The Political Ecology of Urban Expansion and Air Pollution in Kathmandu

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Abstract

This study analyzes the relationship between rapid urbanization, political priorities, and air quality issues in Kathmandu city of Nepal, aiming to identify sustainable urban planning solutions. Utilizing secondary data sources, such as governmental reports, environmental studies, and urban development records, the research employs a mixed-methods approach to analyze the factors driving urban expansion and their impact on air pollution. Key variables measured include population density, urban growth rate, traffic volume, industrial activity, and green space availability. The findings reveal that unregulated urban growth, driven by economic and infrastructural priorities, significantly contributes to deteriorating air quality. Political decisions often prioritize development over environmental protection, leading to insufficient enforcement of pollution control measures. Critical gaps in urban planning policies, such as the lack of green spaces and weak regulatory frameworks for industrial emissions, are identified. To address these issues, the study suggests implementing stricter air quality regulations, promoting green infrastructure, and enhancing public transportation systems. It recommends increasing inter-agency collaboration to integrate environmental considerations into urban development plans and engaging local communities in environmental decision-making processes. The research concludes that balancing development goals with environmental sustainability is essential for mitigating pollution and promoting healthier urban living conditions in Kathmandu.

Keywords*:* environmental health, political ecology, pollution, sustainable development, urbanization

Introduction

Kathmandu, the capital city of Nepal, has experienced rapid urbanization over the past few decades, transforming from a traditional valley town into a sprawling metropolitan area.

This urban expansion is driven by various factors, including population growth, economic development, and increased migration from rural areas. As the city expands, the demand for infrastructure, housing, and transportation rises, thus, leading to significant environmental challenges. Among these challenges, air pollution has emerged as a critical issue, impacting public health and quality of life. The political landscape of Nepal, characterized by a focus on economic growth and development, often places environmental concerns on the back burner, exacerbating the problem. Despite its rapid development, Kathmandu faces severe air quality issues, primarily due to unregulated urban growth and inadequate environmental policies. The city's air pollution levels frequently exceed national and international standards, posing serious health risks to its residents. This pollution stems from various sources, including vehicular emissions, industrial activities, and construction dust. Political decisions favoring economic and infrastructural development often lead to the neglect of environmental regulations and the enforcement of pollution control measures. Consequently, the unbridled expansion of urban areas without sufficient green spaces and regulatory oversight has resulted in escalating air pollution levels. Addressing this issue requires a comprehensive analysis of the political and ecological dynamics that drive urban expansion and environmental management in Kathmandu.

Political ecology is an interdisciplinary framework that examines the complex relationships between political, economic, and social factors and environmental issues and changes. It emphasizes the ways in which power dynamics and political processes influence environmental outcomes and resource management. Political ecology integrates insights from geography, sociology, anthropology, political science, and ecology to understand how environmental problems are shaped by and, in turn, shape human societies. Central to political ecology is the idea that environmental issues cannot be understood in isolation from the broader political and economic contexts in which they arise. It challenges simplistic explanations of environmental degradation, highlighting the roles of inequality, marginalization, and policy decisions. The political ecology of urban expansion focuses on how urban growth is influenced by political and economic priorities and how this growth impacts the environment. In rapidly urbanizing areas, such as Kathmandu, political decisions often prioritize economic development and infrastructure expansion over environmental sustainability. This can lead to unregulated urban sprawl, where the rapid development of housing, industry, and transportation infrastructure outpaces the implementation of environmental protections. The political ecology approach

examines who benefits and who bears the costs of urban expansion, revealing how marginalized communities often suffer the most from environmental degradation. It also explores the power relations and policy decisions that drive urban growth, including land use planning, zoning laws, and investment in public infrastructure.

Political ecology is a field that combines ecology and political economy to understand the relationships between humans and their environment. It examines how environmental issues are shaped by social, political, and economic factors and how these issues affect social relations and power dynamics. Walker (2005, p. 73) defines political ecology as exploring the complex interdependencies between ecological and political processes, emphasizing the role of power in shaping environmental outcomes. The field emerged in the 1970s as a critique of traditional environmental studies that overlooked socio-political factors. Early work, influenced by Marxist theories, focused on how capitalist production and resource extraction impact environmental degradation and social inequality (Watts, 2017, p. 258). In the 1980s and 1990s, political ecology incorporated feminist, poststructuralist, and postcolonial perspectives, emphasizing the diverse experiences of marginalized communities, particularly in the Global South (Davis, 2015, p. 263). Scholars began examining the interplay between local and global processes, analyzing how global trends influence local environmental conditions (Neumann, 2014, p. 101). Contemporary political ecology integrates new theoretical insights and methodological approaches, emphasizing participatory methods and the importance of local knowledge in sustainable environmental management (Bixler et al., 2015, p. 165). Political ecology remains crucial for developing equitable and sustainable solutions that address both environmental and social injustices.

Pollution refers to the introduction of harmful substances or products into the environment, leading to adverse effects on natural ecosystems and human health. Pollution can take many forms, including air, water, soil, and noise pollution. It is often a byproduct of industrial activity, transportation, agriculture, and urban development. The sources and impacts of pollution are unevenly distributed, with certain communities and regions bearing disproportionate burdens. Pollution is a major global challenge, contributing to a range of health problems, loss of biodiversity, and climate change. Air pollution specifically involves the contamination of the atmosphere by harmful substances, including gases, particulates, and

biological molecules. Major sources of air pollution include vehicle emissions, industrial discharges, construction activities, and the burning of fossil fuels. Common air pollutants include particulate matter (PM2.5 and PM10), nitrogen oxides (NOx), sulfur dioxide (SO_2), carbon monoxide (CO), and volatile organic compounds (VOCs). Air pollution has significant health impacts, contributing to respiratory and cardiovascular diseases, premature death, and decreased quality of life. It also affects the environment, causing issues such as acid rain, reduced visibility, and harm to wildlife. Urban areas, like Kathmandu, often experience higher levels of air pollution due to dense populations and concentrated sources of emissions. Mitigating air pollution requires stringent environmental regulations, investment in cleaner technologies, and public awareness campaigns to reduce emissions and protect public health.

In an effort to address the critical issue of air pollution in Kathmandu, this study investigates on the issues of how rapid urbanization in Kathmandu contributes to the city's air quality problems, the political and economic factors that influence urban planning and environmental policies in Kathmandu and the potential solutions for mitigating air pollution in Kathmandu through sustainable urban planning practices. The primary objective of this research is to investigate the complex relationship between rapid urbanization, political priorities, and air quality issues in Kathmandu. It seeks to propose sustainable urban planning solutions, including stricter air quality regulations, the promotion of green infrastructure, and the enhancement of public transportation systems.

The research methodology for studying the political ecology of urban expansion and air pollution in Kathmandu predominantly involves the use of secondary data sources and qualitative analysis. This approach leverages existing governmental reports, environmental studies, urban development records, and policy documents to gather comprehensive data on urbanization patterns and air quality metrics. Qualitative analysis is conducted through a thematic examination of policy documents, planning records, and relevant literature to understand the political and economic drivers of urban expansion and their impact on air quality. Secondary data from case studies and reports by several national and international organizations has provided insights into the governance and regulatory frameworks influencing urban development. This comprehensive approach has allowed for an in-depth analysis of the

relationship between urbanization, political priorities, and environmental degradation, facilitating the identification of sustainable urban planning solutions.

Urbanization and Environmental Change

Urbanization, defined as the increasing population concentration in cities, has profound impacts on the environment globally. As cities expand, they alter land use patterns, leading to significant changes in natural landscapes. One major consequence is the "urban heat island" effect, where urban areas experience higher temperatures than their rural surroundings due to the extensive use of concrete and asphalt, which absorb and retain heat, contributing to local climate changes and exacerbating heat-related health issues (Grimmond, 2007, p. 84). Urbanization drives increased consumption of resources such as water, energy, and land, leading to higher levels of waste production and pollution. Urban areas are major contributors to greenhouse gas emissions due to transportation, industrial activities, and energy use, thus playing a significant role in global climate change (Seto & Satterthwaite, 2010, p. 128). The expansion of urban land is also associated with the loss of biodiversity and the disruption of ecosystems, as natural habitats are converted into urban landscapes (Wei & Ye, 2014, p. 762). In developing countries, rapid and sometimes unplanned urban growth leads to distinct environmental challenges, such as severe air pollution and water scarcity in China (Liang et al., 2019), and heightened pollution levels and inadequate infrastructure in India. Uncontrolled urban sprawl increases vulnerability to natural disasters like flooding due to encroachment on floodplains and insufficient drainage systems (Cohen, 2006, p. 68). South Asia, one of the most rapidly urbanizing regions, faces significant environmental challenges due to urban growth. In Nepal, particularly in the Kathmandu Valley, urbanization has led to increased air pollution, higher energy consumption, and greater waste production (Pradhan-Salike & Pokharel, 2017, p. 57). The conversion of natural land to urban areas has reduced the capacity for natural water absorption, leading to frequent flooding (Timsina et al., 2020, p. 23), while increased vehicular traffic and industrial activities have deteriorated air quality, posing health risks to the population.

Political and Economic Drivers of Urban Expansion

Political decisions play a critical role in shaping urban growth, influencing spatial distribution, infrastructure development, and overall urbanization patterns. In the context of Kathmandu Valley of Nepal, political instability and transitions have significantly impacted

urban expansion. Government policies often prioritize certain areas for development, leading to rapid urbanization in those regions (Timsina et al., 2020, p. 19). Political decisions regarding land use planning and zoning regulations directly affect urban growth, with policies that encourage or restrict land development, provide housing incentives, and designate industrial zones driving expansion. In Kathmandu, the lack of stringent land use policies has led to unplanned urban sprawl, as political decisions have often favored short-term economic gains over sustainable urban planning (Thapa & Murayama, 2010, p. 72). Economic opportunities, such as better employment prospects, higher wages, and improved living standards, attract people to urban areas, with rural-to-urban migration significantly driving urbanization in Kathmandu Valley (Rijal et al., 2020, p. 3). Investment in infrastructure, including transportation networks, utilities, and communication systems, promotes urban growth by improving the quality of life and attracting businesses (Thapa & Murayama, 2011, p. 27). Effective urban governance, involving coordination among governmental and non-governmental stakeholders, is essential to guide urban development and address challenges such as informal settlements and inadequate infrastructure (Suhartini et al., 2019, p. 25; Baud et al., 2021, p. 3). Strengthening governance structures and developing robust policy frameworks are crucial for promoting sustainable urban growth, integrating land use planning, environmental management, and economic development (Rimal et al., 2020, p. 631). Political decisions are instrumental in shaping the trajectory of urban development, with long-lasting implications for the social and environmental landscape. As Kathmandu Valley continues to urbanize, the need for forward-thinking policies and coordinated governance becomes increasingly urgent to mitigate the adverse effects of unchecked growth and ensure a more sustainable urban future.

Impact of Urbanization in Bangladesh

Urban expansion in Bangladesh, particularly in major cities like Dhaka, is driven by rapid population growth, rural-to-urban migration, and economic development initiatives. The influx of people seeking better employment opportunities and living standards has led to significant urban sprawl and increased demand for housing, infrastructure, and services (Hassan, 2017; Dewan et al., 2012). This rapid urbanization has often occurred in an unplanned manner, resulting in environmental degradation and the loss of green spaces and agricultural land. Consequences include strain on infrastructure, inadequate waste management, and increased

vulnerability to natural disasters. Overcrowding and insufficient urban planning have led to congested streets, limited access to clean water, and inadequate sanitation facilities (Dewan et al., 2012). Encroachment on wetlands and other sensitive areas exacerbates flooding and other hazards (Hassan, 2017). One critical issue is the significant increase in air pollution due to rapid industrialization, increased vehicular emissions, and construction activities, posing severe health risks (Khandker et al., 2023). The dense urban environment and lack of effective pollution control measures result in adverse health impacts, with air pollution levels in Dhaka frequently exceeding WHO limits. Social and economic costs include public health impacts and reduced productivity. The political ecology of climate change adaptation in Bangladesh reveals conflicts, inequalities, and vulnerabilities, with marginalized communities bearing the brunt of environmental degradation (Sovacool, 2018). Existing literature primarily documents the urbanization process, environmental impacts, and air pollution levels but lacks comprehensive analysis of the political and economic drivers. This research addresses gaps by examining political and economic factors driving urban expansion in Kathmandu, how governance and policy decisions impact growth and air quality, and exploring socio-economic inequalities related to air pollution exposure. This approach suggests potential policy interventions to mitigate adverse effects.

Findings and Discussion

Kathmandu is a melting pot of various ethnic groups. As the cultural heart of Nepal, it holds significant importance in the country's arts, history, and economy. Kathmandu has experienced rapid urban expansion, making it one of the fastest-growing cities in South Asia. However, this swift development has led to a surge in pollution levels. The situation worsened following a devastating 7.8 magnitude earthquake in 2015, which left many parts of the city in ruins. The debris and dust from these damaged areas contribute significantly to the pollution. In 2019, Kathmandu had an annual average PM2.5 level of 48 $\mu g/m^3$, categorizing it as 'unhealthy for sensitive groups,' which is defined by a PM2.5 range of 35.5 to 55.4 $\mu g/m^3$. This indicates substantial pollution levels throughout the year, with certain months, like January, reaching as high as 102.7 $\mu g/m^3$. This level falls into the 'unhealthy' category (55.5 to 150.4 $\mu g/m^3$), posing serious health risks to the population. The city's pollution is due to both human activities and geographical factors. Located in a valley surrounded by mountain ranges, Kathmandu's position

impedes the dispersion of pollutants. Additionally, being flanked by China and India, both of which have significant pollution issues, exacerbates the situation. Major pollution sources in Kathmandu include the large number of old, poorly maintained vehicles that emit high levels of harmful pollutants. The open burning of organic material and refuse, a common practice due to inadequate waste management infrastructure, also contributes significantly to air pollution. The combustion of materials like wood and plastic releases toxic fumes detrimental to human health (IQAir, 2024). Kathmandu's rapid urbanization, while driving economic growth, has also intensified environmental challenges that threaten public health and the city's livability. Addressing the city's pollution crisis requires a multifaceted approach, including improved waste management, stricter vehicle emissions regulations, and sustainable urban planning that considers the unique geographical and cultural context of the valley.

Urban Growth Pattern in Kathmandu

Kathmandu is experiencing rapid urban expansion driven by various socio-economic factors, resulting in significant spatial transformations. The spatial distribution of urban expansion in Kathmandu is characterized by outward spread from the central city into surrounding rural and semi-urban regions. Khanal et al. (2019) utilized Open Street Map (OSM) and Landsat data to detect spatiotemporal patterns, revealing that the city's expansion predominantly occurs along major transportation routes and peri-urban areas, reflecting suburbanization trends. Shrestha (2021) identified significant growth in the northern and western parts of the Kathmandu Valley, attributed to the availability of relatively flat land suitable for development. Kathmandu's population density and urban growth rates have increased substantially over the past few decades. Ishtiaque et al. (2017) reported a 300% expansion in the urban area of Kathmandu Valley between 1989 and 2016 using Landsat imagery, placing significant pressure on infrastructure and resources. Rijal et al. (2020) identified population growth, economic opportunities, and rural-urban migration as primary contributors to this increasing density. Thapa and Murayama (2010) used the Analytic Hierarchy Process (AHP) to model urban growth, showing new developments primarily occurring on the city's outskirts, in areas previously agricultural or forested. Rimal et al. (2020) projected future urban expansion patterns using remote sensing and spatial modeling techniques, indicating that if current trends

continue, new developments will likely encroach further into peripheral areas, demanding strategic urban planning to balance development with environmental conservation.

Air Quality Data and Pollution Hotspots

Kathmandu's air quality is largely impacted by high concentrations of particulate matter. PM2.5 and PM10 are critical indicators of air pollution due to their adverse health effects. According to Becker et al. (2021), in-situ measurements and remote sensing data reveal substantial variability in PM concentrations across Kathmandu. Regmi et al. (2023) utilized low-cost sensors and satellite-based column aerosol optical depth (AOD) data to analyze surface-level PM2.5 concentrations across Kathmandu. Their study corroborates the findings of elevated PM levels in central and industrial zones, further emphasizing the need for improved air quality monitoring and management in these regions. Urban areas, especially those with high traffic density and industrial activities, exhibit elevated PM2.5 and PM10 levels. Central locations often report PM2.5 concentrations exceeding 100 $\mu g/m^3$, particularly during peak traffic hours. Mahapatra et al. (2019) used satellite observations and modeling to pinpoint regions with severe air quality issues. High traffic congestion and commercial activities lead to elevated PM levels in the central locations like New-Road and Sundhara of Kathmandu. Heavy vehicular movement and construction activities contribute significantly to air pollution in Ring-Road areas. Peripheral areas with a concentration of brick kilns, such as Bhaktapur, have high PM emissions due to industrial activities. Air pollution in Kathmandu exhibits pronounced seasonal variations, influenced by meteorological conditions and human activities. Putero et al. (2015) observed that PM levels tend to be higher during the winter months (November to February) compared to the monsoon season (June to September). During winter, temperature inversions trap pollutants close to the ground, leading to higher concentrations of PM2.5 and PM10. Conversely, monsoon rains help in washing out airborne particles, resulting in relatively cleaner air. Maharjan (2021) reported a significant reduction in PM levels during the COVID-19 lockdown, indicating the impact of reduced human activity on air quality. This period saw lower traffic volumes and industrial activities, leading to a noticeable decline in PM concentrations.

Political Influence on Urban Planning in Kathmandu

Urban planning in Kathmandu is significantly shaped by political priorities and economic incentives. In Kathmandu, political decisions often reflect the interests of powerful elites and

political actors who influence urban planning processes. According to Stone and Sanders (1987), urban development is inherently political, with decision-making processes dominated by coalitions of influential stakeholders who prioritize their interests. In Kathmandu, political agendas have led to uneven development and the prioritization of certain areas over others. Poudel et al. (2023) asserts that "haphazard urbanization" in the Kathmandu Valley is a result of fragmented and inconsistent planning policies driven by short-term political goals rather than long-term strategic visions. This ad-hoc approach has exacerbated urban sprawl, increased vulnerability to natural disasters, and strained existing infrastructure. Political instability and frequent changes in government have hindered the implementation of coherent urban planning strategies. The lack of continuity in political leadership has resulted in fragmented policies that fail to address the city's growing urban challenges comprehensively.

In Kathmandu, economic considerations often drive policy choices that prioritize rapid economic growth and development. Muzzini and Aparicio (2013) argue that urban growth in Nepal, including Kathmandu, is closely linked to economic incentives such as investments in infrastructure, real estate development, and industrial expansion. The political economy of road building in Nepal, as analyzed by Rankin et al. (2017), has demonstrated how economic incentives influence policy decisions. Investments in road infrastructure are often motivated by the potential for economic benefits, such as improved connectivity and increased land values. These decisions have also been influenced by political considerations, such as gaining electoral support or favoring certain constituencies. In Kathmandu, economic incentives have led to significant investments in commercial and residential real estate development. These investments are often driven by the potential for high returns, leading to rapid and unplanned urban expansion. The focus on economic gains has resulted in the neglect of environmental and social considerations, contributing to issues such as inadequate infrastructure, pollution, and social inequities.

Impacts of Pollution led by Rapid Urbanization

Rapid urbanization in Kathmandu has brought significant economic and social opportunities but has also introduced substantial environmental and health challenges. Rapid urbanization in Kathmandu has led to severe environmental degradation. According to Rijal et al. (2020), the city's expansion has resulted in the loss of green spaces and increased pressure on

natural resources. The transformation of land use patterns, from agricultural to urban, has also increased soil erosion and reduced groundwater recharge capabilities (Rimal et al., 2020). The haphazard urbanization of Kathmandu has heightened the city's vulnerability to natural disasters. Poudel et al. (2023) discuss how unplanned development has led to increased disaster risk creation, particularly in terms of landslides and floods. The lack of proper infrastructure and regulatory oversight has left many areas poorly equipped to handle natural calamities, posing a significant threat to the urban population. Urban growth has also intensified socioeconomic inequities in Kathmandu. The influx of people into the city has strained public services and infrastructure, leading to inadequate housing and increased informal settlements. This has disproportionately affected the urban poor, increasing social inequalities and limiting access to essential services such as clean water, sanitation, and healthcare (Muzzini & Aparicio, 2013). Air pollution in Kathmandu has been a critical issue, with particulate matter (PM2.5 and PM10) levels frequently exceeding safe limits. Becker et al. (2021) showcased the significant variability in particulate matter concentrations across the city, emphasizing the health risks posed by prolonged exposure. PM2.5, which refers to fine particulate matter with a diameter of less than 2.5 micrometers, is particularly harmful as it can penetrate deep into the lungs and enter the bloodstream, causing severe respiratory and cardiovascular problems (Mahapatra et al., 2019). There is the increasing rate of respiratory complications and diseases to people residing in Kathmandu due to this pollution.

National and Local Government Initiatives to mitigate adversities resulted by Unmanaged Urbanization

The Nepal government has implemented several national policies to address the challenges of rapid urbanization and air pollution in Kathmandu. The National Urban Development Strategy (NUDS) is a comprehensive framework aimed at guiding urban development, emphasizing sustainable urban planning, green infrastructure, and improved public transportation to mitigate pollution (Ministry of Urban Development, 2017). The National Environment Protection Act and the Environment Protection Rules provide the legal basis for controlling pollution and promoting sustainable development, mandating environmental impact assessments (EIA) and setting standards for air quality, waste management, and industrial emissions (Ministry of Forests and Environment, 2019). Additionally, policies to promote clean

energy and reduce dependence on fossil fuels include subsidies for electric vehicles and incentives for renewable energy projects. At the local level, Kathmandu Metropolitan City (KMC) has developed the Kathmandu Valley Air Quality Management Action Plan to reduce pollution sources, enhance air quality monitoring, and engage the community in pollution control efforts (Kathmandu Metropolitan City, 2020). Key initiatives include promoting public transportation, developing non-motorized transport infrastructure, and implementing stricter vehicle emissions regulations. Efforts to improve waste management practices include promoting recycling and composting and establishing efficient waste collection and disposal systems. The government recognizes the need for a collaborative approach involving multiple stakeholders, including international organizations, NGOs, and the private sector, for successful policy implementation. Future policy directions should integrate climate change adaptation and mitigation strategies into urban planning, enhancing the resilience of urban infrastructure, promoting energy-efficient buildings, and increasing urban green spaces (Ministry of Forests and Environment, 2019). Despite various policies, Kathmandu faces significant challenges in managing rapid urbanization and air pollution due to inadequate enforcement of regulations and insufficient infrastructure development. Limited public awareness and engagement further hinder sustainable practices and compliance with environmental standards.

Discussion

The findings of this study revealed the severe impacts of rapid urbanization and air pollution in Kathmandu. Significant levels of particulate matter (PM2.5 and PM10) across the city highlighted a pressing public health issue, with pollution hotspots primarily in traffic-congested and industrial areas (Becker et al., 2021). Seasonal variations, with pollution peaking during winter months due to temperature inversions (Putero et al., 2015), further has worsened these conditions. Interpreting the findings through the lens of political ecology has revealed that the lack of regulatory oversight and the prioritization of economic growth over environmental sustainability have led to these adverse outcomes. Unplanned and rapid urban expansion has resulted in environmental degradation, increased disaster risks, and socio-economic inequalities (Poudel et al., 2023; Rimal et al., 2020). The long-term effects of this unregulated growth are alarming, posing significant health risks to residents, including respiratory and cardiovascular

diseases (Mahapatra et al., 2019), and contributing to climate change and local environmental degradation.

Political and economic factors profoundly influence urban development in Kathmandu. Political priorities often shape urban development, favoring projects that benefit specific interest groups, leading to unbalanced growth (Stone & Sanders, 1987). Economic incentives drive the focus on industrial and commercial development, sometimes at the expense of environmental and public health considerations (Rankin et al., 2017). This dynamic has resulted in inadequate regulatory frameworks and enforcement mechanisms, exacerbating the city's pollution problems. Current environmental regulations in Kathmandu exhibit both strengths and weaknesses. While some policies aim to control pollution and promote sustainable development, their implementation and enforcement are often lacking. Compared to international standards, Kathmandu's environmental policies fall short in several areas, including emission controls, public transportation infrastructure, and urban green space provisions. Strengthening these regulations and aligning them with global best practices could significantly improve air quality and urban sustainability.

Effective urban planning requires the involvement of local communities in decision-making processes. Public participation is crucial in shaping policies that affect residents' lives. Strategies to enhance community engagement include transparent communication, inclusive planning processes, and supporting community-driven initiatives. Case studies of successful community-led projects demonstrate the potential for local solutions to contribute to sustainable urban development. To mitigate air pollution and balance development with environmental sustainability stricter enforcement of existing regulations, introduction of new policies aligned with international standards, and integration of green infrastructure into urban planning are required. Investing in public transportation can significantly reduce pollution levels. Integrating green spaces and improving public transportation systems offer numerous benefits, including improved air quality, enhanced urban biodiversity, and increased recreational opportunities for residents.

Conclusion

This research has revealed the complexity between rapid urbanization, environmental degradation, and socio-political dynamics. Despite government initiatives aimed at controlling

urban sprawl and reducing pollution levels, the city's growth remains largely unregulated, increasing air quality issues and health risks for its residents. The significant results indicate that the city's geographical constraints, coupled with outdated infrastructure and vehicular emissions, contribute heavily to its air pollution. Political priorities often skew urban development towards short-term economic gains, neglecting long-term environmental sustainability. Economic incentives drive policy decisions that favor rapid development, further straining the city's already limited resources and leading to inadequate enforcement of environmental regulations. Current policies, while a step in the right direction, suffer from weaknesses such as poor implementation and lack of alignment with international best practices. In this context, the role of community engagement and local participation cannot be overstated. Successful policy implementation requires the active involvement of local communities, ensuring that development initiatives are both sustainable and inclusive. To mitigate air pollution and promote sustainable urban development, the government should enhance regulations, enforce stricter compliance, and invest in green infrastructure and public transportation. Promoting the integration of green spaces within urban landscapes and improving the public transit system will significantly reduce pollution levels. Public awareness campaigns and community engagement initiatives are crucial for fostering a culture of environmental stewardship. By balancing development with environmental sustainability, Kathmandu can pave the way for a healthier and more livable urban future.

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