaptation strategies. The effectiveness of these approaches varies based on cost, implementation feasibility, and long-term sustainability.

Urban greening and awareness programs have moderate effectiveness, as they enhance urban microclimates and improve public health but require long-term investment and maintenance. Similarly, shifting working hours is a highly effective and immediate measure for heat exposure reduction, yet it is limited to employment sectors with flexible policies. Home and infrastructure modifications, such as improved ventilation and insulation, also provide high effectiveness in reducing indoor heat, but their cost-prohibitive nature may prevent low-income communities from adopting them widely. Education-based strategies, such as awareness campaigns and community engagement, show moderate effectiveness in both heat and flood preparedness, as they foster behavioral change but require continuous reinforcement and incentives. Governmental warning systems and policies rank high in effectiveness, particularly in disaster preparedness and response, yet their impact depends on the efficiency of local governance and enforcement.

For flood-prone areas, water management and sanitation infrastructure demonstrate high effectiveness in preventing waterborne diseases and improving hygiene, but financial constraints often hinder widespread implementation. Public healthcare and outreach programs also enhance community resilience, particularly in disaster aftermaths, but their impact is limited by healthcare infrastructure availability. Relocation and evacuation preparedness is a highly variable strategy, as it is extremely effective in mitigating immediate risks but often faces social and economic resistance due to displacement concerns. Housing and community infrastructure improvements rank among the most effective adaptation measures, as they directly enhance resilience, safety, and long-term stability, yet they require substantial funding and policy commitment. Similarly, enhanced hygiene measures and access to clean water provide high effectiveness in reducing disease transmission, though their sustainability is contingent on investment in infrastructure and proper maintenance.

Lastly, specialized assistance programs for low-income groups hold moderate effectiveness, as they offer targeted support to vulnerable populations but often lack scalability and financial resources to reach all affected communities comprehensively. The most effective strategies for climate adaptation in urban slums are those that combine infrastructure development, policy enforcement, and community engagement. While financial and governance limitations may hinder widespread implementation, prioritizing low-cost, high-impact solutions such as education, early warning systems, and water management can significantly enhance climate resilience and social equity in these vulnerable communities.

Future Research Direction

Starting with spatial analysis, Rana et al., (2022) and Vellingiri et al., (2020) advocate for mapping hot spot areas and conducting studies on a larger scale to better understand geographical vulnerabilities. Teare et al., (2020) suggest that future research should not only consider larger sample sizes but also delve into the specifics of housing design, such as orientation, color, and nearby shade, to assess their impact on indoor temperatures and climate resilience. The identification of vulnerable groups and the development of tailored adaptive strategies are underscored by Egondi et al., (2015), who call for individual-level studies. This is echoed by Khan et al., (2014), who emphasize the importance of access to essential equipment and alternative settlements to enhance community resilience.

The evaluation of intervention outcomes is a critical area highlighted by Tran et al., (2013), who stress the need for research into the connections between exposure, outcomes, and the effectiveness of implemented interventions. Similarly, Sariffudin et al., (2016) point out the significance of collaborative planning that integrates public and governmental inputs, which is crucial for effective urban development and governance. Anderson et al., (2023) recommend exploring sustainable strategies to address the impacts of climate change on health, particularly in informal settlements, suggesting a focus on adaptable solutions for vulnerable communities. Adelekan (2012) and Waters and Adger (2017) both highlight the importance of climate change

mitigation and adaptation in urban centers, emphasizing the need for responsive institutional structures and the integration of low-income communities into transformational urban planning.

Pandey et al., (2017) call for empirical research to assess coping strategies among slum households, while Bambrick et al., (2015 advocate for localized studies to inform national policy and address community-specific priorities. Toan et al., (2014) propose comparing perceptions with actual health data to refine the understanding of climate change's health impacts, and Sverdlik et al., (2011) suggest broad research into the societal effects of climate change, including health, economy, and the environment. These recommendations collectively form a blueprint for future research directions, emphasizing the need for comprehensive, multidisciplinary approaches to effectively address the multifaceted challenges posed by climate change. Through focused studies on spatial analysis, vulnerable populations, intervention effectiveness, and collaborative urban planning, among others, researchers can contribute to building resilience, informing policy, and promoting sustainable development in response to global climate challenges.Top of Form

CONCLUSIONS

The study underscores the complex interplay between climate change and socioeconomic vulnerabilities in urban slums, revealing a significant gap in adaptive capacities and policy measures. Through a meticulous analysis of global literature, it highlights the pressing need for targeted adaptation strategies that address both immediate and systemic challenges posed by climate change. Recommendations for future research include spatial analysis, intervention effectiveness, and collaborative urban planning to foster sustainable development and enhance community resilience. The study advocates for a multidisciplinary approach to climate adaptation, emphasizing the role of inclusive policies and equitable resource distribution in achieving environmental and climate justice for the world's most vulnerable populations.

ACKNOWLEDGMENTS

Thank you to Ryanne Zephyra Dema and Rossifedora Currie Tipong for motivating us to complete this manuscript.

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