URBAN PLANNING STRATEGIES FOR ADDRESSING DUAL CHALLENGES: AIR AND NOISE POLLUTION MITIGATION

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ABSTRACT

Rapid global urbanisation is taking place with every passing second. As of now, the number of people living in cities comprises of more than half of the world's population which in turn contributes to the global GDP in the capacity of more than 80% of its total. From reports it has been inferred that till the time frame of 2050 two-thirds of the population of the world will be residing in areas that are urban. But with pros comes cons and the worst con of it all is the devastating impact that it leaves behind on the environmental landscape in the form of air pollution resulting from industrial activities, transportation and construction as well as noise pollution resulting from road traffic, construction and other urban activities. This widespread degradation of the environment arising out of the various air as well as noise pollutants needs to be curbed to the ground on an immediate basis. The principles that have been globally recognised as a source for the purpose of the betterment of the quality of the environment comprising of the human settlements have been the Rio Earth Summit, Habitat II and Kyoto. Examination of the broad issue of pollution caused as a result of urbanisation which is at its peak and rising at an alarming rate with every passing day needs to be looked upon as it is hampering the existence of the urban population alongside the ever-expanding urban development as a cohesive unit and moreover leading to a curtailing in the creation of a sustainable future. This paper discusses how as to constitute urban planning effectively and implement strategies that will mitigate the rising issue of pollution and in this way work to build a pathway towards sustainable urban development.

Keywords: Urbanisation, Urban Planning, Environment, Pollution, Mitigate, Sustainable

INTRODUCTION

Roughly half of the global population currently resides in urban areas, drawn by the promise of a higher quality of life. Many of these urban centres are experiencing rapid expansion, giving rise to megacities, which are metropolitan areas with populations surpassing 10 million inhabitants. These dense concentrations of people and activities are placing escalating pressure on the natural environment, resulting in significant impacts at the urban level.[1] In the year 2000, approximately 48% of the world's population resided in urban areas, and it is projected that the number of urban dwellers will increase by 2% annually over the next three decades. The global population is expected to rise from 6.1 billion in 2000 to 8.1 billion by 2030, with the vast majority of this growth concentrated in urban areas, expanding from 2.9 billion to 4.9 billion individuals. Urban populations in less developed regions are anticipated to double from 2 billion to 3.9 billion. These concentrations of people and their activities have repercussions at various scales, ranging from urban to global levels.[2] Urbanization stands out as one of the predominant demographic shifts of the 21st century.

One of the most significant challenges facing the contemporary civilized world is pollution, which essentially refers to the contamination of the natural habitat and environment. Air pollution and noise pollution are among the various types of pollution.[3] Presently, air pollution stands as the primary culprit for the deterioration of environmental quality in numerous cities worldwide, resulting in adverse effects on people's health. As per the latest report from the World Health Organization (WHO), over 80% of urban dwellers are exposed to air quality levels surpassing emission limits concerning air pollution. The key atmospheric pollutants include carbon monoxide (CO), particulate matter (PM), nitrogen oxides (NOx), volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), ozone (O3), and sulphur dioxide (SO2). The escalation in emissions of these pollutants can be attributed to the rapid industrialization and urbanization observed in developing nations. The deterioration of air quality in urban settings has garnered significant attention from both the scientific community and public opinion. This is primarily due to the robust correlation between

[1] Mario J. Molina & Luisa T. Molina, Megacities and Atmospheric Pollution, 54(6) Journal of the Air & Waste Management Association, (2004), https://www.tandfonline.com/doi/abs/10.1080/10473289.2004.10470936.
[2] Mario J. Molina & Luisa T. Molina, Megacities and Atmospheric Pollution, 54(6) Journal of the Air & Waste Management Association, (2004), https://www.tandfonline.com/doi/abs/10.1080/10473289.2004.10470936.
[3] Pallavi Yadav & R.S. Yadav, Noise Pollution and its Enacting Laws in India, 1(2) G- Journal of Environmental Science and Technology, (2013), https://gjestenv.com/index.php/gjest/article/view/19.

exposure to air pollution and the heightened risk of adverse short- and long-term effects on human health. Urban air pollution also inflicts environmental damages, such as accelerating the corrosion and deterioration of materials, and harming historical monuments and buildings.[4] In addition to the environmental challenges posed by cities' reliance on fossil fuel-based economies and sprawling urban development patterns that necessitate extensive commuting, there are significant economic repercussions. High levels of fuel consumption contribute to poor air quality and increased noise pollution in public urban spaces, with obvious detrimental effects on human health.[5] Urban areas worldwide, spanning across both developed and developing nations, have witnessed a concerning trend towards automobile dominance, leading to decreased sustainability. This shift is particularly pronounced in developing countries, where cities grapple with a rapid surge in transport-related issues. These challenges include pollution, congestion, accidents, declining public transportation, environmental degradation, climate change, energy depletion, visual disruption, and limited accessibility for the urban poor.[6] Urban areas are experiencing faster growth compared to nonurban areas, and this expansion is often accompanied by increased levels of pollution.[7] The formation of urban street canyons, created by high-rise buildings, limits the dispersion of vehicle emissions, thereby exacerbating roadside air quality and posing significant health risks to the public. Unfortunately, this issue is frequently overlooked in city planning. Elevated air pollutant concentrations within urban street canyons, characterized by close-set buildings, negatively impact public health by exposing pedestrians, drivers, and occupants of naturally ventilated buildings to harmful levels of pollution. In recognition of the detrimental effects of air pollution, the World Health Organization (WHO) has promulgated science-based guidelines for four key air pollutants: particulate matter (PM), nitrogen dioxide (NO2), ozone (O3), and sulphur dioxide (SO2). To ensure adherence to these crucial benchmarks, many cities have established comprehensive air quality monitoring networks. While existing air quality monitoring networks primarily focus on quantifying ambient air pollutants, concentrations of these pollutants are demonstrably

[4] Daniele Sofia, Filomena Gioiella, Nicoletta Lotrecchiano & Aristide Giuliano, Mitigation strategies for reducing air pollution, 27(16) Environmental Science and Pollution Research, (2020), https://link.springer.com/article/10.1007/s11356-020-08647-x.

[5] Inigo Delgado-Enales, Javier Del Ser & Patricia Molina-Costa, A framework to improve urban accessibility and environmental conditions in age-friendly cities using graph modeling and multi-objective optimization, 102 Computers, Environment and Urban Systems, (2023), https://www.sciencedirect.com/science/article/pii/S0198971523000297?via%3Dihub.

[6] Dorina Pojani & Dominic Stead, Sustainable Urban Transport in the Developing World: Beyond Megacities, 7(6) Sustainability, (2015), https://www.mdpi.com/2071-1050/7/6/7784.

[7] Mario J. Molina & Luisa T. Molina, Megacities and Atmospheric Pollution, 54(6) Journal of the Air & Waste Management Association, (2004), https://www.tandfonline.com/doi/abs/10.1080/10473289.2004.10470936.

higher in close proximity to roadways due to the presence of emission sources. This phenomenon, known as the street canyon effect, leads to the trapping of pollutants between buildings, thereby exacerbating health risks for pedestrians, drivers, and occupants of nearby structures. While conventional air quality monitoring networks prioritize the assessment of ambient pollutants, roadside concentrations demonstrably exhibit significant elevations. This phenomenon is directly attributable to the close proximity of vehicular emission sources. The burgeoning urban population not only fuels traffic congestion and associated emissions, but also necessitates the development of medium-to-high-density housing solutions, particularly around transportation hubs and commercial centres. However, the proliferation of high-rise and densely packed buildings creates deep street canyons that impede pollutant dispersion, thereby exacerbating roadside air pollution.[8] Contiguous urban regions, characterized by their spatial proximity, serve as powerful economic magnets due to the concentrated presence of economic activity, diverse services, and abundant opportunities. This phenomenon of urbanization is demonstrably outpacing growth in non-urban areas. However, this expansion is often accompanied by a concerning rise in air pollution levels. Rapid urbanization presents a multifaceted challenge as it introduces a multitude of environmental stressors. These stressors, which encompass noise pollution, air pollution, overcrowding, and a dearth of green spaces, have been demonstrably linked to elevated levels of stress, anxiety, and depression among urban residents. Disrupted sleep patterns, for example, are a known consequence of noise pollution, and chronic sleep deprivation is a risk factor for various mental health disorders. Air pollution, on the other hand, has been associated with cognitive decline and an increased risk of developing psychiatric conditions. The limited availability of green spaces in many urban areas further exacerbates these issues by depriving residents of opportunities for relaxation and stress reduction in nature. Therefore, prioritizing the creation of green, sustainable spaces alongside robust measures to reduce pollution must be central to urban planning and development strategies. These initiatives are crucial for fostering and promoting mental well-being within city populations.[9]

Ensuring the health and wellbeing of both current and future generations stands as a clear and explicit objective of sustainable urban development. Emphasizing smaller and medium-sized

[8] Yuhan Huang, Chengwang Lei, Chun-Ho Liu, Pascal Perez, Hugh Forehead, Shaofei Kong & John L. Zhou, A review of strategies for mitigating roadside air pollution in urban street canyons, 280 Environmental Pollution, (2021), https://www.sciencedirect.com/science/article/abs/pii/S0269749121005534?via%3Dihub.
[9] Li Mei, & Wang Jun, Urban Environment, Green Spaces, and Mental Health: An Interdisciplinary Investigation, 5(1) JHASR, (2023), https://journals.sagescience.org/index.php/JHASR/article/view/85/77.

cities is essential for making significant strides toward more sustainable urban development. Medium-sized cities in the developing world hold significant potential for fostering more sustainable transformations compared to megacities. These cities typically possess a smaller ecological footprint and, in principle, offer greater flexibility for urban expansion, adoption of environmentally friendly transportation modes, and environmental conservation efforts. However, smaller developing cities may face challenges due to limited resources.[10]

Addressing these issues requires the identification and implementation of effective long-term air pollution mitigation strategies. Hence, it is crucial to establish a strategic plan with actionable steps aligned with pertinent directives in the realm of air quality. The implementation of these actions heavily relies on local policy frameworks, economic conditions, available technologies, and public sentiment.[11] Through effective planning, megacities can effectively tackle their air quality issues by implementing measures such as the adoption of advanced emission control technologies and the establishment of comprehensive mass transit systems.[12] To mitigate the harmful effects of air pollution, there is an urgent need for a more rigorous and effective framework of decisions, combined with advancements in technology.[13] To address the complex challenges faced by cities in contemporary times, urban planners are beginning to utilize Decision Support Systems (DSS) supported by artificial intelligence (AI). Urban areas confront numerous hurdles that could impede their social advancement in the future, with overpopulation in urban environments being one such challenge, often at the expense of rural areas. To address these challenges, urban planners and designers are increasingly exploring the potential of artificial intelligence (AI) to aid decision-making processes and formulate urban plans focused on enhancing accessibility.[14]

[10] Dorina Pojani & Dominic Stead, Sustainable Urban Transport in the Developing World: Beyond Megacities, 7(6) Sustainability, (2015), https://www.mdpi.com/2071-1050/7/6/7784.
[11] Daniele Sofia, Filomena Gioiella, Nicoletta Lotrecchiano & Aristide Giuliano, Mitigation strategies for reducing air pollution, 27(16) Environmental Science and Pollution Research, (2020), https://link.springer.com/article/10.1007/s11356-020-08647-x.
[12] Mario J. Molina & Luisa T. Molina, Megacities and Atmospheric Pollution, 54(6) Journal of the Air & Waste Management Association, (2004), https://www.tandfonline.com/doi/abs/10.1080/10473289.2004.10470936.
[13] Sunil Gulia, Nidhi Shukla, Lavanya Padhi, Parthaa Bosu, S.K. Goyal & Rakesh Kumar, Evolution of air pollution management policies and related research in India, 6 Environmental Challenges, (2022), https://www.sciencedirect.com/science/article/pii/S2667010021004054?via%3Dihub.
[14] Inigo Delgado-Enales, Javier Del Ser & Patricia Molina-Costa, A framework to improve urban accessibility and environmental conditions in age-friendly cities using graph modeling and multi-objective optimization, 102 Computers, Environment and Urban Systems, (2023), https://www.sciencedirect.com/science/article/pii/S0198971523000297?via%3Dihub.

I. AIR POLLUTION & THE GHASTLY IMPACT OF URBANISATION

Air Pollution in Urban Areas:

Air pollution emerged as a major concern at the 1972 UN Stockholm Conference, prompting the creation of the United Nations Environment Programme (UNEP). Partnering with the World Health Organization (WHO), UNEP tackled the growing issue of urban air quality. The devastating 1952 London Fog, which tragically claimed over 3,000 lives (Ministry of Health, 1954), served as a stark reminder of the dangers. To combat this threat, UNEP and WHO joined forces in 1974 to launch the Global Environment Monitoring System's urban air pollution monitoring network, GEMS/Air. This global initiative provided air monitoring equipment to developing countries, fostering a network that has collected air quality data from over 50 cities across 35 nations. The 1992 UN Conference on Environment and Development in Rio de Janeiro prioritized atmospheric protection, but the pressing issue of urban air pollution remained largely unaddressed.[15] The past few decades have witnessed a dramatic rise in air pollution as a paramount public health concern within megacities. Initially, primary air pollutants stemmed chiefly from coal combustion, releasing high volumes of sulphur compounds. However, the contemporary air quality challenge centres on photochemical smog. This secondary pollutant is predominantly generated by vehicular emissions, although industrial activities, power generation, and solvent use are also contributory factors. While sulphur dioxide pollution remains a pressing issue in many developing world megacities, photochemical smog presents the most significant threat to global air quality. Furthermore, air pollution fosters the formation of both localized urban haze and regional haze, while also contributing measurably to climate change.[16] Outdoor air pollution constitutes a critical public health challenge on a global scale, contributing to an estimated 8% of worldwide mortality. This pervasive environmental hazard demonstrably exhibits a correlation with a broad spectrum of detrimental health effects, impacting virtually every human organ system.

Changes observed over time in urban characteristics and air pollution typically demonstrate a correlation between economic growth and air pollution, particularly in rapidly urbanizing

[15] David Mage, Guntis Ozolins, Peter Peterson, Anthony Webster, Rudi Orthofer, Veerle Vandeweerd & Michael Gwynne, URBAN AIR POLLUTION IN MEGACITIES OF THE WORLD, 30(5) Atmospheric Environment, (1996), http://alpha.chem.umb.edu/chemistry/ch471/documents/mageetal.pdf.
[16] Mario J. Molina & Luisa T. Molina, Megacities and Atmospheric Pollution, 54(6) Journal of the Air & Waste Management Association, (2004), https://www.tandfonline.com/doi/abs/10.1080/10473289.2004.10470936.

regions. There is a well-established disparity in outdoor air quality, with urban locations experiencing substantially higher levels of pollution than their rural counterparts. As economic growth progresses, barriers to accessing clean, modern energy sources for cooking and lighting diminish, consequently leading to a decrease in household air pollution.[17] However, this progress is often accompanied by a rise in outdoor air pollution. While the detrimental effects of air pollution have held historical significance, only in recent decades has the issue garnered widespread attention among stakeholders. Ongoing observations of its detrimental health impacts highlight critical uncertainties and limitations within existing air quality management policies and control strategies.[18] Urbanization, while serving as a cornerstone of economic growth, poverty reduction, and human development, presents significant challenges in achieving the United Nations' Sustainable Development Goals (SDGs). A major hurdle is urban air pollution, a top global public health risk. According to the World Health Organization (WHO, 2020), over 80% of urban residents with access to air quality monitoring systems breathe air exceeding WHO safety limits.

Urban Air Pollution Sources:

Urban air pollution arises from a multitude of sources, including road transportation, industrial activities, and household emissions. Notably, research consistently demonstrates that vehicle emissions are frequently identified as the predominant contributor.[19] This environmental hazard has demonstrably severe health consequences, with the World Health Organization (WHO) estimating that urban air pollution contributes to approximately 1.3 million deaths annually.[20]

[17] Cathryn Tonne, Linda Adair, Deepti Adlakha, Isabelle Anguelovski, Kristine Belesova, Maximilian Berger, Christa Brelsford, Payam Dadvand, Asya Dimitrova, Billie Giles-Corti, Andreas Heinz, Nasim Mehran, Mark Nieuwenhuijsen, Francois Pelletier, Otavio Ranzani, Marianne Rodenstein, Diego Rybski, Sahar Samavati, David Satterthwaite, Jonas Schondorf & Mazda Adli, Defining pathways to healthy sustainable urban development, 146 Environment International, (2021), https://www.sciencedirect.com/science/article/pii/S0160412020321917?via%3Dihub.

[18] Sunil Gulia, Nidhi Shukla, Lavanya Padhi, Parthaa Bosu, S.K. Goyal & Rakesh Kumar, Evolution of air pollution management policies and related research in India, 6 Environmental Challenges, (2022), https://www.sciencedirect.com/science/article/pii/S2667010021004054?via%3Dihub.

[19] Yuhan Huang, Chengwang Lei, Chun-Ho Liu, Pascal Perez, Hugh Forehead, Shaofei Kong & John L. Zhou, A review of strategies for mitigating roadside air pollution in urban street canyons, 280 Environmental Pollution, (2021), https://www.sciencedirect.com/science/article/abs/pii/S0269749121005534?via%3Dihub.

[20] Jamie Hosking, Pierpaolo Mudu, Carlos Dora, Claudia Adriazola, Benjamin Welle, Salvador Herrera, Alejandra Costa, Rajiv Bhatia, Jurg Grutter, Gail Jennings, Lisa Kane, Todd Litman, Hisashi Ogawa & Cristina Tirado, Health in the green economy: health co-benefits of climate change mitigation – transport sector, World Health Organization, (2011), https://iris.who.int/bitstream/handle/10665/70913/9789241502917_eng.pdf.

Significance of Addressing the issue of Air Pollution:

Air pollution presents a significant public health threat, manifesting in a range of respiratory illnesses, lung cancer, and the worsening of pre-existing conditions like asthma and allergies. Notably, urbanization exacerbates these health challenges within densely populated areas.[21] Furthermore, SO2 and NOx, while serving as the primary precursors of acid rain, also contribute to the degradation of forest, lake, and river ecosystems. Additionally, these pollutants have been implicated in the damage sustained by buildings and statues within urban environments.[22] The escalating levels of air pollutant emissions and ambient concentrations within megacities pose a multifaceted environmental challenge. These pollutants exert a demonstrably detrimental influence on public health, visibility, and regional ecosystems. Evaluations of these cascading effects encompass: human health impacts, visibility reduction, repercussions on regional ecosystems (including acidification, nitrogen deposition, photo-oxidant damage, and diminished photosynthetically active radiation), alterations to regional climate patterns, and the long-distance transport of pollutants.[23] Urban environments are well-documented to exhibit significantly elevated concentrations of air pollutants, primarily attributable to industrial activities, transportation emissions, and construction dust. Prolonged exposure to these pollutants, particularly fine particulate matter (PM2.5) and nitrogen dioxide (NO2), has been demonstrably associated with an increased risk of various mental health disorders, including depression and anxiety. Epidemiological studies consistently reveal a correlation between residence in areas with poor air quality and a heightened vulnerability to developing mental health conditions. Consequently, mitigating air pollution within urban centres is an essential public health strategy for safeguarding mental well-being. A multitude of research studies have established a strong link between inhaling air pollutants and a greater likelihood of developing depression. These compelling findings highlight the critical need for stricter environmental regulations in urban centres. Such regulations are essential to lessen the

[21] Mughair Aslam Bhatti, Zhiyao Song, Uzair Aslam Bhatti & Syam M.S, AIoT-driven multi-source sensor emission monitoring and forecasting using multi-source sensor integration with reduced noise series decomposition, 13(1) Journal of Cloud Computing, (2024), https://journalofcloudcomputing.springeropen.com/articles/10.1186/s13677-024-00598-9.

[22] Yuhan Huang, Chengwang Lei, Chun-Ho Liu, Pascal Perez, Hugh Forehead, Shaofei Kong & John L. Zhou, A review of strategies for mitigating roadside air pollution in urban street canyons, 280 Environmental Pollution, (2021), https://www.sciencedirect.com/science/article/abs/pii/S0269749121005534?via%3Dihub.

[23] Mario J. Molina & Luisa T. Molina, Megacities and Atmospheric Pollution, 54(6) Journal of the Air & Waste Management Association, (2004), https://www.tandfonline.com/doi/abs/10.1080/10473289.2004.10470936.

detrimental impact of air pollution on the urban ecosystem.[24]

II. NOISE POLLUTION & THE DAUNTING CONSEQUENCE OF URBANISATION

Noise Pollution in Urban Areas:

Noise pollution encompasses unwanted or disruptive sounds that interfere with our daily lives. These sounds often originate from urban development, with major contributors including road traffic, airplanes, and railways.[25] In Indian cities, the average noise levels throughout the day routinely surpass 80 decibels, a level exceeding the recommended limits and significantly impacting human hearing perception. To safeguard public health in the European Region, the World Health Organization (WHO) has established new noise exposure guidelines. These guidelines recommend limiting average noise levels from transportation sources to 53 decibels (dB) for road traffic, 54 dB for railways, and 45 dB for aircraft.[26]

Urban Noise Pollution Sources:

Major Noise Sources

1. Road Traffic - Traffic on roads is a leading and pervasive source of noise pollution in urban environments, and it continues to be a growing problem. Notably, a significant rise in motor vehicle ownership over the past three decades has demonstrably led to a corresponding increase in overall road traffic noise levels.

2. Air Traffic - Residents of the greater metropolitan area have expressed significant concern about aircraft noise. The United States Code, specifically Title 49 on Transportation (Subtitle VII: Aviation Programs, Chapter 447: Safety Regulation, Section 44715: Controlling Aircraft Noise and Sonic Boom), empowers the Federal Aviation Administration (FAA) Administrator to establish regulations as needed. These

[24] Li Mei, & Wang Jun, Urban Environment, Green Spaces, and Mental Health: An Interdisciplinary Investigation, 5(1) JHASR, (2023), https://journals.sagescience.org/index.php/JHASR/article/view/85/77.
[25] Brind Kumar, Sharad V Oberoi & Akash Goenka, A Brief Review of the Legislative Aspects of Noise Pollution, Proceedings of Workshop on Environmental Pollution: Perspectives and Practices, (2004), http://home.uchicago.edu/~mstaisch/Sharad/papers/Legislative%20Aspects%20of%20Noise%20Pollution.pdf.
[26] Dorina Pojani & Dominic Stead, Sustainable Urban Transport in the Developing World: Beyond Megacities, 7(6) Sustainability, (2015), https://www.mdpi.com/2071-1050/7/6/7784.

regulations aim to protect public health and well-being from the harmful effects of aircraft noise and sonic booms.

3. Rail Traffic - Train operations and maintenance/construction activities are the two primary sources of noise and vibration within the railway network. While electric train hubs experience less noise, areas with frequent freight trains or specific operational needs (night operations, stopping patterns) can face localized noise issues. Although generally impacting a smaller population compared to road or air traffic due to being concentrated near tracks, rail noise can still be substantial. Despite advancements in quieter locomotives, the problem persists due to trends towards longer, more frequent, and faster trains, coupled with urban densification.[27]

Road traffic is the dominant source of noise pollution in most urban centres. The volume and speed of traffic directly correlate with noise levels. Additionally, factors like one's proximity to the noise source significantly influence how much noise people are actually exposed to.[28]

Significance of Addressing the issue of Noise Pollution:

Beyond the immediate irritation it causes, noise pollution can lead to a range of health problems. In the short term, it can induce temporary hearing loss. Over the long term, exposure to noise pollution has been linked to chronic conditions such as depression, anxiety, and sleep disturbances. These chronic conditions, if left unaddressed, can further escalate to more serious health risks in the medium to long term, including permanent hearing loss and cardiovascular diseases. In addition to the health risks mentioned above, residents in noisy urban areas may also experience social and behavioural changes. Considering this scenario, urban planners face the critical challenge of creating more liveable cities, especially for these demographics who are disproportionately impacted by both noise pollution and its associated social consequences.[29] Children in high aircraft noise areas may experience learning difficulties,

[27] Brind Kumar, Sharad V Oberoi & Akash Goenka, A Brief Review of the Legislative Aspects of Noise Pollution, Proceedings of Workshop on Environmental Pollution: Perspectives and Practices, (2004), http://home.uchicago.edu/~mstaisch/Sharad/papers/Legislative%20Aspects%20of%20Noise%20Pollution.pdf.
[28] Jamie Hosking, Pierpaolo Mudu, Carlos Dora, Claudia Adriazola, Benjamin Welle, Salvador Herrera, Alejandra Costa, Rajiv Bhatia, Jurg Grutter, Gail Jennings, Lisa Kane, Todd Litman, Hisashi Ogawa & Cristina Tirado, Health in the green economy: health co-benefits of climate change mitigation – transport sector, World Health Organization, (2011), https://iris.who.int/bitstream/handle/10665/70913/9789241502917_eng.pdf.
[29] Dorina Pojani & Dominic Stead, Sustainable Urban Transport in the Developing World: Beyond Megacities, 7(6) Sustainability, (2015), https://www.mdpi.com/2071-1050/7/6/7784.

including delayed reading skills, poorer attention spans, and increased stress. Similarly, high levels of road traffic noise have been linked to decreased performance in reading and math. A prominent consequence of urban noise pollution is the surge in stress residents experience. The constant barrage of sounds, from car horns to machinery, overwhelms the nervous system. This triggers the body's stress response, flooding it with hormones like cortisol. Chronically elevated stress levels can have a significant detrimental impact on mental well-being. Curbing traffic volume offers a multitude of advantages. It not only mitigates noise pollution and greenhouse gas emissions, but also fosters public health improvements. Furthermore, traffic calming measures, such as reduced speed limits and diverting traffic away from residential areas, can promote active transportation options within neighbourhoods. This shift towards walking and cycling can indirectly contribute to further noise reduction.[30] Urban noise pollution is a hidden threat to mental well-being. The relentless barrage of sounds from traffic, construction, and everyday activities can trigger chronic stress, disrupt sleep patterns, and exacerbate anxiety. Addressing this issue requires creative solutions to quieten our cities and create more peaceful environments for residents. By creating quieter environments through the implementation of noise reduction measures and thoughtful urban planning strategies, cities can significantly improve the mental well-being of their residents.[31]

III. AIR AND NOISE POLLUTION - LANDSCAPE OF THE LAWS AND REGULATIONS

Conventions/Treaties Governing Air & Noise Pollution:

The United Nations has played a key role in promoting environmental protection. The 1972 UN Conference on Human Environment in Stockholm marked a significant turning point. Following this conference, the United Nations Environment Programme (UNEP) was established to implement environmental policies within the UN framework.

Furthermore, the Charter of Economic Rights and Duties of States emphasizes the shared responsibility of member nations for protecting the environment. Article 30 specifically states

[30] Jamie Hosking, Pierpaolo Mudu, Carlos Dora, Claudia Adriazola, Benjamin Welle, Salvador Herrera, Alejandra Costa, Rajiv Bhatia, Jurg Grutter, Gail Jennings, Lisa Kane, Todd Litman, Hisashi Ogawa & Cristina Tirado, Health in the green economy: health co-benefits of climate change mitigation – transport sector, World Health Organization, (2011), https://iris.who.int/bitstream/handle/10665/70913/9789241502917_eng.pdf.
[31] Li Mei, & Wang Jun, Urban Environment, Green Spaces, and Mental Health: An Interdisciplinary Investigation, 5(1) JHASR, (2023), https://journals.sagescience.org/index.php/JHASR/article/view/85/77.

that all countries have a duty to preserve and improve the environment for both current and future generations. This article also encourages each nation to develop environmental and development policies that reflect this responsibility.

1. **Agenda 21,1992** - Agenda 21 is a blueprint for sustainable development adopted by over 178 governments at the 1992 UN Conference on Environment and Development (UNCED) in Rio de Janeiro. It outlines a comprehensive plan for tackling environmental challenges through global, national, and local collaboration.

2. **Geneva Convention on Long-Range Transboundary Air Pollution,1979** - The Convention on Long-Range Transboundary Air Pollution (CLRTAP) is an international agreement that aims to protect human health and the environment from air pollution as well as reduce and prevent air pollution, including long-range air pollution that travels across borders.

3. **Kyoto Protocol to the United Nations Convention on Climate Change,1997** - The Kyoto Protocol is built upon the goals set by the United Nations Framework Convention on Climate Change (UNFCCC). Specifically, it aimed to achieve stricter emission reductions for greenhouse gases. The ultimate goal of the Kyoto Protocol was to stabilize the concentration of these gases in the atmosphere at a level that would prevent significant disruptions to the climate system.

4. **Montreal Protocol on Substances that Deplete the Ozone Layer,1987** - This treaty is an international agreement designed to protect the Earth's ozone layer. It achieves this by gradually eliminating the production of various substances believed to be responsible for depleting the ozone layer.

5. **Stockholm Convention on Persistent Organic Pollutants,2001** - This international treaty, targets the elimination or severe restriction of POPs. These chemicals pose a significant threat due to their persistence in the environment, ability to accumulate in living organisms, and harmful impacts on human health and ecosystems.

6. **United Nations Conference on the Human Environment,1972** - This conference, held in Stockholm, Sweden, marked a significant turning point. It was the first major UN conference to address international environmental issues, placing environmental

concerns on the global agenda.[32] The Stockholm Declaration wasn't just a statement of intent. It played a crucial role in introducing new concepts and principles into international environmental law. Previously, these principles were primarily used in national legislation. The Declaration's influence led to the establishment of three key legal principles that now form the foundation of environmental discussions and legal frameworks. Among the legal principles introduced by the Stockholm Declaration, the precautionary principle is arguably the most prominent, and potentially the most controversial. The Stockholm Declaration established another key principle: additionality. Principle 12 recognizes the need for additional international support, including technical and financial resources, for developing countries. This principle emphasizes the importance of developed nations helping developing countries address environmental challenges. The Stockholm Declaration also incorporated a well-established national principle – the polluter-pays principle (PPP). This principle, enshrined in Principle 22, states that those who generate pollution are responsible for bearing the costs of managing it. The purpose of PPP is to prevent environmental damage and safeguard human health by incentivizing polluters to adopt cleaner practices.[33]

7. **U.N. Conference on Environment and Development (Rio Declaration), 1992** - The 1992 UN Conference on Environment and Development (UNCED), held in Rio de Janeiro, produced a landmark document: the Rio Declaration. This declaration outlines 27 principles designed to guide countries towards achieving sustainable development on a global scale.[34] Sustainable development seeks to meet current needs without compromising the ability of future generations to meet their own needs. The Rio Declaration, adopted in 1992, marked a significant step forward for the precautionary principle. Principle 15 notably provided the first definition of this principle within an international agreement. Following this milestone, the precautionary principle has been increasingly incorporated into various legal frameworks. This includes its inclusion in multilateral and regional agreements, as well as national laws around the world. The

[32] ST. Thomas University Law Library, https://law-stu.libguides.com/c.php?g=900143&p=6476317, (last visited Nov. 3, 2024).
[33] Pamela Chasek, The Legacies of the Stockholm Conference, International Institute for Sustainable Development, (2022), https://www.iisd.org/system/files/2022-05/still-one-earth-conference-legacy.pdf.
[34] ST. Thomas University Law Library, https://law-stu.libguides.com/c.php?g=900143&p=6476317, (last visited Nov. 3, 2024).

concept of additionality, introduced in the Stockholm Declaration, was further elaborated upon in the Rio Declaration. Principle 7 acknowledges the concept of "common but differentiated responsibilities." This principle recognizes that developed and developing countries have different levels of responsibility for addressing global environmental issues. The Rio Declaration, adopted in 1992, solidified the polluter-pays principle (PPP) as a cornerstone of international environmental policy. Principle 16 explicitly incorporates PPP, making it a widely recognized principle. Furthermore, PPP is now enshrined in numerous international agreements, both legally binding and non-binding.[35]

Legal Landscape in India Tackling Air Pollution:

India has grappled with air pollution for nearly a century, but the situation has become especially critical in recent decades. This can be largely attributed to rapid, unplanned urbanization. India's massive population (second-highest globally) further exacerbates the problem. Many Indian cities rank among the world's most polluted. According to the WHO, India was among the most polluted countries between 2008 and 2013. By 2019, air pollution had become the fourth leading cause of death worldwide, surpassing other chronic health issues. A 2019 study estimated that air pollution contributes to 17.8% of all deaths in India, potentially hindering the country's economic growth ambitions. The increasing severity and prevalence of air pollution events over the past two decades have made it a top concern for Indian regulatory bodies.[36]

Various laws and regulations have been implemented in India to address air pollution, dating back to pre-independence times. The first legislation targeting air pollution was introduced in Bengal and later in Bombay, aimed at mitigating smoke nuisances from furnaces and fireplaces in urban areas. Subsequent laws, such as the Motor Vehicles Act of 1939 and the Factory Act of 1947, included provisions to regulate vehicular and industrial pollution, respectively. Following international calls for environmental action, India established the Central Pollution Control Board (CPCB) in 1974 to monitor and prevent

[35] Pamela Chasek, The Legacies of the Stockholm Conference, International Institute for Sustainable Development, (2022), https://www.iisd.org/system/files/2022-05/still-one-earth-conference-legacy.pdf.
[36] Sunil Gulia, Nidhi Shukla, Lavanya Padhi, Parthaa Bosu, S.K. Goyal & Rakesh Kumar, Evolution of air pollution management policies and related research in India, 6 Environmental Challenges, (2022), https://www.sciencedirect.com/science/article/pii/S2667010021004054?via%3Dihub.

water pollution, later expanding its mandate to include air pollution control under the Air (Prevention and Control of Air Pollution) Act of 1981. This act was amended in 1987 to empower pollution control boards to address severe air pollution emergencies. Additionally, the Environment (Protection) Act of 1986 served as a comprehensive framework for environmental protection, with subsequent legislation creating bodies such as the National Environment Tribunal and the National Environment Appellate Authority. The establishment of the National Green Tribunal in 2010 further reinforced environmental protection efforts. Various rules and notifications, such as the Environmental Impact Assessment Notification of 1994 and the National Clean Air Programme of 2019, have been issued to effectively manage air quality and promote sustainable economic growth. In recent developments, the Commission for Air Quality Management has replaced the Environmental Pollution Control Authority in the National Capital Region and adjoining areas.[37]

In the T. Damodar vs. State of Andhra Pradesh case, Justice P.A. Choudhary of the Andhra Pradesh High Court emphasized the importance of a healthy environment for a fulfilling life. He argued that Article 21 of the Indian Constitution, guaranteeing the right to life and liberty, encompasses the protection of nature. Without a healthy environment, Justice Choudhary reasoned, true enjoyment of life is not possible.

In India, there is currently no specific law exclusively addressing the issue of noise pollution, unlike many developed countries around the world which have enacted legislation to control noise pollution. For instance, in England, the Noise Abatement Act of 1960 contains provisions such as prohibiting the operation of loudspeakers between certain hours and for certain purposes, with exceptions for essential services like the police and fire brigade. Similarly, in the United States, the Noise Pollution and Abatement Act of 1970 regulates and addresses noise control and abatement. Additionally, specific legislation on noise control exists in various jurisdictions within the United States, such as the Noise Control Code of 1972 at the federal level, as well as local regulations like the New York Noise Control Code of 1972 and the Chicago Noise Control Regulations of 1971. In Great Britain, noise pollution falls under the Control of Pollution Act of 1974, while Japan has

[37] Sunil Gulia, Nidhi Shukla, Lavanya Padhi, Parthaa Bosu, S.K. Goyal & Rakesh Kumar, Evolution of air pollution management policies and related research in India, 6 Environmental Challenges, (2022), https://www.sciencedirect.com/science/article/pii/S2667010021004054?via%3Dihub.

the Noise Control Laws of 1968 to address the issue of noise pollution. In recent years, India has witnessed a new problem of noise pollution stemming from the indiscriminate use of loudspeakers. This issue arises particularly from their widespread use in religious places and during religious ceremonies and discourses, often infringing upon people's basic freedoms and human dignity. While India does have enactments for environmental protection, the government has yet to fully grasp the severity of the noise pollution problem. However, noise pollution has been included within the scope of the Air Pollution Act and the Environment Protection Act, allowing the central government to establish rules for its control. In line with this, the government has notified Ambient Air Quality Standards for noise. Additionally, the Central Pollution Control Board has approved Noise Standards for various noise sources, although these have not yet been formally notified by the government. While these measures may aid in controlling noise pollution to some extent, there is an urgent need for specific and stringent legislation to effectively address the rapid growth of noise pollution in the country and ensure a noise-free environment for its citizens. For instance, the Bihar Control of the Use and Play of Loudspeakers Act of 1955 imposes restrictions on the use and play of loudspeakers near hospitals, telephone exchanges, educational institutions, and hostels, with provisions for enforcement through complaints or police reports.

Legal Framework for Noise Pollution Control in India:

The existing legal provisions for controlling noise in India include Section 268 and Section 290 of the Indian Penal Code.

Section 268 of the Indian Penal Code states that a person is guilty of public nuisance if they perform any act or illegal omission that causes injury, danger, or annoyance to the public or to individuals residing or occupying property nearby, or which is likely to cause obstruction, danger, or annoyance to persons using any public right.

Rule 21 of the Bihar and Orissa Motor Vehicles Rules, 1930 stipulates that the driver of a motor vehicle must refrain from honking the horn for any purpose other than ensuring safety in traffic, and continuous honking is prohibited. Additionally, it prohibits the use of cut-out exhaust whistles, sirens, klaxons, electric horns, and similar appliances in areas within a district as notified by the District Magistrate.

Rule 5.5 of the Delhi Motor Vehicles Rules, 1940 prohibits motor vehicles from being fitted with multitoned horns that produce a succession of different tones or any other sound-producing device that emits an unduly harsh, shrill, loud, or alarming noise.

Rule 5.6 mandates that every motor vehicle must be equipped with a silencer that reduces exhaust noise to a reasonable and practicable extent.

Rule 5.9 states that every motor vehicle must be constructed and maintained in a manner that prevents undue noise when in motion.

Similar provisions to the Delhi Motor Vehicles Rules, 1940 have been incorporated into the Punjab Motor Vehicles Rules, 1940.

This passage outlines the legal framework in India for addressing noise pollution. Here's a breakdown of the key points:

Constitution of India-

- Right to Life (Article 21): Guarantees the right to life with dignity, including living peacefully and comfortably in one's home, free from noise pollution.
- Right to Information: Citizens have the right to know about noise pollution regulations and permits issued by the government.
- Directive Principles of State Policy: The state has a duty to create a pollution-free environment.
- Fundamental Duties: Every citizen has a responsibility to protect the environment.

Criminal Procedure Code (CrPC)-

- Section 133: Empowers magistrates to issue orders for removing or reducing noise pollution as a public nuisance.

Indian Penal Code (IPC)-

- Chapter IV (Sections 268-295): Defines and penalizes public nuisance, including noise

pollution, with fines.

Law of Torts-

- Allows individuals to file civil lawsuits for damages caused by noise pollution as a nuisance.

Other Relevant Laws-

- Factories Act: While lacking specific noise control provisions, it recognizes noise-induced hearing loss as an occupational disease.
- Motor Vehicle Act: Regulates the use of horns and engine modifications.
- The Noise Pollution (Regulation and Control) Rules, 2000: Sets noise standards for different areas, restricts loudspeaker use in specific zones and times, and mandates noise abatement measures.

Overall, India has a comprehensive legal framework for addressing noise pollution, encompassing the constitution, criminal and civil law, and specific noise pollution regulations. However, there are areas for improvement, particularly regarding noise from railways and airplanes. The Railways Act and the Aircrafts Act lack specific noise pollution control measures.[38]

IV. STRATEGIC IMPLEMENTATIONS IN MITIGATING AIR & NOISE POLLUTION

Formulating Strategies to Achieve Urban Planning Effectively:

Humans, or "Homo sapiens," have had an undeniable impact on the planet. Technological, industrial, and scientific advancements are an inherent part of human progress. However, simply wishing to preserve the world in its pristine state is unrealistic. The key takeaway is the need to find a balance. We must strive to guide and direct development in a way that fosters a

[38] Mario J. Molina & Luisa T. Molina, Megacities and Atmospheric Pollution, 54(6) Journal of the Air & Waste Management Association, (2004), https://www.tandfonline.com/doi/abs/10.1080/10473289.2004.10470936.

more harmonious relationship between humans and the natural environment.

Effectively mitigating air pollution requires a comprehensive strategy targeting various sources of human-generated emissions. Some of these strategies are:

Public and active transport-

The passage advocates for a shift towards public and active transportation options like buses, trams, subways, trains, walking, and cycling. It emphasizes the significant benefits this can bring to both human health and the environment.

Aeration-

Implementing air exchange systems with particle filters, along with proper ventilation and air-conditioning systems, represents an effective approach to reducing air pollution in indoor spaces.

Household sector-

Efforts to reduce energy consumption by households and buildings are crucial due to their significant contribution to greenhouse gas emissions. One effective strategy is to enhance the combustion efficiency of solid household fuels. Each individual must adopt behavioural actions to minimize energy consumption and emissions associated with home heating.

Shipping sector-

Shipping-related activities exert a significant influence on air pollution, particularly in coastal regions but also on a global scale. To address this issue, a range of technical strategies for reducing ship emissions must be implemented.

Industrial Sector-

Among the diverse industrial sectors, the chemical industry stands out as a primary source of key pollutants such as volatile organic compounds (VOCs), toxins, and polycyclic aromatic hydrocarbons (PAHs). One effective mitigation strategy to curb air pollution originating from the industrial sector involves the adoption of advanced technologies within industrial processes.

New regulations-

While enabling legislation is crucial, enforcement is equally essential. If mitigating air pollution is not a priority for a megacity, it is likely to exacerbate the issue. Many developing countries possess comprehensive regulations on pollution; however, these regulations are often ineffective due to inadequate institutions, legal systems, political will, and competent governance. Air quality management policies need to establish updated air quality standards that optimize overall population benefits, mitigate illnesses associated with air pollution, and minimize gas emissions resulting from urban activities.

Promotion of hybrid vehicles-

It is widely acknowledged that vehicle emissions, including nitrogen oxides (NOx), hydrocarbons (HC), ozone (O3), volatile organic compounds (VOC), carbon monoxide (CO), and particulate matter (PM), significantly contribute to air pollution. In this context, alongside the implementation of increasingly stringent standards for vehicle emissions, the most effective policy is the promotion of zero-emission vehicles. Specifically, by utilizing alternative fuels such as electricity, biofuels, liquefied petroleum gas (LPG), compressed natural gas (CNG), liquefied natural gas (LNG), and methane, these vehicles can emit lower concentrations of pollutants.[39]

Interdisciplinary Research-

Addressing the urgent environmental challenges faced by megacities requires the collaboration of leading experts from national and international domains, including science, engineering, economics, and social and political sciences. Through collaborative research efforts, comprehensive evaluations of the complex environmental issues can be conducted, leading to the development of practical solutions.

Clean Vehicle and Fuel Technology-

In developing countries, the adoption of clean vehicle technologies is increasing due to the global application of vehicle emissions controls and the improvement of gasoline fuel

[39] Daniele Sofia, Filomena Gioiella, Nicoletta Lotrecchiano & Aristide Giuliano, Mitigation strategies for reducing air pollution, 27(16) Environmental Science and Pollution Research, (2020), https://link.springer.com/article/10.1007/s11356-020-08647-x.

quality by removing lead. The advancement of the next generation of emissions control technology for new gasoline vehicles will rely on reducing sulphur to extremely low levels. However, progress in reducing emissions from diesel trucks, motorcycles, and two-stroke engines has been slower. Challenges such as fuel contamination and limited financial resources make addressing pollution from these vehicles more challenging.[40]

Various immediate mitigation measures can be implemented to effectively control noise pollution. These remedies can be categorized as follows:

Legislative Remedies-

Law serves as a tool for social transformation, and the legislature holds the authority in the process of lawmaking. Thus, legislative action stands as the most effective approach to governmental and judicial measures against noise pollution.

Many developed countries like the USA, UK, Japan, etc., have already enacted comprehensive laws addressing noise pollution long ago. In contrast, in India, there is a lack of specific and detailed legislation to regulate noise pollution. It is urgently necessary for the Central Government to enact comprehensive legislation addressing various forms of noise pollution and their control. Moreover, safeguarding the natural environment is a constitutional obligation of the state, essential for fostering conditions in society conducive to the full development of an individual's personality.

International Co-operation-

International cooperation can play a significant role in addressing the issue of noise pollution. While national efforts are essential, they can be complemented and reinforced by international measures and collaboration. Such cooperation is particularly beneficial for developing countries that may lack access to the latest technologies and financial resources for conducting their own research programs. International cooperation can contribute to noise pollution control in the following ways:

a) Facilitating the exchange of technology that includes quieter equipment and machinery.

[40] Mario J. Molina & Luisa T. Molina, Megacities and Atmospheric Pollution, 54(6) Journal of the Air & Waste Management Association, (2004), https://www.tandfonline.com/doi/abs/10.1080/10473289.2004.10470936.

b) Promoting collaboration on research programs aimed at exploring various methods of noise control.

c) Sharing legal frameworks and other strategies employed to address noise pollution.

d) Allowing countries to learn from the successes and failures of others in managing noise pollution effectively.

By fostering international cooperation, countries can leverage collective expertise and resources to develop more comprehensive and effective approaches to mitigate noise pollution on a global scale.[41]

Integration of Technology in Enhancing Urban Planning Strategies:

The past few decades have witnessed the exponential rise of Artificial Intelligence (AI) as a fundamental component of our lives. As a dominant technological force, AI has fuelled advancements across a multitude of application domains, fostering significant economic growth and societal progress. While AI-powered solutions have achieved demonstrable maturity within production processes, their integration into urban planning and management remains comparatively nascent. In urban design decision-making, cost effectiveness is a critical factor due to the typically limited municipal public budgets. When considering modifications or additions to urban elements such as mechanical ramps, escalators, or lifts, decisions are often based on estimates of the expected improvements in accessibility. However, several practical challenges complicate this decision-making process.[42] The integration of multi-sensor AIoT (Artificial Intelligence of Things) technologies for air quality measurement and forecasting is rapidly emerging as a critical component of sustainable and smart environmental design, urban development strategies, and pollution control initiatives. The integration of AIoT (Artificial Intelligence of Things) technology in air pollution prediction enables decision-makers to anticipate changes in air quality, particularly related to carbon emissions, with greater accuracy. AIoT technologies allow for more advanced and comprehensive monitoring of air quality by

[41] Brind Kumar, Sharad V Oberoi & Akash Goenka, A Brief Review of the Legislative Aspects of Noise Pollution, Proceedings of Workshop on Environmental Pollution: Perspectives and Practices, (2004), http://home.uchicago.edu/~mstaisch/Sharad/papers/Legislative%20Aspects%20of%20Noise%20Pollution.pdf.
[42] Inigo Delgado-Enales, Javier Del Ser & Patricia Molina-Costa, A framework to improve urban accessibility and environmental conditions in age-friendly cities using graph modeling and multi-objective optimization, 102 Computers, Environment and Urban Systems, (2023), https://www.sciencedirect.com/science/article/pii/S0198971523000297?via%3Dihub.

integrating automated monitoring stations with sophisticated data analytics. This integration enables real-time tracking of pollutant emissions, providing detailed insights into their origins and dispersion patterns.[43]

V. CONCLUSION

Various stakeholders, including citizens, businesses, and organizations, can implement measures to achieve public health benefits alongside efforts to reduce air pollution. The above suggested strategies if incorporated in the form of guidelines, can serve as a foundation for governments to develop a strategic plan aimed at reducing emissions from multiple pollutants and mitigating overall air pollution-related risks.[44] Urban pollution, particularly air pollution stemming from vehicular emissions and industrial activities, poses a significant threat to mental well-being in urban environments. Exposure to polluted air, containing particulate matter and harmful gases, has been linked to increased risks of mental health disorders like depression and anxiety. Prolonged exposure to air pollution can trigger systemic inflammation, oxidative stress, and neuroinflammation, all of which contribute to mental health issues. Therefore, implementing strict emissions controls and green initiatives is crucial for safeguarding mental health in urban populations. Additionally, noise pollution exacerbates urban living challenges, causing chronic stress, sleep disturbances, and cognitive impairments. Mitigation strategies such as urban planning to minimize noise sources and the use of noise barriers should be prioritized to address this issue and promote mental well-being in cities.[45]

[43] Mughair Aslam Bhatti, Zhiyao Song, Uzair Aslam Bhatti & Syam M.S, AIoT-driven multi-source sensor emission monitoring and forecasting using multi-source sensor integration with reduced noise series decomposition, 13(1) Journal of Cloud Computing, (2024), https://journalofcloudcomputing.springeropen.com/articles/10.1186/s13677-024-00598-9.

[44] Daniele Sofia, Filomena Gioiella, Nicoletta Lotrecchiano & Aristide Giuliano, Mitigation strategies for reducing air pollution, 27(16) Environmental Science and Pollution Research, (2020), https://link.springer.com/article/10.1007/s11356-020-08647-x.

[45] Li Mei, & Wang Jun, Urban Environment, Green Spaces, and Mental Health: An Interdisciplinary Investigation, 5(1) JHASR, (2023), https://journals.sagescience.org/index.php/JHASR/article/view/85/77.