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URBAN AIR POLLUTION AS A JUSTICE ISSUE: SPATIAL DISTRIBUTION AND CUMULATIVE HEALTH IMPACTS ON VULNERABLE COMMUNITIES

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Abstract

Urban air pollution is a central example of environmental injustice, as exposure and health risks are distributed unevenly across social groups. This literature study examines the structural origins and cumulative consequences of this inequality. It shows that pollution patterns reflect historical zoning practices, discriminatory housing policies, and the concentration of undesirable facilities in politically marginalized, low income, and minority neighborhoods. As a result, environmental burdens are spatially concentrated. Health impacts are likewise unequal. Pre existing illnesses, limited healthcare access, poor nutrition, chronic stress, and high exposure occupations heighten biological and social vulnerability in these communities. These conditions interact with air pollution to produce disproportionately severe outcomes and reduced adaptive capacity. Urban air pollution injustice is therefore a multidimensional problem rooted in political economic decisions and reinforced by social disparities. Effective responses must go beyond aggregate emission reduction and adopt justice oriented strategies in urban planning, regulation, and public health that address both unequal exposure and the structural determinants of vulnerability.

Keywords: air pollution, environmental justice, urban, social vulnerability, health, urban planning, spatial distribution.

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Introduction

Air pollution has long been recognized as one of the most serious environmental threats to urban public health. Fine particulate matter, nitrogen dioxide, ground-level ozone, and sulfur dioxide are the primary constituents of polluted air, which are closely linked to increased morbidity and mortality from respiratory, cardiovascular, and neurological diseases. As an environmental issue, air pollution has traditionally been approached through technical and epidemiological lenses, focusing on measuring pollutant concentrations, dispersion modeling, and quantifying health impacts at the population level. This approach, while invaluable, often overlooks the uneven distribution of exposure and vulnerability within a city. The smog blanketing city skies is not spatially or socially neutral; it settles and accumulates in ways that systematically reflect and simultaneously reinforce pre-existing patterns of inequality. To fully understand the burden of air pollution, one must shift from asking "how much" and "what are the effects" to asking "who is breathing it" and "why are they the most exposed."

The geographical distribution of urban air pollution sources does not occur randomly. Industrial zones, power generation centers, major transportation corridors such as toll roads and airports, and waste processing centers tend to be concentrated in specific areas. This phenomenon is often exacerbated by urbanization dynamics that trigger patterns of urban poverty and challenges in developing social cohesion (Rojak et al., 2012; Mardikaningsih, 2021). The placement of these facilities is often the result of historical planning processes driven by economic considerations, where land with lower value is chosen to accommodate activities deemed less desirable or risky. These areas, collectively referred to as "sacrifice zones," are disproportionately located near low-income settlements and minority groups. This pattern is not a coincidence, but a consequence of political and economic power dynamics that systematically place the burden of pollution on groups in society with the fewest resources to resist or escape. Thus, an air pollution map of a city often overlaps significantly with maps of poverty, racial segregation, and political disenfranchisement.

The experience of living with polluted air extends far beyond health statistics. It permeates daily routines, limits choices, and shapes

perceptions of place and the future. Families in heavily polluted areas may restrict their children's time playing outdoors, fearing asthma attacks or long-term exposure. Windows may remain closed even in hot weather, in a futile attempt to block out dust and odors. The smell of chemicals or vehicle exhaust can become a constant sensory background, an inescapable marker of one's place of residence. These living conditions contribute to chronic stress, feelings of powerlessness, and the erosion of quality of life. This burden also encompasses the stigmatization and vulnerability often experienced by families in the context of contemporary social norms (Rejeki, 2024; Zahid, Darmawan, & Khayru, 2022). This burden is aggravated by the uncertainty of the ability to move to a cleaner environment due to financial constraints, creating a "spatial trap" where health is continuously sacrificed. An approach that understands this subjective experience reveals that air pollution is not only a physical agent but also a powerful social marker of marginalization and neglect.

The environmental justice framework emerges as an essential conceptual lens for analyzing this unfair distribution of pollution burdens. Environmental justice argues that poor and minority communities disproportionately bear the burden of environmental hazards, while reaping fewer benefits from economic development and environmental protection policies. This is also inseparable from the process of gentrification in urban renewal, which often sidelines low-income communities (Fauzi, 2022). In urban areas, this is manifested in clear inequalities in air pollution exposure, access to green and recreational spaces, and the quality of housing and infrastructure. This concept challenges the narrative that environmental degradation is a necessary "trade-off" for economic progress, by demonstrating that the costs and benefits of such development are distributed very unevenly. This shifts the discussion from mere technical pollution management to the realms of distributive justice, rights, and equality.

This study intends to explore the complex relationship between air pollution and environmental injustice in urban areas. In an effort to balance economic, social, and environmental interests, public policy must be able to realize genuine sustainability (Mardikaningsih & Hariani, 2021). By integrating a perspective that focuses on the lived experiences of affected communities with an analysis of the political-economic structures

that generate spatial inequality, this study seeks to provide a more holistic understanding of why clean air remains a privilege rather than a universal right in many cities. By tracing how factors such as historical urban planning, real estate market dynamics, industrial regulations, and political participation interact to create a landscape of unfair exposure, this study aims to uncover the mechanisms that perpetuate these injustices and identify potential leverage points for change.

The core of the problem lies in the systematic processes that cause the concentration of pollution sources and impacts in already vulnerable communities. These processes are often the product of historically discriminatory zoning and land-use planning policies, where high-pollution industrial and commercial land uses are intentionally directed toward areas inhabited by low-income groups and minorities. The legacy of policies such as "redlining" which systematically denied financial services and insurance to residents in marginalized neighborhoods remains felt today in the form of depressed property values, lack of investment, and the concentration of environmental hazards. The problem is exacerbated by the need for more stringent environmental management and law enforcement to address violations (Nuraini et al., 2021). Consequently, these communities face a double burden: they are exposed to higher levels of pollution, and they have less capacity to demand accountability or obtain remediation.

A second, interrelated issue is the lack of protective and mitigation infrastructure in areas most exposed to pollution. Wealthy communities are often shielded by zoning buffers, extensive green spaces, and access to indoor air purification technologies. Conversely, low-income communities tend to have higher residential density with poor ventilation, fewer green spaces capable of filtering pollutants, and locations situated directly adjacent to highways or industrial zones. They may also rely more heavily on public transportation or walking, thereby increasing their exposure to ambient air pollution during their commutes. These inequalities are also influenced by patterns of urban sprawl and daily mobility, which impact community cohesion in suburban areas (Wisnujati & Mardikaningsih, 2021). Furthermore, the absence of adequate health clinics and health insurance in these areas worsens the health impacts of pollution exposure,

leading to greater financial burdens for households already experiencing labor precariousness (Mahmudah, 2022).

The ongoing global increase in urbanization makes the issue of environmental injustice related to air pollution increasingly acute. As cities grow, pressure on land and resources intensifies, often leading to the expansion of industrial zones and transportation infrastructure further into or around the settlements of vulnerable communities. In many major cities worldwide, air pollution levels have reached life-threatening stages, yet policy responses and resources for adaptation and mitigation remain uneven. Understanding these patterns of injustice is essential for designing effective and equitable interventions. This must be based on a foundation of sustainable public policy and reflections on social welfare theory (Rizky & Udjari, 2021). Without an explicit analysis of injustice, pollution control policies risk exacerbating existing disparities.

This issue is also gaining significant political and social momentum. Environmental justice movements across the globe are increasingly highlighting air pollution as a fundamental human rights and social justice issue. Furthermore, it is important to encourage pro-environmental behavior through an internal locus of control and strong environmental awareness among the public (Nuraini et al., 2022). Affected communities are becoming more vocal in demanding their right to breathe clean air, and strategic litigation is beginning to be used to hold governments and corporations accountable. In this regard, the manifestation of leadership oriented toward public service becomes crucial in creating effective governance (Rojak, 2021). Systematic academic study is required to synthesize evidence, strengthen conceptual arguments, and provide a solid empirical basis for advocacy and justice-oriented policymaking. Given the nexus between colonialism and vulnerability, this study also needs to examine how structural inequalities persist (Gani, 2022), while continuing to strive for a balance between individual freedom and collective responsibility in maintaining social solidarity (Saputra & Darmawan, 2021). Thus, examining this topic contributes not only to academic literature but also to broader social movements in facing future multicultural challenges and policy conflicts (Hariani & Halizah, 2024).

This study aims to conduct a critical literature review that analyzes the relationship between air pollution and environmental injustice in

urban areas through two complementary lenses. Specifically, this review seeks to outline the political, economic, and historical mechanisms that lead to the uneven distribution of air pollution sources and exposure within cities. Furthermore, this study aims to analyze how social and biological vulnerability factors exacerbate the health impacts of pollution exposure on already marginalized populations, thereby deepening urban health inequalities. The expected theoretical contribution is a coherent synthesis that links environmental justice theory with urban political economy analysis and social epidemiology. Practically, the findings of this review are expected to provide an analytical framework for identifying policy intervention points that can address the root causes of environmental injustice and for designing pollution control and public health strategies that are explicitly oriented toward justice and equity.

Method

This research is a qualitative literature study designed to comprehensively investigate the relationship between air pollution and environmental injustice in urban areas. A qualitative approach was chosen because it aligns with the explorative and interpretative nature of this research, which aims to understand the complexity of the social, political, and historical mechanisms underlying the unjust distribution of pollution, as well as to interpret the meanings and experiences of such injustice (Maxwell, 2013). Unlike quantitative studies that might measure statistical correlations, this literature study focuses on a critical synthesis of theoretical arguments, empirical findings, and policy analyses from various disciplines. This method allows the researcher to construct a coherent analytical narrative by linking insights from environmental geography, urban sociology, social epidemiology, and environmental justice studies, thereby producing a deep and nuanced understanding.

The implementation of this study follows systematic literature review procedures adapted for qualitative research (Snyder, 2019). The first stage involves formulating clear research questions derived from the problem statement. Subsequently, an extensive and systematic literature search was conducted using scientific databases such as Scopus, Web of Science, PubMed, and Google Scholar. The keywords used include combinations of “air pollution,” “environmental justice,” “urban inequality,” “spatial

distribution," "health disparities," "vulnerability," "urban planning," and "political economy." The primary inclusion criteria were peer-reviewed journal articles, books, and book chapters published within a relevant timeframe that discuss the social, political, or distributive dimensions of urban air pollution, with an emphasis on injustice. Selected sources then underwent a process of thematic analysis (Braun & Clarke, 2006). Through in-depth and iterative reading, textual data were extracted and coded to identify emerging themes, such as "legacy of discriminatory planning," "dynamics of polluting facility siting," "socio-demographic vulnerability," and "compounded health impacts." These themes were then organized, compared, and interpreted to construct two main lines of argument addressing the research questions, while remaining attentive to contradictions and gaps in the existing literature. This analytical process was iterative and reflective, ensuring that the resulting synthesis is not merely descriptive but also provides critical insight into the causes and consequences of environmental injustice related to air pollution.

Result and Discussion

Structural Roots of Inequality: The Political-Economy of Urban Planning and Air Pollution Distribution

The spatial pattern of air pollution in urban areas is not the result of random processes or neutral technical decisions. It is the product of a long history of political and economic decision-making embedded in the structure of the city itself. This aligns with findings that urban poverty patterns and social segregation have a close correlation with spatial patterns in metropolitan areas (Fauzi, 2021). The distribution of pollution sources such as industrial zones, major highways, ports, and power plants consistently follows pre-existing maps of social inequality. This relationship can be traced back to early planning and zoning policies, which were often explicitly designed to segregate land use based on class and race. In many industrial cities, areas with the lowest land value often inhabited by migrant laborers or minority groups were systematically allocated for heavy industry and transportation infrastructure. The economic logic underlying this is simple yet brutal: reduce production costs by minimizing land value while anticipating lower political resistance from a disempowered population. In this context, the dynamics of

changing human relationships in contemporary urban society complicate how this inequality is perceived and responded to by various community groups (Irfan & Al Hakim, 2022). Thus, the foundation for environmental injustice is laid through land-use decisions that perpetuate the link between poverty and pollution.

The legacy of discriminatory housing policies, such as the "redlining" practice historically utilized in the United States, provides a clear example of how injustice is institutionally engineered. Redlining maps, created by government agencies, explicitly ranked neighborhoods based on their racial and class composition, marking areas inhabited by Black people and immigrants as "risky" for mortgage investment. This denial of credit effectively hindered wealth accumulation through homeownership in those communities, leading to declining property values, neglected maintenance, and attracting stakeholders seeking locations for undesirable facilities. Although these legal practices have been abolished, their spatial and economic impacts have persisted for generations. Areas once "redlined" are disproportionately more likely today to be the sites of highways built in the mid-20th century, which cut through communities and brought motor vehicle pollution directly into their neighborhoods, as well as hosts to remaining industries or waste disposal sites.

The process of siting locally unwanted land uses (LULU) further clarifies these power dynamics. When a city needs to build a waste incinerator, chemical plant, or bus depot, the siting process almost always involves conflict. The "path of least resistance" theory argues that these facilities end up being placed in locations where the political cost of doing so is lowest. Communities with limited social and political capital due to poverty, language barriers, immigrant status, or a history of exclusion often lack the resources to organize effective protests, hire legal experts, or lobby elected officials. These limitations are often exacerbated by food insecurity in low-income, densely populated households, which forces the struggle for environmental rights to become secondary to fulfilling basic needs (Mahmudah, 2021). They may also be presented with promises of jobs or limited economic compensation, which, while not commensurate with long-term health risks, may appear attractive amidst economic hardship. Thus, political and economic powerlessness is not only a consequence but also a cause of further pollution concentration.

The logic of the real estate market plays a pivotal role in reinforcing these patterns. Air pollution functions as a negative externality that significantly reduces property values. This reduction creates a destructive feedback loop: when an area becomes polluted, homeowners with financial means move away, draining private investment and quality public services. This further lowers the area's attractiveness, drawing in more polluting industries or infrastructure because the land becomes cheaper, and pushing out remaining residents who have the means to leave. This cycle, often termed "neighborhood decline," results in low-income households being trapped in increasingly degraded environments. They cannot move due to their low property values or the lack of affordable housing options in cleaner locations, effectively becoming captives of the pollution they face. This condition underscores the importance of understanding the social relationship between urban residential characteristics and the social determinants of population health (Warin, 2022).

Transportation planning is another arena where technical decisions and massive infrastructure investments have created and deepened injustice. The development of highway networks in the mid-20th century was often deliberately routed through poor and minority neighborhoods, which were viewed as obstacles that could be cleared with minimal political cost. These corridors not only severed and destroyed cohesive communities but also became major sources of persistent particulate matter and nitrogen dioxide pollution. Residents living near major highways, disproportionately from low-income groups, face chronic exposure to vehicle emissions. Furthermore, the lack of investment in affordable and reliable public transportation in suburban or marginalized areas forces a reliance on older, more polluting personal vehicles for those who can afford them, or on long commutes via polluted public transit. Thus, the city's mobility system itself becomes a machine that generates inequality in pollution exposure.

Environmental regulation, while intended to protect public health, can inadvertently contribute to spatial injustice if applied uniformly without considering the cumulative burdens already borne by specific communities. Ambient air quality standards, for instance, often monitor and enforce limits based on broad regional averages an aggregate approach that can obscure highly localized "pollution hotspots" near specific emission sources (Morello-Frosch, Pastor, & Sadd, 2012). An industry might technically

comply with its smokestack emission regulations, yet pollutant concentrations at its property boundary, right across the street from residential areas, can far exceed standards deemed safe for health. The lack of dense, high-resolution monitoring in disproportionately burdened neighborhoods means such violations and over-exposures may go undetected by conventional surveillance systems (Cushing et al., 2016). This demands an active role for the public in managing ecological issues through participatory practices and community-based social support (Zulkarnain et al., 2021). Furthermore, the permitting process for new industrial operations or expansions may formally require Environmental Impact Assessments (EIA), but these analyses rarely adequately evaluate uneven distributive impacts or acknowledge the cumulative burdens of multiple facilities already operating in the area, thereby failing to prevent "cumulative impacts" (Cole & Foster, 2001). Consequently, this seemingly neutral regulatory framework can indirectly provide legitimacy and legal permission for uneven pollution patterns, thus perpetuating environmental injustice instead of correcting it.

The broader political-economic dynamics at the metropolitan level further reinforce environmental segregation and pollution. Core cities often host older, more polluting industries and infrastructure, while wealthier satellite cities attract clean investments and corporate offices. However, core city residents who work in service industries in the suburbs may have to travel across the region, breathing pollution along transportation corridors while not enjoying the economic benefits of clean employment. The outflow of capital from industrialized city centers toward greener suburbs leaves behind an environmental footprint that lacks the resources for environmental remediation and public health. This regional pattern demonstrates that environmental injustice occurs not only within city limits but is also restructured through relationships between jurisdictions in a metropolitan area. In this context, the formation of social networks through interest-based communities in urban areas can be a vital capital for citizens in responding to such environmental pressures (Rejeki, 2021).

Public investment decisions regarding green spaces and pollution-mitigation infrastructure also follow clear geographic biases. City parks, green belts, and vegetative sound barriers are highly effective at filtering pollutants and providing health benefits. However, such investments tend

to be concentrated in neighborhoods that are already affluent and politically empowered, which further widens the gap in exposure to and access to healthy environments. In underserved areas, existing green open spaces may be neglected or even converted to other, more profitable uses. This lack of protective infrastructure is not a passive omission, but a reflection of budget priorities and public resource allocation that consistently benefit areas already holding the advantage.

Law enforcement activities and monitoring by environmental regulatory bodies also exhibit systematic and predictable geographic variations that directly mirror social inequalities. Complaints from citizens in wealthier, more educated neighborhoods tend to receive faster and more serious responses because they often possess the social and political resources to mobilize regulatory attention (Konisky & Reenock, 2018). Conversely, complaints from low-income communities may go unreported entirely due to a historical distrust of the government, ignorance of complaint processes, or fear of economic retaliation from dominant industrial employers (Bullard, 2000). This situation emphasizes how critical citizen political participation in electoral democracy and civil society movements is for demanding public accountability (Rojak, Khayru, & Darmawan, 2021). Even when complaints are successfully reported, they may not be followed up with equal force due to a lack of organized political pressure and sustained advocacy from those communities a phenomenon well-documented in studies on environmental law enforcement disparities (Lynch et al., 2017). This stark difference in law enforcement creates an unequal regulatory environment where companies operating near poor and minority communities face significantly lower risks of surveillance, inspection, and punishment. Ultimately, this disparity effectively grants companies a kind of "license to pollute" more in locations already most vulnerable, thereby further deepening the cycle of environmental and health injustice.

The distribution of air pollution is a mirror of urban power architecture. It is the result of cumulative decisions regarding where people live, where industries are placed, how transportation is organized, and how public resources are allocated. All of these phenomena must be viewed through the lens of societal psychology in the Society 5.0 era, which demands a balance between technology and humanity (Darmawan et al.,

2021). These decisions are shaped by market forces that prioritize short-term economic efficiency over social justice, and by political structures that provide greater voice and influence to some rather than others. This challenge necessitates robust conflict management to create harmony within work teams and community groups (Al-Hakim & Irfan, 2024), as well as the accommodation of social change within fair sustainability policies (Halizah & Mardikaningsih, 2022). The consequence is a clearly patterned landscape of environmental risk, where an individual's postal code becomes a strong predictor not only of the air quality they breathe but also of their life expectancy and health opportunities. In the global era, the role of media is also crucial in shaping public opinion regarding environmental conflicts and their implications for democracy (Khayru, Rojak, & Fajar, 2024). This injustice is embedded in the city's physical network in the layout of streets, the location of factories, and land ownership lineages making it appear natural or inevitable, when in fact it is the product of human choices that can be changed. Furthermore, it is important to remember that the performance of public organizations in community service must remain focused on the well-being of employees and citizens (Gautama et al., 2021), while continuing to strive for social recovery for those experiencing stigmatization, including the stigma surrounding mental illness that often accompanies economic marginalization (Aisyah & Issalillah, 2022).

Cumulative Impacts: The Interaction of Pollution Exposure, Social Vulnerability, and Health in Urban Communities

High exposure to air pollution does not impact all individuals equally, even within the same geographic location. The health effects of fine particulate matter, ozone, and other pollutants are significantly exacerbated by what is termed social and biological vulnerability. Social vulnerability refers to conditions that reduce an individual's or community's capacity to anticipate, cope with, withstand, and recover from environmental hazards. These factors include socioeconomic status, education level, race and ethnicity, age, and access to healthcare and other resources. Biological vulnerability refers to physiological factors or pre-existing health conditions that increase a person's sensitivity to the toxic effects of pollutants. The interaction between high pollution exposure and this dual vulnerability creates disproportionately

severe health impacts on already marginalized populations, thereby deepening existing urban health inequalities. In this regard, the dynamics of diversity within organizations and society must be managed to ensure they do not widen these gaps (Rojak & Darmawan, 2012).

Low-income communities and minority groups residing in polluted areas often experience higher rates of underlying health conditions that can be aggravated by air pollution. The prevalence of asthma, chronic obstructive pulmonary disease (COPD), diabetes, and cardiovascular disease is disproportionately higher among these populations (Sahu & Dutta, 2020). These conditions can be triggered by factors such as chronic stress, limited access to nutritious food, and exposure to other toxic environmental stressors within the home, such as mold or secondhand smoke. These persistent conditions of urban poverty are often exacerbated by cultural and structural factors that limit a community's ability to escape these traps (Rojak, 2024). When individuals with already compromised respiratory or cardiovascular systems are exposed to additional air pollution, their physiological response can be more severe (Bostan, 2022). For example, fine particulate matter can trigger more intense inflammation in the already inflamed airways of asthma sufferers, leading to more frequent and severe attacks requiring emergency care. Air pollution acts as a disease accelerator, exacerbating pre-existing conditions and causing greater morbidity.

Access to quality healthcare is a critical determinant of how the health impacts of air pollution are manifested and managed. Communities disproportionately exposed to pollution often face barriers to accessing primary and specialist healthcare services. These barriers can include a lack of health insurance, geographic distance from medical facilities, transportation costs, or distrust of the medical system (Madhusoodanan, 2023). Consequently, pollution-related diseases may not be diagnosed early or managed optimally. This underscores the need for strengthened environmental management and stricter law enforcement so that public health facilities are protected from contamination (Nuraini et al., 2021). A child from a poor family experiencing wheezing due to pollution may not be taken to a doctor regularly for asthma evaluation, or may lack access to effective preventative medication. When a respiratory crisis occurs, the family may depend on expensive emergency rooms as their only point of care. These delays in care and suboptimal disease management lead to

worse health outcomes, lost school and work days, and greater financial burdens, thereby further impoverishing the family and limiting opportunities for social mobility.

Nutrition and housing conditions serve as essential social determinants of health that interact with pollution exposure. Malnutrition or poor dietary patterns can weaken the immune system and reduce the body's ability to repair cellular damage caused by pollutants. Children in low-income households may suffer from specific nutritional deficiencies that make them more susceptible to respiratory infections, which can then be worsened by air pollution (Muñoz-Pizza et al., 2020). Furthermore, housing conditions in polluted areas often exacerbate exposure. Homes with poor ventilation can trap outdoor pollutants indoors, creating unhealthy interior environments. This is acutely felt by communities living on the outskirts of industrial urban areas, where poverty and the informal economy create limited social networks (Sulistyo, 2024). Leaks, dampness, and mold common in low-quality housing can synergistically irritate the respiratory tract alongside outdoor pollutants. Residents may also lack the means to purchase air purifiers or filters to reduce indoor pollutant concentrations. The household environment itself becomes a space where social and biological vulnerabilities meet and amplify the impacts of outdoor environmental pollution.

Chronic psychosocial stress, frequently experienced by those living in poverty and facing insecurity, serves as another vulnerability factor that exacerbates the impact of air pollution (Kodavanti, 2019). Chronic stress triggers physiological responses, including increased cortisol levels and systemic inflammation. This physiological status can alter the way the body responds to pollutants. Several studies indicate that individuals experiencing high psychosocial stress may exhibit greater inflammatory or cardiovascular reactions to air pollution compared to those with lower stress levels. Furthermore, stress itself can cause or worsen conditions such as hypertension and depression. When air pollution then adds to this physiological burden, the risk of adverse health events, such as heart attacks or strokes, can increase significantly (Guo et al., 2023). The social burden of marginalization is translated into greater biological vulnerability to environmental toxins.

Age is a particularly critical dimension of biological vulnerability. Children are especially susceptible to the effects of air pollution because their respiratory and immune systems are still developing, their breathing rates are higher relative to body weight, and they spend more time outdoors (Perera, 2024). Air pollution exposure during childhood is linked to stunted lung development, increased asthma risk, and potential long-term neurological effects. In poor and polluted communities, these children's vulnerabilities are compounded by social factors such as a lack of access to safe playgrounds, which may force them to play near busy roads, and exposure to additional indoor pollutants. At the other end of the age spectrum, the elderly, especially those with pre-existing chronic conditions, are also highly vulnerable. Air pollution can worsen heart and lung diseases, leading to hospitalization and premature death. Low-income elderly individuals living in polluted areas may also experience social isolation and mobility difficulties, limiting their ability to seek medical care or even avoid exposure on days with very poor air quality. Amidst this uncertainty, the implementation of adaptive approaches in the management of economic and social crises within organizations becomes vital (Arifin & Darmawan, 2022).

Employment and daily mobility patterns also shape individual vulnerability. Many residents of low-income communities work in jobs that require them to be outdoors or near pollution sources, such as construction, road maintenance, or warehouse work located near highways. This increases the total dose of pollutants they inhale beyond their residential environmental exposure (Yoo et al., 2023). Furthermore, those dependent on active transportation such as walking or cycling to work may have to traverse highly polluted corridors during their commutes, experiencing peak exposures that can be extremely dangerous. Conversely, middle-class office workers are often able to avoid peak exposure by traveling in private air-conditioned vehicles or working inside buildings with air filtration systems. Thus, employment and mobility patterns not only reflect social inequality but also actively mediate the level and duration of pollution exposure, which further differentiates health outcomes.

The cumulative burden of multiple toxic environmental exposures is a critical aspect that determines and deepens vulnerability in socially and economically underserved communities (Bullard, 2000). Air pollution is rarely the sole environmental hazard; rather, communities geographically located near

major highways, industrial zones, or waste disposal sites often face multiple burdens, such as soil contamination from decommissioned industrial sites, access to contaminated drinking water, or constant high-level noise exposure from traffic (Mohai et al., = 2009). This phenomenon explicitly documents the heavy burden of environmental injustice and health risks borne by communities surrounding waste disposal sites (Issalillah & Mardikaningsih, 2022). The combination of these various environmental stressors does not merely stand alone; rather, they can have additive or even synergistic effects that are more harmful to human health (Gee & Payne-Sturges, 2004). For example, exposure to lead from old paint or contaminated soil is already known to permanently damage a child's cognitive development, and when combined with exposure to fine particulate air pollution (PM2.5) which is also linked to neurotoxic effects the combined cumulative impact can be far greater than the sum of the impacts from each toxic substance separately (Cardenas-Iniguez et al., 2022). The human body, constantly facing multiple environmental assaults from various pathways, experiences a chronic state of physiological and toxicological overload, which drastically reduces its natural capacity to adapt and repair itself, thereby significantly increasing vulnerability and the risk of various adverse health outcomes, including respiratory disease, neurological disorders, and cancer (Drago et al., 2024). In this context, law enforcement against environmental violations in industrial areas needs to be strengthened to prevent the recidivism of such violations (Rahmawati et al., 2023).

Limitations in adaptive capacity and community resilience further exacerbate these impacts. Adaptive capacity refers to the resources and capabilities a community possesses to make adjustments that reduce potential harm from environmental hazards (Zolnikov, 2019). Wealthy communities may have access to real-time air quality information, can afford to purchase air purifiers for every room, and possess the flexibility to change outdoor plans or work from home on high-pollution days. Low-income communities often lack these resources. They may lack access to easily understood information about pollution risks, be unable to afford mitigation technology, and lack the work flexibility that would allow them to avoid exposure. The lack of safe green space and indoor recreational facilities means that options for healthy physical activity are limited. To address this, the role of urban forests in improving urban environmental quality becomes very strategic (Dahar et al., 2022). This powerlessness locks in patterns of high

exposure and poor health outcomes (Ma et al., 2020). Public education and awareness efforts to encourage sustainable behavioral change must be continuously optimized (Gautama & Mardikaningsih, 2022).

These exacerbated health impacts have far-reaching social and economic consequences for the community, creating a negative feedback loop. Medical expenses for pollution-related illnesses can deplete family savings, driving them deeper into poverty. Children who are frequently ill miss school days, which disrupts their learning and limits future educational attainment and economic prospects. Adults who fall ill lose work days, threatening their income and job stability. The premature death or disability of a parent can economically devastate a family. Thus, the health impacts of air pollution are not merely a result of social injustice, but also a primary driver of ongoing inequality by damaging the human and economic capital of the most affected communities. Amidst the dynamics of modernity, indigenous societies in urban areas even continue to strive to maintain their traditions amidst environmental pressures and rapid social change (Amri & Khayru, 2022).

The impact of air pollution on marginalized urban communities extends far beyond the direct toxic effects of the pollutants themselves. Vulnerabilities arising from low socioeconomic status, pre-existing health conditions, limited access to healthcare, poor nutrition, inadequate housing, chronic stress, extreme age, and high occupational exposure interact in complex ways with pollution exposure to produce worse health outcomes. These factors not only increase an individual's biological vulnerability but also shape patterns of exposure through work and mobility, and limit the capacity to avoid or mitigate those impacts. Furthermore, the cumulative burden of multiple environmental stressors and the resulting social disadvantages create a cycle that deepens poverty and health inequality. Therefore, environmental injustice related to air pollution is a multi-dimensional issue in which structural, social, and biological factors are interconnected to disproportionately jeopardize the health and well-being of already vulnerable populations, thereby perpetuating an unjust distribution of the burden of disease within the city. The importance of concrete steps, such as changing public behavior toward the use of environmentally friendly materials for example, the use

of biodegradable shopping bags serves as one small but meaningful contribution to environmental sustainability (Hariani & Al Hakim, 2022).

Conclusion

This literature review definitively demonstrates that air pollution in urban areas is a profound environmental justice issue, rather than merely a technical or public health challenge that is evenly distributed. The analysis reveals that the spatial distribution of air pollution sources and exposure is not random, but rather a direct product of political-economic and historical processes in urban planning. Discriminatory zoning and housing policies, the logic of real estate markets that lower property values in polluted areas, and the strategic placement of undesirable facilities along the "path of least resistance" have systematically concentrated the pollution burden on low-income communities and minority groups. Furthermore, this study confirms that the health impacts of this exposure are exponentially exacerbated by the social and biological vulnerabilities inherent in the same populations. The interaction between high pollution exposure and factors such as pre-existing health conditions, limited access to healthcare, poor nutrition, chronic stress, as well as risky employment and mobility patterns, results in disproportionate morbidity and mortality. Thus, environmental injustice related to air pollution is cumulative and mutually reinforcing, embedded within the spatial structures of the city and worsened by underlying social inequalities, which together create and sustain deep and persistent urban health disparities.

The findings of this study carry fundamental implications for theory, policy, and practice. Theoretically, this study reinforces the need for intersectional and structural approaches in environmental justice and urban health studies, explicitly linking political economic analysis with social epidemiology and health geography. For policymakers, the most urgent implication is the need for a paradigm shift from uniform pollution control approaches toward an explicitly justice-oriented approach. This means that air quality policies, spatial planning, housing, and transportation must be designed with a dual objective: reducing overall pollution and actively narrowing the gaps in exposure and vulnerability. Environmental regulations need to incorporate distributive and cumulative impact analyses into the permitting process, and air quality monitoring must be significantly

strengthened in identified hotspots. Public investment in green spaces, healthy housing, and sustainable transportation should be strategically prioritized in the most burdened communities. Furthermore, public health systems need to develop the capacity to proactively address the burden of pollution-related diseases in these areas through screening, disease management, and partnerships with community organizations.

Based on these findings and implications, several targeted recommendations are proposed. First, for city and regional governments, it is recommended to develop and implement an "Environmental Justice Index Map" that integrates real-time air pollution data with social vulnerability data (poverty, race, health, housing) to identify and prioritize intervention areas with spatial precision. Second, robust and well-funded participatory planning mechanisms must be mandated for projects impacting land use and transportation, ensuring that affected communities have a decisive voice in decisions influencing their environment and health. Third, for researchers, it is suggested to conduct more longitudinal studies examining the cumulative health effects of air pollution exposure interacting with social stressors at the individual and household levels, to further quantify the burden and inform targeted interventions. Fourth, education and training for urban planners, environmental engineers, and public health professionals must mandatorily include modules on environmental justice and social determinants of health, to equip them with the necessary framework to design equitable solutions. Finally, public and private funding for the clean energy transition and circular economy must explicitly link incentives to job creation and health benefits in communities most exposed to pollution, thereby ensuring that the green transition is also a just transition.

References

Aisyah, N. & F. Issalillah. 2022. Social Stigma toward Mental Illness: Manifestations in Society and Barriers to Recovery, *Studi Ilmu Sosial Indonesia*, 2(1), 307-332.

Al-Hakim, Y. R., & Irfan, M. 2024. Conflict Management and Harmony in Work Teams: Management Strategies, Causal Factors, and Impacts on Team Effectiveness. *Studi Ilmu Sosial Indonesia*, 4(1), 361-390.

Amri, M. W., & Khayru, R. K. 2022. Keeping Tradition in the Midst of Modernity: The Social Life of Indigenous Communities in Urban Areas. *Journal of Social Science Studies*, 2(1), 135-138.

Arifin, S., & Darmawan, D. 2022. Adaptive Approach in Crisis Management for Economic Uncertainty in Organization. *Journal of Social Science Studies*, 2(1), 271-276.

Bostan, P. 2022. Health effects of outdoor air pollutants. *World Journal of Environmental Research*, *12*(2), 70–81. https://doi.org/10.18844/wjer.v12i2.8095

Braun, V., & V. Clarke. 2006. Using Thematic Analysis in Psychology. *Qualitative Research in Psychology*, 3(2), 77–101.

Bullard, R. D. 2000. *Dumping in Dixie: Race, Class, and Environmental Quality (3rd ed.)*. Westview Press, New York.

Cardenas-Iniguez, C., Burnor, E., & Herting, M. M. 2022. Neurotoxicants, the Developing Brain, and Mental Health. *Biological Psychiatry Global Open Science*, 2(3), 223–232. https://doi.org/10.1016/j.bpsgos.2022.05.002

Cole, L. W., & S. R. Foster. 2001. *From the Ground Up: Environmental Racism and the Rise of the Environmental Justice Movement*. New York University Press, New York.

Cushing, L., R. Morello-Frosch., A. Hubbard., & M. Pastor. 2016. Extreme Heat, Racial Segregation, and the Structure of Urban Landscapes: The Case of California. *Environmental Science & Technology*, 50(13), 7064–7072.

Dahar, D., Arifin, S., Nuraini, R., & Mardikaningsih, R. 2022. Urban Forest: The role of improving the quality of the urban environment. *Bulletin of Science, Technology and Society*, 1(1), 25-29.

Darmawan, D. et al. 2021. *Psychological Perspective in Society 5.0*, Zahir Publishing, Jogjakarta.

Drago, G., Aloi, N., Ruggieri, S., Longo, A., Contrino, M. L., Contarino, F., Cibella, F., Colombo, P., & Longo, V. 2024. Guardians under Siege: Exploring Pollution's Effects on Human Immunity. *International Journal of Molecular Sciences*, *25*(14), 7788–7788. https://doi.org/10.3390/ijms25147788

Fauzi, A. 2021. Spatial Patterns of Poverty and Social Segregation in Metropolitan Areas, *Studi Ilmu Sosial Indonesia*, 1(1), 147-160.

Fauzi, A. 2022. Gentrification in Urban Renewal and the Marginalization of Low Income Communities, *Studi Ilmu Sosial Indonesia*, 2(1), 235-260.

Gani, A. 2022. The Colonialism-Vulnerability Nexus: A Political Ecology Study of Structural Inequality in Climate Change, *Studi Ilmu Sosial Indonesia*, 2(1), 85-108.

Gautama, E. C., & Mardikaningsih, R. 2022. Driving Sustainable Behavior Change Through Education and Public Awareness. *Journal of Social Science Studies*, 2(1), 259-264.

Gautama, E. C., Mardikaningsih, R., Wisnujati, N. S., & Cruz, C. da. 2021. The Relationship between Employee Welfare and Public Organization Performance in Community Services. *Journal of Social Science Studies*, 1(2), 197-202.

Gee, G. C., & D. C. Payne-Sturges. 2004. Environmental Health Disparities: A Framework Integrating Psychosocial and Environmental Concepts. Environmental Health Perspectives, 112(17), 1645–1653.

Guo, T., Wang, W., Chen, X., Guo, H., Wang, K., Ma, Y., Deng, H., Li, X., Shan, A., Wu, Q., & Li, Y. 2023. *Psychosocial Stress Modifies the Acute Cardiac Health Effects of Traffic-Related Air Pollution*. https://doi.org/10.1021/envhealth.3c00104

Halizah, S. N., & Mardikaningsih, R. 2022. Accommodating Social Change in Sustainability Policy: Solutions for a Just and Relevant Society. *Journal of Social Science Studies*, 2(2), 299-304.

Hariani, M., & Al Hakim, Y. R. 2022. Analysis of Community Behavior Against the Use of Bio-Degradable Shopping Bags as a Substitute for Single-Use Plastic Bags. *International Journal of Service Science, Management, Engineering, and Technology*, 2(1), 1-4.

Hariani, M., & Halizah, S. N. 2024. Multicultural Perspective in Conflict Management Policy: A Literature Study on Challenges and Opportunities In Indonesia. *Studi Ilmu Sosial Indonesia*, 4(1), 337-360.

Irfan, M. & Y. R. Al Hakim. 2022. Changing Patterns of Human Relations in Contemporary Urban Society, *Studi Ilmu Sosial Indonesia*, 2(1), 333-356.

Issalillah, F., & Mardikaningsih, R. 202). Environmental Justice and Health Burdens in Marginalized Communities Near Waste Sites. Studi Ilmu Sosial Indonesia, 2(1), 145-168.

Khayru, R. K., Rojak, J. A., & Fajar, A. S. M. 2024. The Role of Media in the Global Era in Shaping Public Opinion on Conflict and the Implications for Democracy. *Studi Ilmu Sosial Indonesia*, 4(1), 417-438.

Kodavanti, U. P. 2019. Susceptibility Variations in Air Pollution Health Effects: Incorporating Neuroendocrine Activation. *Toxicologic Pathology*, 47(8), 962–975. https://doi.org/10.1177/0192623319878402

Konisky, D. M., & C. Reenock. 2018. Regulatory Enforcement, Riskscapes, and Environmental Justice. *Policy Studies Journal*, 46(1), 7–36.

Lynch, M. J., P. B. Stretesky., & R. G. Burns. 2017. *Environmental Law, Crime, and Justice: An Analysis of the Extent and Causes of Environmental Inequity.* In Environmental Crime and Criminality: Theoretical and Practical Issues. Garland Publishing, Texas.

Ma, X., Li, X., Kwan, M. P., & Chai, Y. 2020. Who Could Not Avoid Exposure to High Levels of Residence-Based Pollution by Daily Mobility? Evidence of Air Pollution Exposure from the Perspective of the Neighborhood Effect Averaging Problem (NEAP). *International Journal of Environmental Research and Public Health*, *17*(4), 1223. https://doi.org/10.3390/IJERPH17041223

Madhusoodanan, J. 2023. Fixing Air Pollution Could Dramatically Improve Health Disparities. *Nature*, *621*, S30–S34. https://doi.org/10.1038/d41586-023-02614-5

Mahmudah, S. 2021. Food Vulnerability of Poor Households in Densely Populated Urban Areas, *Studi Ilmu Sosial Indonesia*, 1(2), 125-140.

Mahmudah, S. 2022. Economic Informality and Urban Worker Precarity in City Governance, *Studi Ilmu Sosial Indonesia*, 2(2), 231-258.

Mardikaningsih, R. 2021. Urbanization and Social Inequality: Challenges in Building Social Cohesion in a City-Based Environment. *Journal of Social Science Studies*, *1*(1), 135-140.

Mardikaningsih, R., & Hariani, M. 2021. Realizing Sustainability in Public Policy: Building a Balance between Economy, Social, and Environment. *Journal of Social Science Studies*, 1(1), 191-196.

Maxwell, J. A. 2013. *Qualitative Research Design: An Interactive Approach (3rd ed.)*. SAGE Publications, Thousand Oaks.

Mohai, P., D. Pellow., & J. T. Roberts. 2009. Environmental Justice. *Annual Review of Environment and Resources*, 34, 405–430.

Morello-Frosch, R., M. Pastor., & J. Sadd. 2012. The Air is Always Cleaner on the Other Side: Race, Space, and Ambient Air Toxics Exposures in California. *Journal of Urban Affairs*, 34(4), 417–439.

Muñoz-Pizza, D. M., Villada-Canela, M., Reyna, M. A., Texcalac-Sangrador, J. L., & Osornio-Vargas, A. 2020. Air pollution and children's respiratory health: a scoping review of socioeconomic status as an effect modifier. *International Journal of Public Health*, *65*(5), 649–660. https://doi.org/10.1007/S00038-020-01378-3

Nuraini, R., Darmawan, D., Mardikaningsih, R., Hariani, M., & Halizah, S. N. 2022. Keberlanjutan kelestarian lingkungan: Peran kunci lokus kendali internal dan wawasan lingkungan dalam mendorong perilaku pro-lingkungan. *TIN: Terapan Informatika Nusantara*, 3(3), 116-122.

Nuraini, R., Handayani, S., Wisnujati, N. S., Darmawan, D., & Kurniawan, Y. (2021). Environmental Management and Law Enforcement. Studi Ilmu Sosial Indonesia, 1(1), 65-76.

Nuraini, R., Handayani, S., Wisnujati, N. S., Darmawan, D., & Kurniawan, Y. 2021. Environmental Management and Law Enforcement. *Studi Ilmu Sosial Indonesia*, 1(1), 65-76.

Perera, F. P. 2024. *Outdoor Air Pollution*. 317–331. https://doi.org/10.1093/oso/9780197662526.003.0025

Rahmawati, F., R. Mardikaningsih, & F. Issalillah. 2023. Environmental Violation Recidivism in Industrial Estates under Organizational Compliance Frameworks, Studi Ilmu Sosial Indonesia, 3(2), 247-276.

Rejeki, S. 2021. Social Network Formation Through Shared Interest Communities in Urban Areas, *Studi Ilmu Sosial Indonesia*, 1(1), 227-250.

Rejeki, S. 2024. Family Institutional Change in Contemporary Society Norms Authority and Obligations. *Studi Ilmu Sosial Indonesia*, 4(1), 229-254.

Rizky, M. C., & Udjari, H. 2021. Reflections on Social Welfare Theory in the Juridical Foundation of Sustainable Public Policy. *Journal of Social Science Studies*, 1(1), 185-190.

Rojak, J. A. (2024). Persistent Urban Poverty: An Evaluation of Cultural Claims and Structural Explanatory Alternatives. Studi Ilmu Sosial Indonesia, 4(2), 129-150.

Rojak, J. A. 2021. The Effectively Leading Manifestation of Public Service-Oriented Governance. *Journal of Social Science Studies*, 1(2), 89-96.

Rojak, J. A., & Darmawan, D. 2012. Dinamika Keberagaman Gender dan Etnis dalam Organisasi Kontemporer. *Jurnal Ekonomi dan Bisnis*, 2(2), 45–58.

Rojak, J. A., Darmawan, D., Mardikaningsih, R., Ernawati, & Kemarauwana, M. 2012. Dinamika urbanisasi dan pola kemiskinan kota serta implikasi pencegahan. *Jurnal Ekonomi dan Bisnis*, 2(1), 53–65.

Rojak, J. A., R. K. Khayru, & D. Darmawan. 2021. Citizens' Political Participation in Electoral Democracy and the Dynamics of Civil Society Movements, *Studi Ilmu Sosial Indonesia*, 1(1), 161-176.

Sahu, M., & Dutta, P. 2020. Air Pollution and Public Health: Linking Exposure to Disease. *Environmental Reports.*, 2(1), 1–5. https://doi.org/10.51470/er.2020.2.1.01

Saputra, R. & D. Darmawan. 2021. Between Individual Freedom and Collective Responsibility: Dynamics of Social Solidarity in the Age of Individualism, *Studi Ilmu Sosial Indonesia*, 1(1), 251-274.

Snyder, H. 2019. Literature Review as a Research Methodology: An Overview and Guidelines. *Journal of Business Research*, 104, 333–339.

Sulistyo, B. 2024. Urban Poverty, Informal, Economy, and Social Networks in Industrial Urban Peripheries. *Studi Ilmu Sosial Indonesia*, 4(2), 151-182.

Warin, A. K. 2022. Social Relationship Between Urban Living Characteristics and Social Determinants of Population Health, *Studi Ilmu Sosial Indonesia*, 2(2), 307-332.

Wisnujati, N. S. & R. Mardikaningsih. 2021. Urban Sprawl, Daily Mobility, and Community Cohesion in Suburban Fringe Areas, *Studi Ilmu Sosial Indonesia*, 1(2), 275-300.

Yoo, E.-H., Cooke, A., & Eum, Y. 2023. Examining the geographical distribution of air pollution disparities across different racial and ethnic groups: Incorporating workplace addresses. *Health & Place*, 84, 103112–103112. https://doi.org/10.1016/j.healthplace.2023.103112

Zahid, R. A., D. Darmawan, & R. K. Khayru. 2022. Mental Illness Stigma in Families and the Reach of Private Law Protection, *Studi Ilmu Sosial Indonesia*, 2(2), 207-230.

Zolnikov, T. R. 2019. *Introduction to Climate Change Vulnerability, Adaptation, and Resiliency*. 1–10. https://doi.org/10.1007/978-3-030-01213-7_1

Zulkarnain, M. A. B., Khayru, R. K., Issalillah, F., & da Cruz, C. 2021. Citizen Engagement in Ecological Issue Management through Participatory Practices and Community-Based Social Supports. *Journal of Social Science Studies*, *1*(1), 227-232.