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AI for Making Smarter Cities

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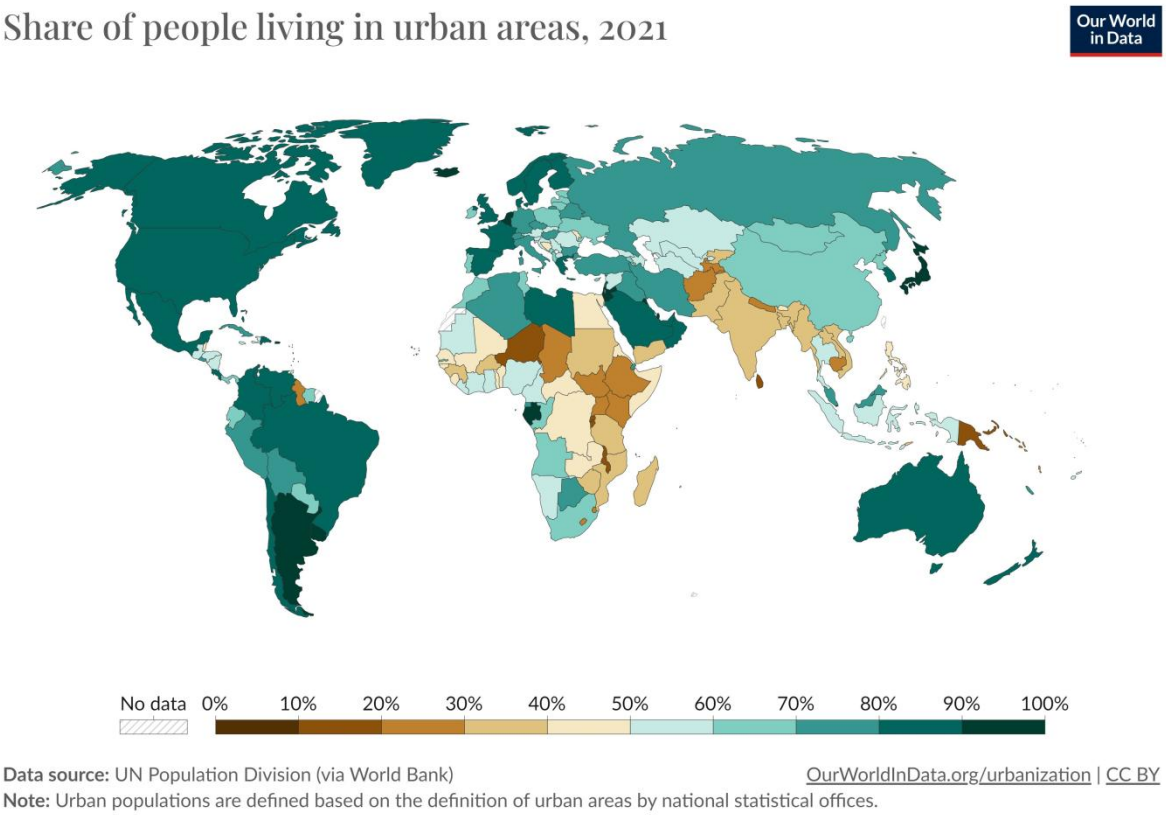
Abstract: ***With the planet grappling with unprecedented climate and environmental challenges, there is another area of concern that can no longer be ignored- that of increasing urbanisation. It is estimated that two out of every three people in the world will live in cities by 2050, putting tremendous pressure on the existing infra structure across the world, more so in developing and underdeveloped economies who do not have the resources to accommodate this surge in demand. Smart cities that use technology to make urban areas more efficient in the use of scarce resources like energy and water and make them more sustainable is widely acknowledged as the only feasible solution going forward. This paper examines how AI can make cities smarter and what are the benefits in making this investment.***

Keywords: urbanisation, sustainability, smart cities, AI, climate change, environment, water and energy

1. Introduction

Growing urbanisation across the world is a reality that cannot be ignored. Studies have revealed that as two out of every three people in the world will live in cities by 2050**[1]**. This will put undue pressure on the existing urban infra structure already failing to stay sustainable in the face of climate change and environmental challenges. The world map below illustrates how urbanisation is becoming a worldwide trend. It is important to note that although countries like India look a lot lesser urbanised in the figure below, their population is so high that even with this percentage of urbanisation, the urban stress would be far beyond what is experienced in countries which are fully urbanised. A case in point is the example of three India is also home to three of the world's 21 megacities: Mumbai, Delhi, and Kolkata, with a population of 19, 15, and 14 million people respectively, which collectively is more than the total population of Australia! With an increasing number of people moving to urban areas as rural jobs and agriculture become less rewarding, there is an increasing pressure put on the infra structure which is not geared for this influx. Increasing influx of lower income residents has also led to the mushrooming of slums. According to the World Bank, slums now account for one-quarter of all urban housing and more than 35% of the urban population lives in these neighbourhoods in India **[2].**



Already it is widely conceded that Cities are responsible for higher levels of energy consumption and held responsible for 70% of global GHG emissions**[3]**, making them both responsible and vulnerable to the adverse impacts of climate change. Moreover, Cities worldwide generate over 720 billion tons of waste annually **[4].** Most of this end up in

landfills or waste dumps leading to soil and ground water pollution and production of greenhouse gases posing a huge environmental threat.

Acknowledging this vital link between growing urbanisation and climate change, it was included in the UNSDG goals. Goal 11 of The Sustainable Development Goals (SDGs) calls on member states to "make cities and human settlements inclusive, safe, resilient and sustainable." A specific target of this Goal is to, "by 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries" **[5].**Moreover, according to the UN High-Level Panel for the post-2015 Agenda (henceforth, HLP), by 2030, there will be over one billion more urban residents in the world and, for the first time, the number of rural residents will start to shrink (HLP 2013), making the task even tougher.

It was in this context that smart cities emerged as the solution. What makes a city smart? "A smart city is a place where traditional networks and services are made more efficient with the use of digital solutions for the benefit of its inhabitants and business**."[6].** Smart cities leverage data and digital technology for more efficient use of natural and scarce resource to ensure fewer emissions. They have intelligent smarter urban transport networks for efficient fuel and energy use, upgraded water supply and recycling facilities to ensure minimal water wastage and proper waste disposal facilities to avoid polluting the environment and have and more efficient ways lighting and heating systems using renewable energy. It doesn't here, it helps build an administrative framework which is more responsive and ensures public safety and has arrangements for the physically challenged and the ageing population.

The focus of this paper is to analyse how AI lies at the core of these smart cities and can help bring in the urgent improvements that we need.

2. How AI can help create smart cities

Artificial intelligence can play a huge role in helping sustainable efficient smart cities in the following ways:

2.1 Increasing efficiency and optimising energy consumption:

Smart cities are expected to be sustainable and hence increasingly deploy renewable energy for consumption by its residents. Since renewable energy systems are dependent on natural sources their intermittency does become a stumbling block. This intermittency can be navigated with more accurate forecasting and planning.

Operational uncertainties in conventional electricity grids arise due to variations on the demand side. Since mots existing infra structure have grids using fossil fuel energy systems, integration of renewable energy transmission can also become a challenge unless its supply is smooth and planned in advance. Solar energy is "characterized by randomness, indirectness, and volatility that poses operational challenges for PV integration into the grid" [7]. This load demand and supply/generation mismatch leads to frequent fluctuations in the system and could cause breakdowns in the entire system leading to partial or total loss of electrical supply. [8] Use of AI can help build a reliable and comprehensive framework for effective power system control and management [9]. Machine learning (ML) and deep learning models provide accurate demand and supply forecasting timely feedback, enabling e efficient two-way communication between the grid and customers and significantly enhancing the security, reliability, and efficiency of the system [10]]. This makes people more comfortable with renewable resources and more conscious of their consumption patterns which in a larger context have a direct bearing on the optimization of energy. Since most renewable energy systems have high installation costs attached to them, error in choosing the site for installation may prove to be very expensive in the long run. A slight error in the optimal angle of installation can reduce the efficiency of the panel. AI helps understand the right balance of Solar irradiance, Latitude, elevation, weather conditions, temperature fluctuations through the day, cloud cover, pollution levels, shading and land availability to ensure minimal error in installations and increase productivity and ensure operational efficiency [11]. Similarly for wind energy factors like Wind speed and direction, air pressure, humidity and weather conditions, land criteria, Elevation and terrain must be assessed concurrently to make accurate predictions of efficiency and productivity for which data inferences are the key. AI weather models provide accurate details of cloud cover, humidity and wind patterns historical datasets, real-time information from local weather stations, satellite imagery, cameras, and sensor networks to ensure optimisation at all levels. Predictive analytics are also very important for maintenance and to ensure timely corrective action and repairs. Operational and maintenance costs effect economies of scale and inputs that can help make even the slightest difference can be beneficial [12].

2.2 For effective and optimal utilisation of water resources

Increasing urbanization and high population density puts a lot of pressure on available water resources. Making water management both challenging and crucial at the same time. Conventional systems of water management, designed for a specific estimate of people are now struggling to cater to the rising demand [13]. The UN World Water Development Report 2023 has already given out a stern warning on the imminent risk of a global water crisis. It warns that between two and three billion people worldwide experience water shortages already. These shortages will worsen in the coming decades, especially in cities, if international cooperation in this area is not boosted [14]. The risk could be exasperated by changing precipitation patterns, unprecedented rise in temperature and increase in the frequency of droughts and flooding making dependable water cycles extinct. Since increasing urbanization also eats into groundwater reserves which are now depleting at an alarming rate, there is an urgent need to develop management strategies that can respond dynamically to the patterns of climate change and lead to optimization of resources [15].

Increasing urbanization also has led to further soil erosion, deforestation, and poor urban planning also has eaten into the crucial wetlands. These ecosystems also play a vital role in maintaining the natural cycle of water and g stability in the natural ecosystem. Furthermore, water pollution is caused by industrial discharges, agricultural effluent, inadequate wastewater treatment, etc. [16].

Artificial Intelligence (AI) and Big Data Analytics (BDA) provide real-time data of consumption and supply patterns, efficient data analysis leading to scientific data-driven decision-making in water management [17]. These technologies have the potential to transform and support the development of sustainable and effective water management practices [18]. AI tools help in accurate real-time monitoring and analysis of water resources, which can support data-driven decision-making and optimization of water allocation and demand forecasting [19]. These algorithms not only predict supply and demand accurately to ensure proper allocation but are also useful for predicting water quality and can help in timely intervention or restructuring the allocation patterns.

Available of data also helps in better dissemination of real time analysis which can be used to not only manage the water resources more effectually but can also help in better integration between various stake holders in the decision making process of water resource management – this inclusivity brings better informed consumers /local communities, industries, environmental organizations, and government agencies together helping them be accountable stakeholders in the management of their water resource making them responsible for its efficient use. If they don't come together to help manage the resources, it results in suboptimal solutions and heightened stakeholders' tensions [20].

Use of remote sensing technologies, such as satellites and drones, has made collection of real time data on water availability, weather, and ecosystem health. This data can be analyzed and turned to actionable insights for more targeted and timely intervention to ensure uninterrupted supplies and efficiency in management of this resource, thereby facilitating a proactive management.

2.3 More effective pollution management

Smart cities can leverage AI tool to monitor the pollution levels and take timely remedial measures. AI tools can also help detect and forecast CO2 which can help administrations take timely steps in reorganising their transport management if needed in the interest of public health.

UNEP's World Environment Situation Room (WESR), launched in 2022, curates, aggregates and visualizes the best available earth observation and sensor data to inform near real-time analysis and future predictions on multiple factors, including CO2 atmospheric concentration, changes in glacier mass and sea level rise. "Over time, the goal is for WESR to become like a mission control centre for planet earth, where all of our vital environmental indicators can be seamlessly monitored to drive actions." [21] AI has shown brilliant results for precise and quick method for identifying pollution hotspot areas [22] which can be decluttered through transport diversion.

2.4 More effective traffic management

Increased traffic in urban areas is the principal cause of air pollution. They are the main emitters of Greenhouse gases which contribute to global climate change. Even in developed economies like the US, tailpipe emissions from cars, trucks and buses account for over one-fifth of the United States' total global warming pollution; transportation, which includes airplanes, trains, and ships accounts for around thirty percent of all heat-trapping gas emissions [23].

Cars, trucks, and buses produce air pollution throughout their life cycle. Vehicles particularly the diesel ones are the principal source of Particulate matter (PM) which comes from vehicle exhaust. These fine particles — less than one-tenth the diameter of a human hair have grave health consequences and can cause severe respiratory issues. They also release Volatile Organic Compounds (VOCs) and Nitrogen Oxides. These two react in the presence of sunlight to form ground level ozone, a main ingredient in smog. Carbon monoxide (CO) that comes from fuel combustion is known to block or impede oxygen flow in the body. Sulphur dioxide (SO2) also pose huge health issues. Poses the largest health risk to young children and asthmatics.

AI tool provide real time data of all the pollutants and their exact concentration hotspots helping in more effective traffic management as administration can use restrictions or redirect traffic to further exacerbate the problem [24]. AI can also help in Route optimization which helps navigate traffic choking points and can be of great help to logistics companies supplying to the urban area in question. Effective transport management can also take the form of ensuring better service of public transport in high density population areas to ensure that there are lesser individually driven vehicles on the road adding to the traffic chaos and pollution.

Finally, AI can play an important role to prevent urban road accidents to warn people around hazardous locations. With the advancements in AI tools and consequent information and communication technologies has made shared mobility possible at a large scale. With the advent of app-based platforms there is better coordination among vehicles on busy routes and pairing to share rides which helps create a more efficient transport system.

An example in point is that of China which brought in an advanced, personalized and flexible demand responsive public transport service called customized bus (CB) [25,26] using AI to prioritise movement of buses at traffic signals; and provide information to passengers about the schedule of the bus near bus stops for inbuilt flexibility basis data analytics for the most popular stops. Another fine example was the use of [117], machine learning clustering techniques to increase the performance of AVL system for planning bus schedules in Portugal [27]. This helped in greater accuracy in demand prediction and more efficient public transport systems. Use of AI will become increasingly prominent with the introduction of Autonomous Vehicles (AV) which totally

rely on AI software based on deep learning techniques. Besides increasing efficiency, AI can also be used to detect road crimes in real time, making the transportation networks safer and user friendly.

2.5 More effective waste management

"Every year we dump a massive 2.12 billion tons of waste on the planet. If all this waste was put on trucks, they would go around the world 24 times" [28]. A larger proportion of this waste is generated form high density urban areas. Due to lack of proper waste disposal mechanisms, landfills are the commonly used dumping grounds which have now become a huge source of pollution with studies revealing that as much as 5% of global GHG emissions come from improper waste management. The most adverse outcome being the emissions of methane gas and CO2 that are generated by waste decomposition. Both these add to the greenhouse effect. Improper waste disposal is also leading to soil and ground water pollution.

Improper waste disposal poses many environmental and health risks, such as groundwater contamination, land degradation, increased cancer incidence, child mortality, and congenital disabilities [29] (Triassi et al. 2015).

Given the magnitude of the problem, Ai is fast emerging as an integral part of the design and operation of urban waste treatment plants since it has the potential of revolutionizing how solid waste is managed, leading to increased operational efficiency and more sustainable waste management practices [30]. Artificial intelligence technologies, particularly for sorting and treating solid waste, are increasingly critical in waste management [31]. Sydney harbour has set a fine example by using technology to monitor key waterways to help reduce the amount of rubbish polluting the Harbour.

The Smarter, Cleaner Sydney Harbour pilot program, co-funded by the New South Wales Government, has sensors fitted to traps on local waterways to alert councils and government authorities in real time when they need emptying, helping them remove litter before it reaches the Harbour. Besides, AI software is being used to identify and segregate types of litter floating in the water – distinguishing between a chip packet, a bottle and can, this can help authorities take preventive measures in the spots from where this litter is being generated [32]. AI can not only help in more accurate segregation of waste but can also pinpoint the areas where there is greater accumulation and can enhance the recycling planning. Artificial intelligence-based technologies like intelligent garbage bins with waste sorting robotic features, classification robots which classify the waste accurately for recycling, predictive models for more efficient waste management, and wireless detection enable the monitoring of waste bins, predict waste collection, and optimize the performance of waste processing facilities [33].

2.6 Enhanced Public safety

Enhanced public safety in the new era is not only about crime but staying safe amid ageing infra structure which could be deeply impacted by the unprecedented changes in the environment causing earthquakes, flash floods etc. Extreme heat and other unforeseen climatic changes are outing the urban infrastructure across the world under tremendous strain. Municipal authorities are now using technology to stay alert and conscious of vulnerability to take remedial action on time [34].

AI can also help authorities stay more alert to crime and augment public safety. Law enforcement agencies can use facial recognition technology to identify suspects and expedite their arrest. High-tech surveillance cameras can recognize dangerous weapons in the hands of would-be criminals and direct nearby officers to the area to investigate. Lastly, AI can use sophisticated sensors to detect gunshots, increase lighting intensity in the area and alert police. The smart surveillance systems can detect threats and be more responsive to avoid crime totally or reach the crim site before too much damage is done [35].

2.7 Streamlined health services

There is increasing evidence of how AI tools can help in improving diagnostic and preventive health care and help in better record keeping, logistics and supply chain management and staff utilisation; all of which help in transforming the medical health care delivery systems and making them more responsive and efficient. AI can also be sued for data collection to detect pandemics and endemics to enable quicker preventive response. it can also be sued for personal health care monitoring. With medical and health apps, people can monitor their own health care and reach out for help faster. Obverse, even the medical system can reach to and aid an ailing individual a lot more accurately, thus making the system more responsive [36].

3. Conclusion

The world can no longer ignore the increasing environmental and health consequences of rapid urbanisation trends across the world. Smart cities driven by AI tools can be useful in ensuring that the urban expansion is sustainable and secure. The trend towards greater urbanisation is irreversible. By 2050, two-thirds (68%) of the global population will be living in cities. As more and more people move towards the cities for economic opportunities as rural economies collapse on account of technology impact on routine jobs, it is important that our cities are able to withstand this influx and are inclusive offering liveable condition to people from all strata.

Cities will continue to be the main drivers of economies across the world and hence it is imperative that governments explore all operativities to make them more inclusive, liveable, and sustainable.

Use of technology also makes people important stake holders in the transformation of the urban landscape as they are kept more informed of the risk of indifference and non-participation/cooperation.

AI powers collective intelligence with an efficient feedback loop is also important, to respond to the needs and priorities

of citizens. As highlighted in the latest Human Development Report, the world has entered the age of the 'Anthropocene' – with human activity becoming the dominant force shaping our planet [37]. Since maximum human activity is centred around our cities, it is important that cities become constructive drivers for this change and don't land up worsening the already precarious situation they find themselves in. it is thus imperative that we use all the technological tools at our disposal to make them productive drivers of development and AI is the perfect solution for now, till such time even better technologies.

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