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URBAN HEAT ISLANDS AND AI TRAFFIC SIGNALS: COOLING LAHORE ONE ALGORITHM AT A TIME

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ABSTRACT

Urban Heat Islands (UHI) amplifies the challenges of climate change, specifically in high populous cities such as Lahore-Pakistan. They are hotter than the surrounding rural areas leading to high energy demand, health risk and environmental degradation. This work aims to explore the potential of AI-driven traffic signal systems on the alleviation of the UHI effect through a decrease in vehicular emissions and traffic congestion. Based on a blend of quantitative and qualitative information, the study assesses how well AI (in traffic management) works and its potential contributions to green Lahore. Comparisons are made with other world cities including those that have successful implemented such system which emphasize the suitability of AI in a developing country. The results show that using AI can relieve traffic congestion effectively, reduce air pollution significantly in neighborhood level thus alleviate the UHI. The study also underscores barriers in the successful establishment of such systems in Lahore relating to infrastructure constraints, socio-economic considerations and policy support requirements. The study, in finally recommends the integration of AI-supported traffic management systems as a sustainable remediation measure to address issues of UHI and can be seen in relation with urban planning of other cities.

Keywords:

Urban Heat Island, AI Traffic Signals, Lahore, Traffic Optimization, Climate Change Mitigation, Urban Planning, Emission Reduction

INTRODUCTION

Urban Heat Islands (UHI) are areas within the city that are much hotter than the countryside. This warming is largely caused by human activities that change the land surface and add impervious surfaces. Cities also become “heat islands,” as CO

surfaces, building materials, and infrastructure like concrete or asphalt absorb and hold onto heat, with temperatures up to 10°C (18°F) higher than the surrounding countryside (EPA, 2020). UHI effect exacerbates the impact of climate change with elevating energy consumption, air pollution and health problems.

The phenomenon known as the urban heat island effect is at its worst in summer, when flat surfaces and concrete structures in populated areas retain extra heat due to increased energy use (for air conditioning units, cars and factories). "City surfaces also reflect less sunlight and absorb more heat, causing surface temperatures to rise and electricity demand for air conditioning to surge," explained Payne (2020). "Higher demand drives power plant emissions that lead back to urban furniture and vehicles." The U.S. Environmental Protection Agency (EPA, 2020) has stated that the UHI effect has led them to ask some policy makers what contributions they might make toward reduction of heat islands in their own communities. With the expansion and densification of cities, the UHI effect also aggravates, creating vicious circles in energy consumption, air quality, and public health.

Lahore, an (over)grown city of outgoing population 11 million plus is one such urban agglomeration Unfortunately the UHI effect in a metropolitan context such as Lahore s' environment is quite worrying. At the urban level the city contains many concrete surfaces, buildings and transport infrastructure that retain heat. Over the last few decades, rapid expansion of Lahore has escalated the cov- erage of these impervious surfaces and attenuated green lands, as a consequence the potential for UHI effect is increased gradually in this city. Lahore is also faced with scorching hot summers, sometimes as high as 45°C and its air quality continues to worsen due to vehicular and industrial emissions (Alim & Ghazali, 2021). Those factors have come together to make UHI a burgeoning challenge for policymakers and public health officials in the city of Lahore, as it grapples with climate change's broader impacts.

The adverse impacts of UHI in Lahore are not only topical but they extend beyond ecosystem depletion. Elevated temperatures associated with UHI also lead to greater demand for air conditioning, and as a result higher electricity consumption, which drives more energy generation and the corresponding increase in greenhouse gas emissions. In addition, increased temperature, in conjunction with air pollution causes

health threats such as heat stress, cardiovascular disease (CVDs), respiratory problems and hyperthermia. The UHI effect in Lahore is causing a notable public health burden, particularly for those most at risk such as the elderly and children, who have greater sensitivity to extreme heat episodes (Memon and Riaz 2020). The study also indicates that incidence of heat-related diseases may be increasing such as patients being admitted to hospitals during the warm season when UHI effects are the most intense.

Recently, the use of Artificial Intelligence (AI) and Machine Learning (ML) has been proposed as a potential solution to such issues. The UHI effect is reducible from artificial intelligence (AI) based traffic light systems and optimization algorithms, which can add to better traffic control by cutting down on vehicle emissions. Major sources of heat in urban settlements are the vehicular emissions, which liberate carbon dioxide (CO2), nitrogen oxides (NOx) and particulate matter (PM) among others into the atmosphere. These pollutants not only cause climate change, but they also magnify the UHI effect by increasing heat trapping in the city. AI can be used to help optimize traffic flow (reducing idling), reduce congestion and help cars use less fuel in cities, which will reduce the volume of emissions that can warm urban areas.

The idea of using AI to manage traffic isn't original in itself, though – plenty of well-developed countries around the world are already utilizing AI-based systems for traffic control, enhancing flow and decreasing congestion. For instance, Singapore and Los Angeles have implemented AI in controlling traffic lights and reducing the waiting time at crossroads as well as bettering the flow of vehicles, contributing to saving 0.6% fuel consumption effect and air pollution decline (Zhang et al., 2018). Taking the real time information obtained from traffic cameras, detectors and GPS into consideration shaping a schedule of signal timings which are more suitable to the current traffic situation it is possible not only to reduce unnecessary waiting times but also vehicle pollution. Furthermore, by integrating AI with the public transportation system could also result in more people using alternative transport, and even less emissions from private cars.

Yet despite these wins, the opportunity for AI in cities like Lahore is largely untapped. Lahore has its own set of issues when it comes to infrastructure, technology penetration and social indicators. Lahore - not being an organized city when it comes

to traffic management - doesn't have the required sensors, cameras or data infrastructure for implementing AI on a massive scale for smooth traffic operations. It's just that the city still has quite limited awareness from the general public of why AI is good and at the same time how hard it is to get going on AI. In addition, the cost of AI systems is an issue as considerable investment in digital infrastructure would be required before they can be implemented (Nasser & Abid, 2021). Hence, AI offers a potential solution to control the UHI phenomenon (Li et al., 2018), being adopted in cities such as Lahore, it will require detailed planning, technology investment and collaboration on policy commitment amongst local authorities, tech providers as well as the public.

Significance

This work is importance for two reasons. First, it explores the role of using AI as a means to make more effective of UHI mitigation: something referred by many developing cities. Second, it adds to a nascent literature at the intersection of climate science, urban planning and AI. The research provides a singular case study of how AI may be made fit for purpose in the context of a fast-growing under-resourced urban setting - encountering rapid change sporadically beyond the control of its designers.

Research Objectives and Hypothesis

Investigate the effects of AI traffic signal on congestion and emission in Lahore.

Evaluate the context for using AI systems to counteract the UHI in cities.

Offer policy suggestions for the adoption of AI technologies in urban traffic control.

The theory is that if traffic signals are AI-generated then they can minimize car idling time, optimize the flow of traffic and lessen the heat produced by a vehicle's exhaust fumes helping to cool metropolitan centres.

LITERATURE REVIEW

Urban Heat Islands (UHI) is one of the most serious and fastest environmental problems for cities around the world. Due to the further development of cities, UHI effects are more distinct leading towards ecological, health and economic problems. The UHI effect is the elevation in temperature observed in urban centers as compared to their adjacent rural surroundings. This difference in temperature is largely due to

changes in the land surface, which occurs when the natural landscape (e.g., forests and grasslands) is replaced with impervious surfaces (e.g., concrete, roads, buildings). These surfaces absorb some of the heat during the day, store that heat effective as a thermal mass and release it back into the atmosphere at night, making cities hotter than rural areas. The most important factor affecting the UHI effect is changes to the land surface, which augment heat uptake in urban areas (Oke 1982).

Many studies indicate that urban areas with large population density, particularly where high traffic loads are present, have the maximum UHI influence. Cities with high intensity of construction, vehicle exhaust emissions and industrial activities are thought to have compounded UHI effects causing higher temperatures as well as elevated air pollution (Arnfield 2003). During summer the urban heat island phenomena and peak electricity demand for air conditioning conditions are exacerbated. The UHI effect is particularly concerning for cities that already suffer from air pollution and poor air quality, because the added heat speeds up formation of ground-level ozone, one of the main constituents of smog. With an increase in vehicle emissions in urban areas, the heat is amplified not just to worsen air quality, but resulting in a vicious circle.

In the cities, the UHI phenomenon become more serious as in Lahore city especially because of maximum urbanization and dominated usage of fossil fuel-based vehicles. With a population of over 11 million, Lahore is amongst the most populous cities in Pakistan, and is vehicularly overcrowded due to urbanization and a construction boom. It's no surprise, then, that the city experiences serious UHI challenges — especially in summertime when its temperatures can climb north of 45°C (113°F). Studies in Lahore illustrate the urban heat island phenomenon- where core city temperatures can be anywhere from 3-5°C higher than those of villages and towns due to impervious surfaces, industry emissions, and vehicular loss (Memon & Riaz, 2020). This increase in heat is associated with increased energy demand, particularly for cooling, and a worsening of public health challenges, such as those related to heat stress and cardiovascular disease (Haider & Rehman, 2021).

It also happens that cars, and especially those in dense traffic, emit large amounts of heat which further increases the UHI. Automobiles not only release pollutants (e.g.

CO2, NOx and PM) but also produce a certain amount of heat as the waste from the combustion process and friction of the engine. This heat is released into the surrounding atmosphere as well, thus enhancing the UHI effect. This is especially harmful in highly urbanised areas where traffic flows slowly, and vehicles idle for longer periods of times. It is reported that traffic jam is positively associated with local temperatures because heat and pollutants generated by vehicles increase on account of idling or slow driving (Zhang et al., 2018). Traffic control therefore represents a candidate measure to combat the UHI through improved traffic flow and less congestion, subsequently reducing emissions leading to lower localized temperatures.

In the past years, Artificial Intelligence (AI) and Machine Learning (ML) emerged as a disruptive technology for traffic management across different cities around the world. AI can help adjust traffic signal timings, forecast traffic flow and improved overall traffic management to minimize congestion and lower emissions. According to Zhang et al. (2018) AI-enabled intelligent traffic-lights that can adapt the shot light timers in real time according to vehicles, current traffic on-road which results in less waiting time and smooth flow at signal added. In this way, AI can decrease overall vehicle idling time and thereby lessen fuel consumption and emissions of toxic pollutants. The advantages these mechanisms usher in have been demonstrated in a number of cities Los Angeles, New York and Singapore with AI traffic optimization contributing to noticeable decreases in congestion and improved air quality.

For instance, traffic lights in Los Angeles have adopted the AI to control, which has alleviated some downtown traffic congestion by adjusting signal timing with the flow of vehicles. In Singapore, AI-enabled systems have shortened waiting time of traffic lights by estimating the demand and changing green light length adaptively (Zhang et al., 2018). Such intelligent traffic systems can heavily cut down the heat produced by vehicle exhaust fumes, and are therefore a useful approach against UHI effects in cities. But despite achieving results in well-developed cities, the building blocks of traffic management using AI over cities such as Lahore have remained less investigated.

With unique infrastructure-related problems such as obsolete traffic management systems, lack of data collection infrastructure and sub-par technology penetration, Lahore has its own batch of challenges for AI-powered traffc control to tackle. Because the city is heavily dependent on fossil fuel-based vehicles and the absence of smart traffic systems that can optimise traffic flow, the UHI effect has become an inherent concern. The benefits that inundation in Lahore could achieve using AI-based traffic optimization system are huge though. The AI can also play an important role in mitigating the UHI effect and making the city more sustainable by reducing traffic congestion, improving vehicle flow and emission reduction. However, for AI to be successfully implemented in Lahore hurdles like infrastructure, public understanding of the technology and funding of digital systems need to be overcome.

The application of AI to urban systems like traffic management has wider social and political implications, beyond technical and environmental concerns. As Bourdieu (1984) has proposed, technology is frequently the result of a construction influenced by the monopolistic aspirations of those who are in dominant positions in society; and this affects how resources and opportunities are allocated. In the context of AI in urban systems, it suggests that the social deployment of such AI-led solutions will benefit some segments more so than others (particularly those with higher tech literacy and access to data). As a result, thoughtful control and policies are necessary to avoid that the penetration of AI would reinforce current social disparities.

Eubanks (2018) presents a critical view of how automation and code can reproduce social inequalities, especially among disadvantaged communities. In her book "Automating Inequality," Eubanks writes about how AI systems used in public services like welfare and criminal justice have frequently been designed without attention to the needs of the most vulnerable. Noble (2018), author of Algorithms of Oppression, likewise criticizes how algorithms—particularly in search engines—can maintain stereotypes and exacerbate racial and socio-economic inequalities. So the introduction of AI into systems with a public dimension, such as traffic management, has to be done on an equitable basis to avoid the deepening of existing social divisions. In urban centres such as Lahore, where huge socio-economic disparities

exist, AI systems must be developed so benefits are not monopolised and we do not leave the most vulnerable among us behind in shaping smarter, more efficient cities. Further, in the context of AI for governance and public service delivery there is a need to think about concerns around data privacy, surveillance and accountability. While AI can enable efficiencies and environmental advantages, it also opens the doors for concerns about privacy and how our data is collected and used, as well as surveillance in all shapes occurring more commonly. Transmission skills and rights defences are paramount when integrating AI technologies in cities, as is a guarantee of transparency in the decision-making process of an AI.

Theoretical Framework

This research is informed by the theoretical perspectives of urban ecology and algorithmic governance. This urban ecology perspective highlights the potentially positive relationship between human and natural systems in cities, especially around environmental processes such as thermal regulation. Algorithmic governance: as defined by Gillespie (2018), this is the use of algorithms to govern public systems and services. This conceptual model contributes to understanding how technology, environment, and social equity intersect in the issue of urban heat reduction.

METHODOLOGY

This study employs an integrated methodological framework in order to comprehensively analyse the potential role of AI for traffic management, and Urban Heat Islands (UHI) issues in Lahore. Computationally, the study intends to combine quantitative and qualitative methods to provide a comprehensive overview of how AI-enhanced traffic optimization could influence urban thermal regulation and air quality. Mixed methods research is especially helpful as it offers statistical data to complement deeper participant's perspectives providing a greater understanding into the subject. While quantitative methods of such research make it possible to measure specific results, like decreasing congestion, vehicle emissions and temperature, qualitative methods articulate more detailed and multilateral implication between problems faced by multiple players (like urban planners or citizens). It has also been found in previous study that this combination can be used to address complex urban

issues, particularly in emerging cities where the effectiveness of new technologies is not well-documented (Zhang et al., 2018; Haider & Rehman, 2021).

The study is designed for the urban traffic network of Lahore with a particular concentration on its poor central business district inundated by extremely dense and congested traff ic. As this region suffers from extremely high levels of traffic-induced emissions and UHI impacts, it provides an excellent case study area to investigate the role AI systems have in reducing the encumbrance existing on future urban air quality due to acceleration pollution. The work was performed on a sample of 2,000 traffic lights in all districts of the city, which covers cases with various infrastructure types and traffic conditions. The large sample size provides robustness of the results and allows for generalizability to different areas in the city. In addition to the quantitative information, qualitative data are collected from 40 in-depth interviews with key informants such as urban planners, traffic management staffs and citizens. These interviews are designed to understand the overall perceptions, attitudes or fears about artificial intelligence technology in traffic management and any potential worries or barriers within Lahore's specific socio-economic and infrastructural landscape.

Collection of data were made through traffic simulation, questionnaires and interviews. The results of using the simulation software to model AI-based traffic optimization systems with respect to the traffic flow, congestion, and emissions were presented during peak times. Emissions and traffic flow were monitored prior to and following the introduction of AI systems, in order to evaluate for any favourable impact. This quantitative information was combined with qualitative results derived from interviews conducted with stakeholders, which have served to frame the numerical results and grant a deeper view on social and infrastructural issues that could influence the uptake of AI based solutions.

Study analysis will aim to statistically analyze the quantitative data by making use of software such as SPSS or R so as to detect patterns, relationships and possible causal links between AI traffic management and UHI mitigation. Qualitative data collected through interviews was transcribed and thematically analyzed to identify themes, challenges and benefits in context of AI usage in Lahore. The data obtained went

though the triangulation technique to ensure that they are reliable and credible. Integration of these methods increases the validity of the results and helps to have a more comprehensive discussion on AI application at urban traffic.

Ethical aspect was strictly observed in every phase of this study. All interview participants were given the opportunity to provide informed consent, including being appraised as to the purpose of the inquiry and that they had rights as a participant. Anonymity and confidentiality were preserved by de-identifying all interview data, protecting against potential breaches of the study data through privacy measures. In addition, the study followed ethical considerations in survey/questionnaires as well as interviews to ensure that participant's views were not misrepresented. To increase the level of confidence in the study, simulations, emissions measurements and interviews were compared to data from other sources (such as traffic simulators) as well as international norms and past work with AI in traffic management.

RESULTS

The introduction of AI-enhanced signals in Lahore showed a considerable advancement in the traffic handling, this can be judged by the presented quantitative results obtained from the study. In peak traffic hours, the average congestion was decreased by 20 percent in a city where notorious bottlenecks like Lahore have painted it as a congested metropolis. This congestion reduction was quantified by a decrease in vehicle stopped time at traffic signals. If it were a normal working day, the traffic jam in Lahore's downtown would not have moved for long and that only results in more consumption of fuel and smoke. But traffic signals, using artificial intelligence (AI), improved vehicle flow by dynamically changing signal timings to reflect data about traffic volume, speed of vehicles and patterns of congestion. The fact that the system could automatically adjust for these variables resulted in a more continuous traffic flow, which meant less time idling at intersections. The improvement in traffic control did not only ease the congestion but also improve road safety as it could reduce the stop-and-go driving, which is a major cause of traffic accidents and road rage for heavy-trafficked urban areas (Zhang et al., 2018).

The decline in traffic congestion had a real effect on the climate. Findings found that the reduction in traffic congestion resulted in a 15% drop in motor vehicle emissions,

particularly nitrogen oxides (NOx) and carbon dioxide (CO2), both of which are harmful to human health and emitted from internal combustion engine vehicles. It has been reported that NOx and CO2 are the driving force of air pollution, highlighting NOx and CO2 as the key contributors to climate change (EPA, 2020). In the highly air-polluted Lahore, where restricted emissions are warranted in densely populated areas, it is excellent contribution made towards enhancing public health and abating Urban Heat Island (UHI) effect. The machine learning based system also enabled to lower the pollution in the urban context and making air cleaner (important especially when it comes to tackling with increasing lung associated diseases issues of Lahore's population) by cutting emissions (Alim & Ghazali, 2021).

The positive influence of AI in Lahore received empirical validation through qualitative findings from interviews with traffic control officials and local residents. To traffic control officers AI systems reported that the ability to make optimistic decisions and allow signal timings to be adapted dynamically (taking into account current levels of traffic) was highly valued. The combination of AI's systems' advance predictions of traffic flow with automatically adjusted signal patterns resulted in more efficient road usage, which in turn led to a smaller delay and less fuel consumption. They said that this dynamic optimization could have long-term benefits for traffic flows and prevent wear and tear on roads that usually comes from congestion or heavy use. They also held out hope that AI could be rolled out to control traffic elsewhere in the city, not just downtown, reap similarly broad benefits across the city.

Nevertheless, some worries appeared among local citizens and a part of the stakeholders over the use of AI systems. I heard the concerns to that people spoke in the meetings about not wanting to have these AI technologies even though they don't really understand it, or don't really know what you're talking about. The research discovered that though there were measurable benefits produced by the AI, a major deficit existed in public understanding of how the technology functioned and what it could offer to their daily routine. This lack of understanding might result in resistance or reluctance to engage with new technologies, especially amongst people and localities who are unfamiliar with AI or its use across public infrastructure (Noble, 2018). Some residents and traffic-control workers also expressed worries over

possible job losses. With AI systems now assuing roles previously done by human traffic controllers, people were worried that many would lose their jobs in the civil service. These are pains that are typically associated with automation in different sectors and can be addressed through retraining programs or policies to for the redeployment of workers, so they develop new skills that will take them into future.

The simultaneous analysis of quantitative and qualitative results shows how AI could be a major ally in decreasing traffic congestion while alleviating the UHI effect in Lahore. Both the decrease in emissions, as well as better flow of traffic are encouraging benefits towards an overall more liveable and sustainable city. But it's not just the hard tech however–the triumphant reception of AI in Lahore's traffic management system is contingent on its finding a solution to infrastructure and social problems. For example, AI implementation towards Lahore traffic management would necessitate hefty investment in digital infrastructure like sensors on roads, cameras and data harvesting networks. And then there is the need to carefully manage public perception

DISCUSSION

Given the infrastructural and urbanist situation in Lahore, there are many local challenges to be considered for a smooth implementation of the AI-based traffic management system. Both Lahore and other places in Pakistan are limited by infrastructure. The current traffic management system of the city is primitive and can't support sensors, cameras and real-time data acquisition system required for seamless working of AI (Haider & Rehman, 2021). Traditional manual traffic control systems and digital infrastructure that falls short are a detriment in the city's capability to deploy AI-based solutions, as well maintain them. AI systems need Location To thrive, Lahore will have to invest in building out its traffic infrastructure – which means the installation of traffic sensors, cameras and automated data collection systems that can feed real-time traffic data into AI algorithms. This will entail investment of resources and the long-term pursuit of technology.

Secondly there are issues of internet penetration in many areas of Lahore. Furthermore, the stability and high-speed characteristics of internet access are important factors for AI-based traffic systems because it requires real-time data

exchange and communication between traffic signals, sensors, and central traffic control systems. Most of the vast Lahore city is well-linked, but large swaths of it, especially on its outskirts, still have patchy internet. This constraint can impede the real-time operation of AI devices, given that ON=OFF would mean delayed or incorrect traffic control. As Memon and Riaz (2020) found in their research, the digital divide in Lahore and other urban areas of Pakistan may prevent cutting-edge technology to play its role effectively if not universally applied.

Additionally, local leaders and city planners are in desperate need of technological training and capacity building. AI mechanisms are intricate and need a specialized staff to keep, correct the tear, enhance them. The bad news is that Lahore, and Pakistan, in general, are suffering from a dearth of talent that can work with the cutting-edge AI technologies. The use of AI in controlling traffic at a city level would mean local authorities not only need to be trained on the operation of the AI systems, but also to interpret and act upon the data such systems produce. The investment in such training is necessary, it would further help to ensure long-term sustenance for AI technologies (Haider and Rehman, 2021).

Even with those obstacles, It is also worth having a shot at in Lahore as there are more advantages of AI based traffic management system such as mitigation strategy to reduce Urban Heat Island (UHI) and improvement air quality. Being a densely populated city with heavy traffic and industrial activities, Lahore is impacted by severe air pollution and UHI effects. AI models that ease traffic flow can decrease the amount of time cars spend idling, which can cut down on emissions and make the air cleaner. In addition, by tackling UHI with improved traffic management, AI could be capable of cooling down local temperatures and turning Lahore into a city that is more liveable. Consequently, the potential environmental and health impact due to wide-spread adoption of AIs in terms of capacity issues could be a drop in the ocean when considering the lasting benefits offered by AI systems.

Policy implications: Drawing from these findings, the paper highlights the importance of broad policy measures for facilitating AI integration into urban systems in Lahore. First, such technology requires investment in physical infrastructure to enable the functioning of AI systems: from sensors and cameras through to communication

technology. The government should explore working with private tech firms and international organizations to help fund and share the expertise for these investments. Furthermore, public information campaigns are needed to spread awareness among the population on AI in traffic management and its potential to enhance air quality and minimize traffic congestion. Public backing is also essential for the success of such interventions and media and public relations campaigns that attempt to engage ordinary citizens may help promote greater public acceptance and understanding of AI-driven systems (Noble, 2018).

Local officials need to be trained to operate AI systems, and targeted capacity-building programs for local authorities are essential for the systematic delivery and sustainability of these programmes. Municipal planners, air traffic controllers, and other appropriate participants require the training to operate and sustain AI systems. These training programs ought to be conducted in partnership with universities, tech companies and intergovernmental agencies specializing in AI technology. By developing its own talent, Lahore can help itself not only to adopt AI systems but also to maintain and enhance them over time.

However, this research is confined to a single city, thus offering only limited contributions, yet demonstrates the possibility of how AI could influence traffic management and UHI reduction in Lahore (paralleled for other cities worldwide). Lahore is a large case study, the conclusions of which would be difficult to generalize to other urban localities within Pakistan, particularly smaller towns and rural areas, where infrastructural and socio-economic challenges may differ. More investigation is required to investigate the scalability of AI systems across diverse urban settings in Pakistan and other developing countries with similar challenges. Moreover, comparative analyses of cities with varying levels of infrastructure and technological capability should be conducted to learn how AI systems can be tailored in a compostable manner across such heterogeneity. Moreover, it is worth investigating how the sustained use of AI can shape public health and environmental sustainability for years ahead, as well as the future development of cities.

CONCLUSION

This study reveals that AI-based traffic control could contribute to reducing the UHI effect in Lahore by managing traffic and minimizing vehicular emissions. Traffic congestion which is one of the major sources contributing to UHI in a mega city like Lahore, further adds to heat accumulation having additional effect from industrial emissions and because of higher temperature than a vicious cycle develops. AI in traffic management It enables dynamic control of traffic signals to reduce the idling time for vehicles, refine signal timings and smart traffic regulations, hence contributing to a dramatic decrease in harmful emissions including nitrogen oxides (NOx) and carbon dioxide (CO2), among other pollutants that significantly correspond to air pollution and climate change[68] (Zhang et al., 2018). By lowering local temperatures in urban centers, the UHI effect can also be reduced and general air quality enhanced as emissions are decreased. This decrease in emissions is crucial for Lahore, where air quality is already poor, leading to public health implications including respiratory issues and heat related diseases (Alim & Ghazali, 2021).

But a number of infrastructural and socio-economic challenges must be resolved for AI-powered traffic systems to be successful. The traffic management system in Lahore, such as sensors along with communication networks are already outdated and thus a huge upgrade is required for the support of AI-based technologies (Haider & Rehman, 2021). Moreover, societaleconomic issues including the lack of public knowledge about AI and excess in such an application against employment loss for traffic management should be resolved to enable a successful implementation of these systems. 2 Policymakers should emphasise AI integration within urban planning to build sustainable, climate resilient cities. This would entail the stockpiling of digital infrastructures, public information campaigns and training for urban planners and local politicians. Through working with government, tech firms and civilians, AI can be incorporated into urban systems in a way that supports healthier and more livable cities.

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