



Journal of Emerging Trends in Social Sciences and Humanities

A Double-Blind, Peer-Reviewed, HEC recognized [Y-category](#) Research Journal

E-ISSN: [3006-7898](#) P-ISSN: [3006-788X](#)

Volume 3 Issue 4, 2026, 125-139



Climate Change Scholarship on Lahore: A Thematic Review

Rakhshanda Iqbal¹ Dr. Rehana Saeed Hashmi²

¹ PhD Student at the Department of Political Science, University of the Punjab, Lahore, Punjab, Pakistan.

² Professor, Department of Political Science at the University of the Punjab, Lahore, Punjab, Pakistan.

Corresponding Author: rakhshandaiqbal14@gmail.com

Article Information

Received:

2026-08-06

Revised:

2026-09-14

Accepted:

2026-10-08

Keywords

Climate Change; Urban Climate Governance; Urban Resilience; Climate Justice; Lahore; Pakistan.

ABSTRACT

Climate change has become a major challenge for rapidly growing cities, particularly in the Global South. Lahore, Pakistan's second-largest city, faces increasing climate-related risks, including rising temperatures, smog, the Urban Heat Island (UHI) effect, air pollution, groundwater depletion, and urban flooding. This review examines the existing literature on climate change in Lahore by analysing key research themes, methodological approaches, and policy discussions. Using a thematic review approach, the study synthesises evidence from published academic studies and relevant policy documents. The findings show that rapid urbanization, land use change, weak environmental governance, and ineffective policy implementation have increased the city's climate vulnerability. Recent research has improved understanding through geospatial technologies and interdisciplinary studies. However, intersectional studies on climate change in Lahore that seek to explore variables such as class, gender, age, and disability are needed to fulfil the important gaps that remain in climate governance and adaptation. This review also identifies these gaps and highlights the need for stronger institutions, evidence-based planning, and inclusive climate policies to improve urban climate resilience in Lahore.



© 2026 by the authors. Licensee Iqbal & Hashmi. This article is an open-access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license <https://creativecommons.org/licenses/by/4.0/>

Publisher: Institute for Educating Environmental Resilience and Governance

1. Introduction

Climate change is no longer just an environmental problem for Pakistan; it has become a major challenge to the country's security, development, and long-term sustainability (Ahmad & Arif, 2026). Although Pakistan produces only a very small proportion of global greenhouse gas emissions, it is still ranked among the ten countries most vulnerable to the effects of climate change (Khan & Zahidi, 2024). Within the country, Lahore, the capital of Punjab, has become one of the city's most seriously affected by this growing crisis. Rapid urban expansion, poor urban planning, and changing climate conditions have greatly increased the city's vulnerability. As a result, Lahore regularly experiences extreme heat, with summer temperatures often rising above 45°C, highlighting the increasing impacts of climate change (Munir et al., 2024).

Lahore was known as the City of Gardens in the past due to its high levels of green spaces and trees. But research in the last few decades reveals that the city has become a concrete jungle because of its rapid urbanization. The process of urbanization resulted in converting green spaces into impervious surfaces and, consequently, the Urban Heat Island (UHI) appeared. It refers to the fact that the city retains excessive amounts of heat (Jabbar et al., 2024). According to researchers,

between 1990 and 2020, the area of built-up regions increased by almost two times, leading to a rise in Land Surface Temperature (LST) (Habib et al., 2022). Furthermore, there is a correlation between temperature rise and rise in heat related incidences like heatstroke and outbreaks of various diseases.

The severe smog in Lahore during winters is another big climatic issue that the city is facing. The air quality of the city is considerably degraded in the last decade, with many occurrences of hazardous air quality during the cold winter seasons (Farsi, 2025). The major source of this pollution is attributed to vehicular emissions, which account for approximately 83% of the total pollution, followed by industrial activities and burning of agricultural wastes (Farsi, 2025; Rafiq-uz-Zaman et al., 2024). In addition, the rise in temperature due to climate change may worsen smog by creating a thermal inversion that increases the exposure of human populations to

harmful levels of air pollution (Munir et al., 2024).

Another key issue identified in the literature is water security. Due to the high water extraction, excess to the demand, the groundwater level in Lahore is decreasing rapidly and alarmingly (Hameed et al., 2021). Meanwhile, intense rain is putting the city's old and poorly maintained drainage system to the test. In turn, katchi abadis (informal settlements) are affected by recurrent urban flooding. Additionally, the issue of climate justice has picked up momentum in the last few years.

The courts have been instrumental in ensuring the government implements climate policies, as evidenced in *Leghari v. Federation of Pakistan*, which is a landmark judgment in which the Lahore High Court played a significant role (Barkat et al., 2025, Rizwan et al., 2026). Therefore, climate change is now a matter of concern in Pakistan's legal system, as it has been framed as an issue of right to life and human dignity (Adil, 2025).

This review aims to compile the recent literature related to climate change in Lahore. It critically analyses the central research themes, methodological approaches, theoretical perspectives and policy debates, as well as knowledge gaps and opportunities for further research. The review states that the climate crisis in Lahore is not a problem that should only be looked upon as climatic. Rather, it is a result of the cumulative impact of urbanization, governance challenges, institutional weaknesses and the social inequality.

2. Research Methodology

This study employs a thematic literature review to examine existing scholarship on climate change in Lahore. Relevant local and international peer-reviewed journal articles, government reports, policy statements, and publications were systematically retrieved from a variety of academic databases such as Google Scholar, JSTOR, ProQuest, EBSCOhost, Web of Science, Scopus, and SpringerLink. The Pakistan Research Repository and Climate Knowledge Portal were used to collect additional grey literature and institutional papers. The data gathered was then examined through the thematic analysis approach to seek out common themes, theoretical

frameworks, methodological trends, and main policy suggestions that are common among the literature. The review brought together inputs from different sources of disciplines to have a comprehensive knowledge of the climate vulnerabilities, adaptation measures, and governance aspects of Lahore. The methodological framework used here provides a comprehensive, transparent and replicable compilation of the available evidence which will serve as a sound reference for future research and policy making around urban climate resilience in Lahore.

3. Thematic Review of Climate Change Scholarship on Lahore

3.1 Climate Change, Urban Climate, and Climate Trends in Lahore

Lahore's climate is classified as semi-arid, traditionally featuring five distinct seasons, including a foggy winter, a pleasant spring, and a rainy monsoon (Jabbar et al., 2024). But a review of the academic literature in the past two decades shows that these historical trends are changing greatly at both the global and local level. Analyzing temperature data from 1962 to 2012, Zia et al. (2015) recorded a linear progression in the city's mean annual temperature (MAT), which rose from 23.8°C to 25.6°C. One of the most significant observations in this trend is the dramatic rise in the mean minimum temperature which is attributed to the built-up surfaces trapping heat in the atmosphere (Zia et al., 2015).

There has been a proliferation of extreme heat events in recent literature, especially regarding heatwaves, and these events have proven to be fatal. The heatwave of 2022 is documented as the worst in Lahore's history, with temperatures reaching a staggering 49°C (Habib et al., 2022). Such heatwaves are no longer considered natural freak events, and the research indicates that due to human-induced climate change, such events are now thirty times more likely to happen (Khan & Zahidi, 2024). These prolonged periods of high heat have led to outbreaks of diseases like cholera and put immense pressure on the city's electricity grid (Habib et al., 2022).

Rainfall trends and monsoon variations are also worrying, as Lahore experiences an average of 575-636mm of rainfall annually, with 40% of total

groundwater recharge occurring in monsoon months of July and August (Abdullah, 2023; Hameed et al., 2021). The trend has significantly shifted, as recently the monsoon has either brought devastating floods or prolonged dry spells (Ahmad & Arif, 2026; Munir et al., 2024). Moreover, a severe drought, with the potential to cause massive animal and agricultural losses, is not uncommon for the region, as demonstrated by the 1998 and 2004 events (Hussain et al., 2020).

As per the scholarship, the most prominent climate change trends are connected to rapid urbanization, as between 1990 and 2020, the city's concrete structures increased by almost 100%, while public green areas (green lungs) were depleted (Jabbar et al., 2024). Specifically, there is a close link (0.941) between the increase in concrete areas and rising temperatures (Zia et al., 2015). Thus, the local climate change trends are primarily driven by human activities, particularly the expansion of urban areas, reducing green areas and contributing to higher Land Surface Temperatures (LST) (Nasar-u-Minallah, 2020).

Climate projections for the future suggest that these challenges will only intensify. Under high-emission scenarios, Pakistan could see an additional temperature rise of 1.3°C to 4.9°C by the year 2100 (Ahmad & Arif, 2026). In Lahore, the modelling predicts that more than half of the city will be urban built-up by 2050 contributing to the highest temperature areas of the city (Jabbar et al., 2024). These results indicate that the city's physical development is not aligned with its climatic safety, and there is a need for urgent changes in the field of urban development (Mazhar, 2024).

3.2 Urbanization, Land Use Change, and Urban Heat Island

Scholarship on Lahore highlights a dramatic physical transformation driven by explosive population growth and unplanned urban sprawl. The population of the city increased from around 1.16 million in 1951 to more than 13 million in 2023, as reported by Rizwan et al. (2026) and Zia et al. (2015). This population pressure has led to rapid expansion of the city, mainly towards the south and south-east, where the river Ravi prevents development in the north and west (Abdullah, 2023; Nasar-u-Minallah, 2018).

To document such changes, researchers used advanced Geographic Information Systems (GIS) and Remote Sensing (specifically Landsat 5, 7 and 8 satellite imagery) (Jabbar et al., 2024; Nasar-u-Minallah, 2020). According to a scholarly consensus Lahore has transformed from the City of Gardens to concrete jungle (Akhtar et al., 2020; Jabbar et al., 2024). Analysis of Land Use/Land Cover (LULC) reveals that the built-up area increased by nearly 100% (from 16.44% to 32.48%) between 1990 and 2020 (Jabbar et al., 2024). This expansion has been very costly, as during this period the city lost its vegetative land by roughly 271.5 km² and cropland by 287 km² (Abdullah, 2023; Habib et al., 2022).

This loss of green space has been directly responsible for the Urban Heat Island (UHI) effect that has turned the city into a heat trap. Scholarship indicates that Land Surface Temperatures (LST) in Lahore's urban core are consistently 1°C to 6°C higher than in the surrounding rural areas (Nasar-u-Minallah, 2018). The areas with high density of the concrete and asphalt like Shalamar, Gulberg and the Walled City have become intense thermal hot spots (Habib et al., 2022; Nasar-u-Minallah, 2018). In these built-up zones, LST has been recorded as high as 45.9°C (Abdullah, 2023).

To quantify this relationship, two indices are used: The Normalized Difference Vegetation Index (NDVI) and the Normalized Difference Built-up Index (NDBI). Studies show a strong negative correlation (-0.98) between NDVI and LST, proving that areas with more trees and parks have significantly lower temperatures due to natural cooling from evaporation (Nasar-u-Minallah, 2020). Conversely, there is a strong positive correlation (+0.98) between NDVI and LST, meaning that every increase in concrete surfaces directly raises the local temperature (Jabbar et al., 2024; Nasar-u-Minallah, 2020).

3.3 Urban Flooding, Water Resources, and Disaster Risk Reduction

Scholarship on Lahore's water systems reveals a city facing a dual crisis of having too much water during the monsoon and too little during the rest of the year (Khan & Zahidi, 2024). Research shows that as Lahore has expanded, its ability to manage water has significantly weakened, leading to serious environmental and health risks.

Urban flooding has become a frequent and nightmarish challenge for Lahore (Ali, 2013). The majority of scholars attribute the main cause to the change from a city of gardens to a concrete jungle, whereby impervious surfaces block rainwater infiltration into the ground (Zia & Shirazi, 2019; Jabbar et al., 2024). The city's drainage infrastructure, much of which dates back to the colonial era, is no longer capable of handling short duration intense rainfall events (Government of Pakistan, 2021; Rehman, 2022). Also, improper solid waste disposal results in clogged drains and the main roads become pools and ponds after one hour of rain (Farsi, 2025; Ali, 2013). Although the Water and Sanitation Authority (WASA) has a Monsoon Action Plan, the evidence suggests that flood mitigation measures are often reactive rather than proactive and do not tackle root causes of flooding (Ali, 2013).

While the city surface floods, its underground water is disappearing at an alarming rate. Groundwater extraction in Lahore has been found to be decreasing by 2 feet annually, caused by high urbanization and unregulated extraction of groundwater (Hameed et al., 2021). Nationally, Pakistan's per capita water availability has crashed from 5,200 cubic meters in 1951 to less than 1,000 cubic meters today, officially placing the region in the water-scarce category (Ahmad et al., 2025; Ahmad & Arif, 2026). In Lahore, the scenario is made worse by contamination as nearly 70% of the surveyed water sources are contaminated with hazardous levels of the arsenic, and the bacteria (Ali, 2013).

The study by Rehman (2022) shows that water governance tends to be fragmented and uneven. Even though the Lahore Development Authority (LDA) has mandated Rainwater Harvesting (RWH) in all new houses since 2014, its uptake has been very limited. Only 96% of the residents have installed these systems, while the rest believed they knew nothing about them and feared that the stored water would undermine building foundations (Hameed et al., 2021). Governance research highlights a class divide in water use, with the wealthy using plenty of water to irrigate their lush lawns and the urban poor saving in buckets and bottles, which becomes a breeding ground for dengue-carrying mosquitoes (Rehman, 2022).

The response to this impending challenge is to build urban resilience through Disaster Risk Reduction (DRR). The Heatwave Management Plan of Lahore 2022-2025 is a DRR initiative that focuses on RWH and identifies the Walled City and the center as high-risk areas (Habib et al., 2022). Researchers recommend using Nature-based Solutions to conserve water in the region by rehabilitating the Ravi River and constructing underground rainwater storage tanks, of which Lawrence Road has 1.4 million gallons' capacity (Hameed et al., 2021; Munir et al., 2024). Resilient Lahore will require a shift from horizontal sprawl to climate-resilient infrastructure that will employ modern technology and Islamic traditions in water conservation (Jabbar et al., 2024; Raza et al., 2024).

3.4 Air Pollution, Environmental Health, and Climate Change

The reviewed literature shows that air pollution is the most evident and acute environmental disaster that is currently inflicting the city of Lahore and making it one of the most polluted megapolises in the world (Ali, 2013; Farsi, 2025). Scholarship after 2013 has emphasized that air pollution in Lahore is often in the hazardous category, mainly because of the high concentration of Particulate Matter (PM_{2.5}), which can be several times more than the World Health Organization (WHO) standards (Ahmad et al., 2025; Rafiq-uz-Zaman et al., 2024).

There is a strong consensus that the transport sector is the leading contributor to Lahore's toxic air, accounting for approximately 83% of total emissions (Farsi, 2025; Munir et al., 2024). This is due to a significant rise in the number of vehicles, especially in Lahore, which is more than 6.2 million, and many of them are powered by poor quality fuel and old 2 stroke engines (Abdullah, 2023; Ali, 2013). Industrial pollution is claimed as the second source of pollution with more than 2980 registered factories in the district having high emission of SO_x, NO_x and heavy metals (Abdullah, 2023; Rafiq-uz-Zaman et al., 2024). Further, seasonal factors including burning of crop residue and the black smoke emitted by traditional brick kilns overhang the city during fall and winter months (Khan & Zahidi, 2024; Munir et al., 2024).

The interconnection between climate change and

air quality is considered a critical theme in the most recent research. The formation of smog in Lahore is significantly worsened by thermal inversion, a meteorological condition where a layer of warm air traps cooler air and pollutants close to the ground, preventing them from dispersing (Munir et al., 2024). Additionally, higher temperatures increase the reactions of chemicals in the atmosphere resulting in increase in ground-level ozone and allergens (Iqbal, 2020; Rafiq-uz-Zaman et al., 2024). Others argue that greenhouse gas (GHG) emissions, especially those from transport and industry, initiate a vicious circle: GHGs trap heat and affect local weather patterns, thereby exacerbating the conditions conducive to the occurrence of smog. Researchers state that the greenhouse gas (GHG) emissions, particularly from transport and industry, lead to a vicious circle. GHGs trap heat and influence the local weather, which in turn creates conditions for the persistence of the smog. (Munir et al., 2024; Zia et al., 2015).

Health consequences of this toxic rain are described as catastrophic. According to the World Bank, air pollution reduces average life expectancy of a Pakistani citizen by 4.3 years (Khan & Zahidi, 2024). Scholarship has documented high prevalence of respiratory diseases such as asthma, chronic obstructive pulmonary disease (COPD), and lung cancer which is directly associated with prolonged exposure to PM_{2.5} (Iqbal, 2020; Rafiq-uz-Zaman et al., 2024). The literature also indicates that cardiovascular diseases, skin diseases, and eye irritation are some other health problems that have increased as a result of exposure to certain gases (Iqbal, 2020; Munir et al., 2024).

The combination of extreme heat and pollution has created additional health challenges as well, under the category of heat stress and epidemics. Water-borne diseases such as cholera and diarrhea have been associated with heat stress and long heat waves (Habib et al., 2022). Extreme temperatures have been shown to impact the body's immune response, increasing its vulnerability to diseases transmitted by vectors, like dengue, that flourish in the water system's disjointed nature of the city (Iqbal, 2020; Rehman, 2022).

The scholarship indicates that the health risks

posed by climate change are not distributed evenly among the population. First and foremost, children are the most vulnerable population group as the air pollution in Pakistan leads to the deaths of 1 out of every 10 children below the age of 5 (Khan & Zahidi, 2024). Moreover, over 44% of children develop growth retardation as a result of malnutrition and exposure to environmental toxins (Iqbal, 2020). In turn, women are particularly exposed to indoor air pollution, which is generated by the biomass fuel combustion process (Iqbal, 2020). Finally, the elderly and those with pre-existing medical conditions are the most vulnerable to mortal risks, especially during heatwaves and smog periods (Habib et al., 2022; Munir et al., 2024). Altogether, the reviewed scholarship demonstrates that the environmental concerns in Lahore are not only a matter of environmental policy but a human rights issue, which requires an immediate response from policymakers and various stakeholders (Ahmad et al., 2025; Munir et al., 2024).

3.5 Climate Governance, Urban Planning, and Institutional Responses

The scholarship on Lahore's climate governance depicts a system struggling with governance deficits and a significant gap between policy making and actual practice (Munir et al., 2024). Lahore's institutional arrangements and governance capacity are complex, with the involvement of federal, provincial, and local entities. The macro-agenda is set by the Ministry of Climate Change (MoCC) at the top and the National Disaster Management Authority (NDMA), yet there is continued inter-agency coordination which is identified by scholarship (Iqbal et al., 2025). The enforcement of laws, such as Pakistan Environmental Protection Act (PEPA) 1997 is a duty of the institutions at the local level such as the Environment Protection Department (EPD) and Environmental Protection Agency (EPA). However, studies have shown that these agencies are poorly funded, understaffed with trained employees and work separately, resulting in policies that are inconsistent and administratively inefficient (Adil, 2025; Barkat et al., 2025).

The barriers to effective adaptation were identified as not having a long-term vision to implement, not having appropriate leadership,

rigid organizational culture, lack of innovation, poor governance, and severe lack of resources for adaptation in a landmark study by Janjua et al. (2010) on the City District Government of Lahore (CDGL). The study also revealed that junior staff are seen as doer not as a thinker, failing to enable them from developing proactive climate strategies (Janjua et al., 2010).

The Lahore Development Authority (LDA), the city's primary planning agency, faces heavy criticism in recent scholarship. A major concern is the absence of microclimatic landscape design in LDA planning documents (Mazhar, 2024). Historically, formal urban planning has focused on spreading out horizontally and on expanding roads at the expense of human thermal comfort, resulting in uncomfortable outdoor environments and hot downdrafts in the urban area (Abdullah, 2023; Mazhar, 2024). Further, when LDA adopts regulations that are climate sensitive, e.g., the 2014 regulation to implement Rainwater Harvesting (RWH), implementation is hampered by weak enforcement and lack of public will to act (Hameed et al., 2021).

To solve these problems, the researchers propose to move to Sustainable Urban Planning by means of Green Infrastructure. This includes moving from horizontal construction to vertical construction to slow the pace of land consumption (Abdullah, 2023). There is also a push for Nature-based Solutions (NbS) and Green Infrastructure. The government's recent drive to plant Miyawaki forests at 51 sites in Lahore through the Parks and Horticulture Authority (PHA) is cited as a positive, proactive step toward regulating the urban microclimate (Jabbar et al., 2024; Ministry of Climate Change, 2021).

3.6 Climate Adaptation, Mitigation and Sustainable Development

The scholarship on Lahore demonstrates that in order to achieve sustainability and escape the current environmental predicament, the city must go beyond a descriptive analysis of the situation and embrace a set of adaptive and mitigative measures. Researchers draw a distinction between mitigation which entails "global and large-scale efforts to reduce greenhouse gas emissions" and adaptation which refers to "measures to cope with climate impacts" (Janjua et al., 2010, p. 288). The latter is regarded as a preferable option by the

local policymakers due to its immediate and localizable benefits such as reduction of urban heat island (UHI) effect (Janjua et al., 2010).

An adaptive capacity denotes the capability of a system to adapt to the changing conditions and absorb shocks. When it comes to Lahore, the adaptability of the system is determined by its low governance capacity, lack of strategic planning and limited financial and human resources (Habib et al., 2022; Munir et al., 2024). In short, scholars emphasize “the absence of long-term vision and organizational slack” in the domain of climate change adaptation (Janjua et al., 2010, p. 291).

The most prominent nature-based solution (NbS) which the literature on climate change in Lahore advocates for is planting trees in order to reduce the Land Surface Temperature. Increasing green cover is deemed to have the most beneficial impact on countering the temperature rise in the city (Jabbar et al., 2024; Nasar-u-Minallah, 2020). The recent practice of planting Miyawaki forests in 51 locations across Lahore is a step towards creating cool micro-climates in the city (Jabbar et al., 2024; Ministry of Climate Change, 2021). However, on a larger scale, the scholars suggest following the examples of the ecosystems-based adaptation such as the Living Indus Initiative and Recharge Pakistan. These are aimed at restoring the Indus basin to build the resilience of Lahore and other urban centers in Pakistan to climate change (Khan & Zahidi, 2024).

Physical adaptations such as cool roofs, green roads and rain water harvesting are expected to play a major role in building climatic resilience in Lahore. According to the Heatwave Management Plan (2022-2025), the municipal authorities should revise building codes and promote cool roofs, green roofing and cool pavements which reflect the sunlight thus reducing the temperature (Habib et al., 2022). Scholars also highlight the importance of constructing Rain Water Harvesting (RWH) structures to store the rainwater which can be used during the dry season while also preventing the urban floods during the monsoon (Hameed et al., 2021). However, the adoption of these measures is limited due to citizens’ concern about their maintenance, technical complexity and high costs (Hameed et al., 2021).

Scholars note that climate change mitigation in

Lahore will require a paradigm shift in the domains of energy and transport. The latter sector is currently the largest contributor to the city’s greenhouse gas emissions. Transitioning towards renewable energy sources is crucial given Pakistan’s geographical location which makes the country one of the most suitable locations for harnessing solar and wind energy (Hussain et al., 2020). In this regard, installing solar panels on the rooftops of residential houses is proposed as it will help alleviate the burden on the city’s electrical grid during the summer (Khan & Zahidi, 2024). In relation to transport, a transition towards electric vehicles (EVs) and developing Bus Rapid Transit (BRT) systems such as Metro Bus are recommended to reduce the transport-related 83% of the city’s emissions (Munir et al., 2024; Rafiq-uz-Zaman et al., 2024). Moreover, the scholars propose promoting bicycling and re-introducing pedestrian friendly areas in order to facilitate low carbon mobility (Khan & Zahidi, 2024).

The literature on climate change in Lahore proposes transitioning towards the ‘Lahore model’ which would make the city a sustainable city. This would involve a shift from the horizontal sprawl to vertical growth in order to conserve the agricultural land by developing high-rises (Abdullah, 2023; Habib et al., 2022). At the global level, this vision aligns with the agenda of the United Nations (UN) Sustainable Development Goals (SDGs) particularly the goals 11 (Sustainable Cities and Communities) and 13 (Climate Action) (Munir et al., 2024). However, the authors caution that without adopting the principles of policy coherence and addressing the challenge of climate justice for the marginalized population this vision cannot be realized (Adil, 2025; Munir et al., 2024).

3.7 Social Vulnerability, Gender, Class and Informal Settlements

Scholarship on climate change in Lahore reveals that climate change is a threat multiplier and intensifies the socio-economic and political inequalities in the city (Ahmad & Arif, 2026; Rizwan et al., 2026). Unlike in the past, the focus has notably shifted from observing purely physical climate aspects to examining the vulnerability of different social groups and communities to climate change (Habib et al., 2022; Munir et al., 2024).

The scholars agree that social stratification is one of the underlying factors which makes Lahore climate vulnerable (Ahmad & Arif, 2026; Mustafa, 2011; Munir et al., 2024). Although the heatwaves and smog impact all social classes, the poor are disproportionately affected by extreme weather conditions due to their limited adaptive capacity (Mustafa, 2011; Munir et al., 2024). There is a stark difference in the living standards of the privileged classes (residing in gated communities) and the working class who are employed as domestic servants and do not have access to public spaces and utilities (Rehman, 2022; Rahat, 2023).

A recurring theme in the recent social vulnerability literature is the concept of legal invisibility of the poor in Lahore (Rizwan et al., 2026). For example, the climate-induced migration from rural Punjab to Lahore often results in the permanent settlement of the migrants in the informal housing of Shahdara or Thokar Niaz Baig (Rizwan et al., 2026). The informal settlers are denied relief, healthcare and education services and are not considered as part of the government's climate change response strategy due to their legal status which does not grant them ownership of the land (Rizwan et al., 2026).

Studies on the gendered vulnerability to climate change in Lahore note that women and girls are more vulnerable in Lahore than men and boys (Adil, 2025; Khan & Zahidi, 2024). The gendered division of labor is a major reason for this, as women are likely to be responsible for household chores such as collecting water and managing household fuel, which are much more difficult during drought or summer heat (Government of Pakistan, 2021). Furthermore, women often have fewer assets and less decision-making power, which limits their adaptive capacity to recover from climate shocks (Government of Pakistan, 2021). There is also an urgent need of policies to better incorporate gender disaggregated information as most urban planning policies ignore the specific needs of women (Adil, 2025; Rizwan et al., 2026).

Informal settlements (katchi abadis) are identified as the hotspots of climate risk in Lahore (Habib et al., 2022; Nasar-u-Minallah, 2018). Approximately 30% to 60% of the city's population lives in these crowded areas, which are

characterized by a lack of piped water, poor sanitation, and high exposure to environmental hazards (Rizwan et al., 2026; Rehman, 2022). Lack of access to safe drinking water in these slums, which are unable to access the municipal supply, provides optimal breeding conditions for mosquitoes, which increases the urban poor's vulnerability to diseases transmitted by the vector (Rehman, 2022).

Livelihood vulnerability is also generated in the process of moving from rural to urban areas. Many climate-displaced migrants were formerly farmers who are now forced into precarious, low-paying jobs in Lahore's informal economy, such as construction, waste-picking, or street vending (Rizwan et al., 2026). They are all reliant on daily wages, so a single day of extreme heat or heavy flooding can push a family into extreme poverty (Rizwan et al., 2026).

Modern scholarship has created an index to measure these risks; Heatwave Vulnerability Index (HVI). This index is based on three factors, namely, physical exposure (Land Surface Temperature), social sensitivity (population density, poverty rate), and adaptive capacity (access to electricity, water) (Habib et al., 2022). These assessments show that the Walled City and central urban cores are the most vulnerable because they have the highest density of people and the lowest amount of green space (Habib et al., 2022). Finally, the literature calls for shifting towards climate justice, where the needs and rights of marginalized communities are at the core of urban policies (Adil, 2025; Munir et al., 2024).

3.8 Climate Justice, Environmental Justice, and Political Economy

The scholarship on Lahore also frames climate change not just as a scientific or technical problem, but as a profound issue of climate justice and human rights (Adil, 2025; Munir et al., 2024). The researchers argue that the city's environmental crisis is inextricably linked to its political economy, which works to short-term economic gains over long-term survival of the population, driven by extractive political institutions and elitist models of policymaking (Ahmad & Arif, 2026; Rafiq-uz-Zaman et al., 2024).

Environmental justice is defined as the right of

every community to a safe and secure environment and to participate in decisions that impact their environment (Ahmad et al., 2025; Barkat et al., 2025). The literature, however, shows that there is a huge distributional inequality (Munir et al., 2024). High consumers and several vehicles are the major contributors to the carbon emissions in the city, whereas the heavy impacts of heatwaves and smog are borne by the vulnerable communities who have limited capacities to adjust (Adil, 2025; Munir et al., 2024). Researchers emphasize that the affluent reside in bio-economic privilege in gated communities and the poor in legally invisible slums, without any protection from toxic air and floods (Rehman, 2022; Rizwan et al., 2026).

3.9 Governance Failures and Institutional Capacity

One of the recurring themes in the scholarship is governance failures that exacerbate the vulnerability of Lahore (Ahmad & Arif, 2026). There is a clear gap between policy development and implementation, also known as a chronic implementation gap (Barkat et al., 2025; Rafiq-uz-Zaman et al., 2024). This is explained as the poor institutional capacity, underfunding, under-resourcing and lack of technical expertise of environmental agencies for dealing with complex climate modeling (Adil, 2025; Janjua et al., 2010). In addition, there are significant challenges in institutional coordination, particularly in the wake of decentralization of power under the 18th amendment, where various parts of the government operate with conflicting mandates (Adil, 2025; Munir et al., 2024).

3.10 Political Commitment and Climate Finance

The scholarship focuses on political commitment as one of the main obstacles to climate resilience. Being a long-term process with no immediate political return, climate adaptation is often neglected in favour of more visible development projects (Janjua et al., 2010; Munir et al., 2024). Climate finance is a key political issue on the international agenda. Pakistan has successfully positioned itself as a norm entrepreneur and an advocate for a 'Loss and Damage Fund' arguing that countries least responsible for global warming should receive financial aid (Khatoun et al., 2025). In spite of being a highly vulnerable country,

however, Pakistan faces a paradox in terms of being able to implement its diplomatic efforts in the allocation of resources for local projects in cities such as Lahore. It faces a severe shortfall in climatic funds, which is due to bureaucratic hurdles (Ali et al., 2023; Iqbal et al., 2025).

3.11 Power Relations and Equity

Power relations determine who survives the climate crisis in Lahore. Scholarship using the lens of political ecology shows that the allocation of land and water is controlled by powerful state and market actors, often at the expense of the poor (Aslam & Raza, 2026; Rehman, 2022). This results in an institutionalized communication hierarchy that silences the voices of scientists and affected communities, while listening to the authoritative voices of the political actors (Farsi, 2025). Researchers advocate for a rights-based framework with the judiciary at its core as a way to achieve equity (Adil, 2025; Barkat et al., 2025).

The landmark Leghari case is seen as a way to use the right to life to force the government to meet its climate obligations and protect the most vulnerable (Barkat et al., 2025; Munir et al., 2024). Eventually, the scholarship advocates that for Lahore to be resilient, it has to develop a different kind of climate justice, namely, the transformative one that would seek to tackle the city's social and political inequality (Aslam & Raza, 2026).

4. Theoretical Perspectives

Studies on Lahore's climate change have also applied social and political theories to explain the phenomena. In other words, the researchers utilize different theoretical frameworks to understand why and for whom the climate is lethal in Lahore (Aslam & Raza, 2026; Munir et al., 2024).

4.1 Urban Political Ecology (UPE)

Urban Political Ecology (UPE) is a significant theory that demonstrates that urban environmental issues are not natural but are created through political and economic decisions (Aslam & Raza, 2026; Rehman, 2022). Under this lens, scholars argue that the conversion of Lahore into a concrete jungle is attributable to the politics of a market economy that prefers the elite housing schemes and big infrastructure projects to the survival of the poor (Rizwan et al., 2026; Zia et al., 2015).

A key utility of applying UPE to Lahore is its ability to trace modern problems back to history. For instance, Rehman (2022) employs UPE to demonstrate that much of the water system that exists in Lahore now is the legacy of colonialism, which preferred the rich over the poor. The political ecologies of stagnant water condition are the explanation of why diseases like dengue are associated with the scarcity of water in poor areas and abundance of water in elite gardens, while the heaviest burden of disease always comes on the back of the working class (Rehman, 2022; Rizwan et al., 2026). However, it can be seen from the literature reviewed that this theory has limitations in providing specific technical solutions for urban planners in the present time, rather than the past.

4.2 Environmental and Climate Justice

Theories of Environmental and Climate Justice have become the center stage of recent research, particularly in the context of human rights (Adil, 2025; Ahmad et al., 2025). Distributional inequality is measured in this framework, which states that the urban poor in Lahore's katchi abadis are most affected by heatwaves and toxic smog because they contribute less to global warming (Munir et al., 2024; Rizwan et al., 2026).

Scholars have applied the concept of procedural justice to show how marginalized groups are excluded from decision-making processes in departments like the Lahore Development Authority (LDA) (Adil, 2025; Mazhar, 2024). The most important aspect of the theory is its connection to judicial activism. The Leghari case is cited as a successful application of justice theory, where the court used 'environmental constitutionalism' to protect the fundamental rights of citizens (Barkat et al., 2025; Munir et al., 2024). However, one of the weaknesses is that the implementation of court decisions does not always lead to cleaner air and water for on-the-ground communities (Ahmad et al., 2025; Munir et al., 2024).

4.3 Vulnerability and Resilience Frameworks

The paradigm of vulnerability assessment has shifted to a new paradigm of resilience planning (Aslam & Raza, 2026; Habib et al., 2022). According to Vulnerability Theory, disaster risk is socially constructed due to structural inequalities and this renders some groups of people legally

invisible during a disaster (Aslam & Raza, 2026; Rizwan et al., 2026). In contrast, Resilience Theory focuses on the city's ability to 'bounce back' and learn from shocks like the 2022 floods (Aslam & Raza, 2026; Janjua et al., 2010).

The utility of these frameworks is seen in technical reports like the Heatwave Management Plan, which uses a mathematical formula ($\text{Vulnerability} = \text{Exposure} + \text{Sensitivity} - \text{Adaptive Capacity}$) to map out high-risk zones in the Walled City (Habib et al., 2022). These approaches, however, are locked in a contradiction as the vulnerability frameworks focus on the social roots of risk while resilience planning is often regarded as too techno-managerial and too obsessed with hardware aspects (such as better drains) rather than the poverty that causes the vulnerability in the first place (Rehman, 2022; Rizwan et al., 2026).

5. Critical Research Gaps

Despite an increasing amount of research on climate change issues in Lahore, there are still some important gaps that need to be addressed. Existing studies have significantly improved understanding of urban climate change. However, many aspects of climate vulnerability, governance, and social impacts require further investigation. Addressing these gaps is essential for developing more effective climate policies and strengthening urban resilience.

A key missing element is the lack of social, behavioral and governance-focused research within the climate science community. These studies also pay comparatively less attention to the effect of social behavior, institutional arrangements, and community adaptation and reactions to climate change on climate vulnerability and adaptation. Likewise, qualitative research, long-term field studies, and interdisciplinary investigations are still scarce and underutilized, in favor of relying on satellite imagery and other technical methods.

The literature also shows that there are significant geographical and policy gaps that need to be addressed. Most studies have been conducted on the selected urban centers while the peri-urban context and informal settlements, the most vulnerable to climate risks, have been under-explored. Moreover, while several climate-related

policies have been developed, there is limited research that focuses on implementation, institutional coordination and long-term effects of these policies.

One notable research gap in the climate change scholarship on Lahore is the lack of intersectional studies incorporating the unequal impacts of climate change across different socio-economic groups. While gender is an important determinant of climate vulnerability, it is rarely taken along with class, age, and disability. Future studies need to be more intersectional, interdisciplinary, community-based and policy oriented to inform climate adaptation and sustainable urban governance in Lahore.

6. Policy and Governance Implications

The reviewed literature suggests that environmental changes are not the only factors influencing Lahore's climate vulnerability; institutional coordination and policy implementation are also weak, and governance is inadequate (Barkat et al., 2025; Munir et al., 2024). Although several climate-related policies and strategies exist, their implementation remains limited because of fragmented institutional responsibilities, inadequate coordination among government agencies, and insufficient technical and financial capacity (Ali & Butt, 2024; Janjua et al., 2010; Rafiq-uz-Zaman et al., 2024).

The literature emphasizes the need for a more holistic climate governance. There should be greater coordination between institutions like Lahore Development Authority (LDA), Water and Sanitation Agency (WASA), Environment Protection Department (EPD) and Provincial Disaster Management Authority (PDMA) in order to better plan, share information and apply climate adaptation measures (Abdullah, 2023; Nawaz & Akbar, 2020; Ahmad et al., 2025; Farsi, 2025). The existing studies also highlight the need to enhance local institutional capacity via appropriate financial resources, technical knowledge, and robust local governance systems that are capable of effectively addressing climate-related issues (Adil, 2025; Janjua et al., 2010; Rizwan et al., 2026).

Another critical implication, which emerges from the reviewed literature, is the need to enhance accountability and inclusive governance. This can

be achieved by implementing effective monitoring systems, clarifying institutional roles, and ensuring policy evaluation mechanisms to promote transparency and accountability (Ahmad et al., 2025; Barkat et al., 2025). In addition, climate policies need to be formulated considering the needs of vulnerable groups, including women, low-income households, and climate-displaced persons through enhancing the inclusiveness of the policies and ensuring access to essential services such as healthcare (Rizwan et al., 2026). Lastly, the literature indicates the necessity of implementing climate-sensitive adjustments to urban development plans to ensure enduring climate-resilient societies through preserving green areas, adopting suitable construction styles, and improving rainwater management practices (Abdullah, 2023; Hameed et al., 2021; Mazhar, 2024).

7. Conclusion

This review brings together the existing research on climate change in Lahore and shows that the city's climate challenges result from the combined effects of environmental change, rapid urban growth, weak governance, institutional limitations, and social inequalities. The reviewed studies consistently highlight increasing temperatures, the Urban Heat Island (UHI) effect, serious air pollution, urban flooding, and groundwater depletion as closely connected problems that affect both environmental sustainability and human well-being. Although recent studies have improved knowledge through the use of geospatial technologies and interdisciplinary research, important gaps still exist in climate governance, policy implementation, and inclusive adaptation measures. By combining evidence from environmental studies, urban planning, governance, and the social sciences, this review shows that climate change is not only an environmental problem but also a challenge for sustainable urban development and climate justice. The findings also suggest that to improve institutional coordination and strengthen policymaking, interdisciplinary and intersectional research that explores the variables such as class, gender, age and disability is essential for building a more climate-resilient, inclusive, and sustainable Lahore.

Conflict of Interest

The authors showed no conflict of interest.

Funding

The authors did not mention any funding for this research.

References

- Adil, A. (2025). Climate Justice in Pakistan: Bridging Human Rights and Environmental Governance. *Available at SSRN*: <https://ssrn.com/abstract=5250325> or <http://dx.doi.org/10.2139/ssrn.5250325>
- Abdullah, M. (2023). *Environmental impacts of urban sprawling and shrinking green cover in Lahore, Pakistan* (Master's thesis). Glasgow Caledonian University. https://www.theseus.fi/bitstream/handle/10024/812130/Abdullah_Muhammad.pdf?sequence=2&isAllowed=y
- Ahmad, I., Haider, A., & Ahmad, K. (2025). The impact of judicial activism on environmental protection and justice in Pakistan: A statistical analysis. *Journal of Asian Development Studies*, 14(2), 1-10. <https://doi.org/10.62345/jads.2025.14.2.1>
- Ahmad, M., & Arif, M. (2026). Pakistan under Climate Change Patterns: Challenges for Security and Survival. *Journal of Climate and Community Development*, 5(1), 1-14. <https://www.joccd.com/index.php/joccd/article/view/110>
- Akhtar, M., Zhao, Y., Gao, G., Gulzar, Q., Hussain, A., & Samie, A. (2020). Assessment of ecosystem services value in response to prevailing and future land use/cover changes in Lahore, Pakistan. *Regional Sustainability*, 1(1), 37-47. <https://doi.org/10.1016/j.regsus.2020.06.001>
- Ali, S. (2013). Environmental problems of Lahore and their reporting. (MPhil Thesis). *Lahore School of Economics*. <http://hdl.handle.net/123456789/6386>
- Ali, T. T., & Butt, S. (2024). Urban Planning a Challenge to Climate Change: A Study of Lahore. *Political Horizons*, 2(2), 192-207. <https://journals.iub.edu.pk/index.php/ph/article/view/3356>
- Barkat, A., Jatoti, A. A., & Anjum, R. (2025). The role of the judiciary in advancing climate justice in Pakistan: a case study of *leghari v. Federation of Pakistan*. *Annual Methodological Archive Research Review*, 3(8), 214-230. <https://doi.org/10.63075/grfdhr60>
- Farsi, S., Asif, M., & Aleem, M. (2025). Environmental coverage on local TV channels in Lahore: a thematic analysis of media practices and gaps. *Journal of Social Sciences Research & Policy*, 3(04), 257-267. <https://doi.org/10.71327/jssrp.34.257.267>
- Government of Pakistan. (2012). *National Climate Change Policy*. Ministry of Climate Change. https://www.gcisc.org.pk/National_Climate_Change_Policy_2012.pdf
- Habib, A., Latif, A., Aleem, A., Arshad, K., Nissar, H., Fahad, A., Klair, A., & Noor, A. (2022). *Heatwave management plan of Lahore (2022–2025)*. The Urban Unit. https://urbanunit.gov.pk/Download/publications/Files/8/2023/HWMP_Lahore_Final%20-final.pdf
- Hameed, R., Javed, M., & Nawaz, M. S. (2021). An assessment of adoption of rainwater harvesting system in residential buildings in Lahore, Pakistan. *Urban Water Journal*, 18(3), 163-172. <https://doi.org/10.1080/1573062X.2020.1860239>
- Hussain, M., Butt, A. R., Uzma, F., Ahmed, R., Irshad, S., Rehman, A., & Yousaf, B. (2020). A comprehensive review of climate change impacts, adaptation, and mitigation on environmental and natural calamities in Pakistan. *Environmental Monitoring and Assessment*, 192(1), 48. DOI: <https://doi.org/10.1007/s10661-020-0192D-7956-2D4>
- Iqbal, M. P. (2020). Effect of climate change on health in Pakistan: climate change and health in Pakistan. *Proceedings of the Pakistan Academy of Sciences: B. Life and Environmental Sciences*, 57(3), 1-12. <http://ppaspk.org/index.php/PPAS-B/article/view/2>

- Iqbal, S., Arshad, J., & Ahmad, S. (2025). The role of global climate governance in tackling climate change: a case study of Pakistan (2010-2024). *Asian Multidisciplinary Research Review*, 7(2), 55-72.
- Jabbar, M., Nasar-u-Minallah, M., & Yusoff, M. M. (2024). Predicting the impact of land use changes on thermal environment in Lahore, Pakistan: Implications for urban planning. *Geography, Environment, Sustainability*, 17(1), 95-109. <https://doi.org/10.24057/2071-9388-2023-2862>
- Janjua, S., Thomas, I., & McEvoy, D. (2010). Framing climate change adaptation learning and action: the case of Lahore, Pakistan. *International Journal of Climate Change Strategies and Management*, 2(3), 281-296. <https://doi.org/10.1108/17568691011063051>
- Khan, R. S., & Zahidi, F. (2024). *Pakistan: On the front line of climate change*. CEJ Research and Publications, IBA Press. <https://cej.iba.edu.pk/pdf/pakistan-on-the-front-line-climate-change-english-metadata-included-rev1.pdf>
- Khatoon, S., Awan, A. U. H., Iqbal, Z., & Bibi, M. (2025). Climate Change Diplomacy and the Role of Pakistan in Global Environmental Negotiations. *Social Sciences Spectrum*, 4(2), 774-792. <https://doi.org/10.71085/sss.04.02.350>
- Mazhar, N. (2024). Urban design, climate+ context: Exploring the interplay of thermal comfort and human perception in the case of Lahore, Pakistan. (Doctoral Thesis, University of Calgary). <https://hdl.handle.net/1880/120026>
- Ministry of Climate Change [MOCC]. (2021). National Climate Change Policy (NCCP) Report. Government of Pakistan, Islamabad. <https://mocc.gov.pk/SiteImage/Policy/NCCP%20Report.pdf>
- Munir, A., Jathol, H., & Nisar, M. (2024). Climate change and Paris Agreement: A Case Study of Lahore. *Annals of Human and Social Sciences*, 5(4), 499-508. [https://doi.org/10.35484/ahss.2024\(5-IV\)45](https://doi.org/10.35484/ahss.2024(5-IV)45)
- Mustafa, G., Khan, S., & Ahmad, M. S. (2024). The role of Facebook in generating public awareness regarding climate change in Lahore Pakistan. *International Journal of Social Science Archives*, 7(2), 352-361.
- Nasar-u-Minallah, M. (2018). Spatial and temporal change assessment in land surface temperature of Lahore using GIS and remote sensing techniques. *Proceedings of the Pakistan Academy of Sciences: A*, 55(3), 67-75. <https://www.paspk.org/wp-content/uploads/2019/07/7-PS-515-Spatial-and-Temporal-Change-Assessment-in-Land-Surface-Temperature.pdf>
- Nasar-u-Minallah, M. (2020). Exploring the relationship between land surface temperature and land use change in Lahore using landsat data: Relationship between land surface and land use data. *Pakistan Journal of Scientific & Industrial Research Series A: Physical Sciences*, 63(3), 188-200. <https://doi.org/10.52763/PJSIR.PHYS.SCI.63.3.2020.188.200>
- Nawaz, M. S., & Akbar, S. (2020). Is Lahore's urban system ready to sustain climate change? The case in Pakistan. *European Journal of Climate Change*, 2(02), 22-32. <https://doi.org/10.34154/2020-EJCC-0202-22-32/euraass>
- Rafiq-uz-Zaman, M., Faridi, M. Z., Khalid, N., & Khan, Z. A. (2024). Smog mitigation and climate resilience in Pakistan: A policy-centric review of strategies and challenges. *Social Sciences Spectrum*, 3(4), 302-317. <https://doi.org/10.71085/sss.03.04.175>
- Rahat, R., Sadaf, F., & Noreen, N. (2023). Behind Closed Gates: Narratives of Exclusion and Inequality of Male Live-in Domestic Workers in the Gated Communities of Lahore. *Pakistan Languages and Humanities Review*, 7(3), 312-326. [http://doi.org/10.47205/plhr.2022\(6-IV\)](http://doi.org/10.47205/plhr.2022(6-IV))

- Raza, A., Sarwar, M., Anjum, G. M., & Ali, A. (2024). Environmental Stewardship in Islam: Addressing Climate Change and Conservation in Lahore. *Al-Aijaz Research Journal of Islamic Studies & Humanities*, 8(1), 77-86. <https://arjish.com/index.php/arjish/article/view/676>
- Rehman, N. (2022). Epidemic infrastructures and the politics of responsibility in Lahore. *Antipode*, 54(5), 1451-1475. <https://doi.org/10.1111/anti.12826>
- Rizwan, M., Jawad Khan, M., & Kelly, L. M. (2026). Climate-induced displacement and urban insecurity in Pakistan: comparative evidence from Karachi and Lahore. *Conflict, Security & Development*, 1-23. <https://doi.org/10.1080/14678802.2026.2696812>
- Zia, S., & Shirazi, S. A. (2019). Spatio-Temporal Analysis of Areas Vulnerable to Urban Flooding: A Case Study of Lahore, Pakistan: Spatio-Temporal Analysis of Areas Vulnerable to Urban Flooding: A Case Study of Lahore, Pakistan. *International Journal of Economic and Environmental Geology*, 10(3), 85-89. <https://doi.org/10.46660/ijeeg.v10i3.371>
- Zia, S., Shirazi, S. A., Bhalli, M. N., & Kausar, S. (2015). The impact of urbanization on mean annual temperature of Lahore metropolitan area, Pakistan. *Pakistan Journal of Science*, 67(3), 332-346. <https://www.researchgate.net/publication/354150468>.