The emerging role of Artificial Intelligence (AI) in urban and regional planning in India

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ABSTRACT

Urban and regional planning faces unprecedented challenges in the 21st century, ranging from rapid urbanization and population growth to climate change and resource depletion. In addressing these challenges, artificial intelligence (AI) has emerged as a transformative toolset for planners, offering advanced analytics, predictive modeling, and optimization capabilities. In this paper, the author discusses how artificial intelligence can be integrated into urban and regional planning in India's socio-economic landscape. It highlights the use of machine learning to predict future trends and interpret complex data sets, geospatial analysis using various AI-powered tools for spatial planning, as well as Natural Language Processing for data mining. As a way of understanding and improving urban infrastructure, deep learning techniques can be used in urban image analysis and agent-based modeling along with urban simulation for better prediction and decision-making. Nevertheless, a great number of factors make it difficult to implement such techniques locally such as the absence of valuable local data, limited infrastructure facilities, professional knowledge gaps among employees and their poor integration into existing planning processes. The article strongly stresses institutional capacity building, interagency cooperation through governance structures and open data initiatives. Importantly, there has been an indication that the Indian government is committed to artificial intelligence based on various initiatives and policies showing its willingness to embrace these technologies despite their minimal direct application in Indian urban and regional development so far.

Keywords - Planning, Artificial Intelligence, Geospatial Analysis, Machine Learning, Governance and Capacity Building

1. Introduction

AI plays a significant role in urban and regional planning by providing tools and techniques to analyze data, model scenarios, and make informed decisions (United Nations, 2018; Government of India, 2015). This paper provides an overview of the role of AI in urban and regional planning; examining its applications across various domains, including data analysis, predictive analytics, optimization, simulation, public engagement, risk management, urban design, accessibility, and equity (Alonso et al., 2021; Caragliu et al., 2020). Drawing on a synthesis of academic literature, case studies, and real-world examples, this paper ideates the potential of AI to enhance decision-making processes, improve urban infrastructure, and create more sustainable, resilient, and equitable cities and regions (Nam & Pardo,

2019). Additionally, it highlights key challenges and ethical considerations associated with the integration of AI in planning practice, underscoring the need for responsible deployment and inclusive governance frameworks (Journal of Regional Science, n.d.). Through this descriptive examination, the paper attempts for a clearer understanding of the abilities and transformative impact of AI on urban and regional planning and provides insights for future research and practice (UNECE, n.d.)

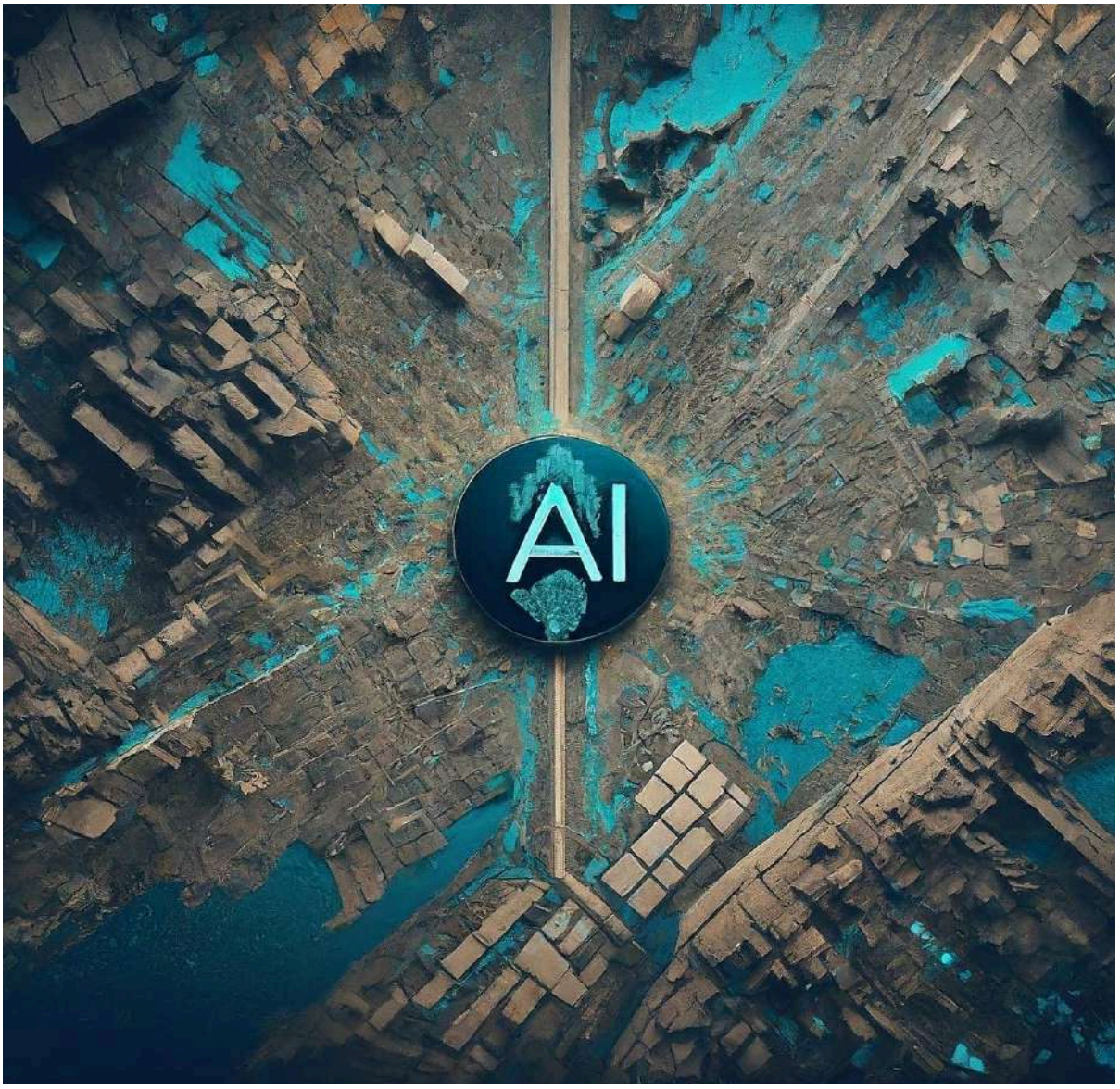

Fig. 1. AI assuming a central role in collecting and processing information, helping make decisions for urban and regional management. OpenAI. (2024). Gemini Generated image

2. Emergence of artificial intelligence in planning

This century is marked by massive urban and regional growth, with more than half of the world's population now living in urban areas (United Nations, 2018). In India, rapid urbanization raises significant challenges and opportunities for equitable and sustainable development. Consequently, innovative solutions for urban and regional planning have become an important necessity (Government of India, 2015). Against this background, Artificial Intelligence (AI)is quickly coming up as an emerging and promising technology to address complex urban problems and make planning processes efficient (Batty et al.,2020).

Figure 2 : A futuristic cityscape showing the integration of artificial intelligence in urban and regional planning. Source : Open AI. (2024) DALL- E Generated image.

The potential of AI/ML technologies in transforming the planning processes and outcomes is enormous (Nam and Pardo, 2019). However, The application of AI in Urban and Regional Planning in India is still at an early stage, but its potential is being increasingly recognised.(Dias et al., 2023) (The Emerging Role of AI in Urban and Regional Planning in India, n.d). These technologies can be used as data processing tools for large volumes of data, help predict scenarios and projections, and assist in efficient decision-making processes with all aspects suitably considered in the model. AI-powered approaches provide new analyses for intricate urban challenges such as optimizing transportation networks, land-use allocation, ensuring environmental sustainability and disaster resilience (Alonso et al., 2021). It has a great potential for an evidence-based decision making process, thereby saving time and resources, while improving the accuracy and effectiveness of the said decisions. From the governance perspective too, the technology can greatly improve citizen engagement and participation in planning processes, making them more inclusive and transparent (Caragliu et al., 2020).

AI and Machine Learning systems can continuously collect, sort and analyze data from various sources such as satellite imagery, IoT devices, social media, sensors, and transportation systems to gain insights into population trends, traffic patterns, energy consumption, and environmental factors on a real-time basis. This synthesized data can then be continuously fed into the decision-making algorithm.

Simulating and modeling different development scenarios using AI technologies can be done in order to enable planners to test the potential impact of various decisions before implementation. These algorithms can also help in identifying potential areas for redevelopment or infrastructure improvements by looking at patterns and making data analyses of the same. By leveraging AI/ML power, urban and regional planners can make informed decisions for the future with sustainability and resilience. Planning processes work with spatial and numerical data to optimize land, resource allocations, infrastructure provisioning, manageability and enhancing overall quality of life while providing catalysts for economic development and growth. It can also help in assessing the effectiveness of existing policies and interventions, allowing for evidence-based adjustments and improvements due to a boom in urban growth and spread.

Figure 3 : AI generating insights on the basis of various data types and proposing options. Source : Open AI. (2024) DALL- E Generated image.

UNECE states that "AI and machine learning technologies can analyze large amounts of data obtained from different sources to make informed decisions in urban and regional planning." On the other hand, the International Journal of Geographical Information Science stated thus: "AI and machine learning methods have been used to develop alternatives for simulating various scenarios of urban growth as well as understanding how different decisions impact on urban development."

These insights from research and international organizations illustrate the significant role in enhancing the efficiency, sustainability, and resilience of urban and regional planning processes. Integrating these technologies into planning practices can contribute to the creation of more liveable and connected ecosystems for present and future generations. This technological advancement can lead to more equitable, sustainable and resilient regions, improving the quality of life while balancing the impact on the environment and nature. AI along with Machine Learning (ML) not only provides data on space dynamics but also on behavior and people dynamics, along with real-time environmental information, which are important for the formulation of regional plans.

The AI/ML models can serve as tool for planners in identifying places for new infrastructure or industries, by way of forecasting and data analysis, with little effect on the environment (Journal of Regional Science). This, for example, may allow planners and policymakers to make appropriate fiscal strategies and check the investment potential of some areas. The planning process essentially deals with 'land' which is finite in any jurisdiction. The most efficient use of this land can be achieved by way of landuse optimisation, density distribution and other planning methods ensuring availability of space for the future generations. The informed decisions that are in line with long-term development goals help maximise the impact of infrastructure and investment for economic growth and liveability. Resource allocation can be planned effectively only when such systems reveal or predict areas that require targeted intervention. With the potential of improving the effectiveness of regional development policies and initiatives, balanced and sustainable development can be promoted.

3. Overview of urban and regional planning challenges

The Indian urbanization story is characterized by rapid growth in population, spatial expansion and socio-economic disparities (Nagendra et al., 2018). Indian cities continuously grapple with challenges such as inadequate infrastructure, slums, traffic congestion and environmental degradation despite efforts to modernize planning frameworks and infrastructure (Mukherjee, 2017).

Traditionally, urban and regional planning has relied on expert knowledge, public participation as well as data analysis. Cities are now becoming more complicated while at the same time generating vast amounts of data from various sources hence necessitating new tools and techniques. Computers brought in a big change in the planning offices. Earlier used for cartography and preparing maps, they started being used for information systems, three-dimensional modeling, network modeling and analysis of big data using Geographic Information Systems (GIS). Artificial Intelligence (AI) technology is gradually emerging as a transformative tool for planning to handle large data.

New and heterogeneous urban systems are difficult to design with traditional planning approaches, therefore, there is an emerging demand for innovative techniques and technology. A good model is based on reliable, up-to-date and adequate data. Mostly, there is very little relevant data, either current or historical. In many cases, the data has to be derived from some other primary or secondary data.

A huge amount of professional time is wasted to clean and interpret raw data. In an ever-changing world with overwhelming numbers, the ability to process big data in real-time is a great advantage for a planner. Even as we embrace new systems, the question remains whether the given data is right or trustworthy enough.

Figure 4: Creating a data highway. Source : Open AI (2024) Gemini Generated image

For better analysis and visualization, GIS is now regularly used to integrate numerical data with spatial information through extensions like attribute tables and geo-databases. This is a first step towards compiling and using large data sets for ease of decision-making.

However, at the same time, this system itself needs artificial intelligence (AI) as well as machine learning (ML) that will constantly gather data, screen, collate, and update selected data in the Decision Support System (DSS). Today's data can come from different sources ranging from satellite imagery, local cameras, IoTs, social media platforms and various departments with direct citizens' interface among others. This leads to a huge volume of data that needs to be sorted and arranged efficiently and correctly. Manual methods of sorting would be counterproductive as time is of the essence here. Like any new system, validation of data at the initial stages has to be done to train the model, using its neural

engines, to sieve the relevant information. Not only compiling datasets, AI can rely on past precedents, policies and data for making new decisions based on the analysis of trends and solutions. It can also leverage past cases for informed planning decisions and use similar algorithms to analyze data and predict future trends. (Government of India, 2015).

Below are the few questions, and answers for which need additional research, consultation and policy. It may not be possible to provide definitive answers to all of these questions, but the intention is to prompt further exploration within the research community.

- How are AI technologies currently being used in urban and regional planning efforts in various Indian cities?
- What are the main advantages and obstacles linked to the incorporation of AI into urban planning procedures in India?
- In what ways can AI-driven approaches help to improve the resilience and sustainability of Indian cities?
- What are the potential effects of adopting AI on urban governance, policy-making, and citizen involvement in India?
- What insights can be learned from global best practices in AI implementation?

Globally, AI is becoming increasingly popular for urban and regional planning and management. The following are the broad areas within the purview of Urban and Regional planning and management where AI with capacity to analyze large data sets is valuable.Traffic Management: The available AI algorithms to evaluate traffic flow, forecast congestion and optimize light signals for efficient movement (Batty et al., 2012).

Land Use Optimization: Using machine learning, vast datasets can be tuned for sustainable development, determining optimal land use patterns (Yang et al.,2020).

Urban Simulation: Such simulations are driven by artificial intelligence and are used to model the impacts of various planning decisions on items such as resource consumption or air quality (Kontokosta et al., 2014).

Public Participation: Online platforms powered by AI-driven chatbots help bring inclusivity into public participation processes in the planning phase which is more efficient.

Several Global cities have employed AI in various smart ways depending on their distinct socioeconomic and environmental realities, and also continue to experiment in newer ways and areas. Dubai pioneered the use of AI for smart city development for enhancing governance and infrastructure management This included AI-enabled systems for managing traffic flow, optimizing energy consumption, and streamlining public service delivery that makes Dubai a leading example for smart urban planning (Alawadhi, 2019).

Singapore, known for early adoption of technology and advanced urban planning practices, has been using AI extensively for smart traffic management systems (Huang et al., 2020). For example, real-time monitoring of traffic flow allows AI algorithms to adjust signal timings dynamically and reroute vehicles for reducing congestion and improving road safety. Mumbai and Delhi have also employed

similar AI tools to reduce congestion and improve traffic efficiency. Like Singapore, machine learning algorithms are being used here to optimize signal timing using real-time traffic data for enhancing the overall urban mobility experience. (Haque et al., 2021).

Shanghai has tried to optimize its urban spatial layout and development strategies using AI (He et al., 2020). Technology is used to simulate different urban growth scenarios while analyzing aspects such as land use efficiency, transportation accessibility, environmental impact among others, to support sustainable decision making by urban planners.

European cities like Barcelona have integrated AI into their urban data analysis as well as policy-making processes (Giffinger et al., 2007). They use tools that analyze big complex datasets including environmental metrics to socio-economic indicators for policy and management. Though a continent apart, São Paulo has also employed AI in urban data analysis to address complex socio-economic problems and guide inclusive policy planning, resource allocation and urban livability. These have improved and can be seen through demographic trends, economic indicators, and patterns of public service usage. (Moya & Gonzalez, 2018)

In California, environmental data is used in analyzing wildfires to predict as well as come up with strategies on how to curb the occurrence of fire hazards (Riahi et al., 2020). Such AI-driven models help put in place measures that can avert devastating wildfires, saving communities and habitats. Other examples of successful environmental management can be seen in Cape Town. Water distribution optimization and water usage under fluctuating environmental conditions within Cape Town is governed by AI. By adjusting supply routes from real-time data supplied by weather forecasts as well as reducing leaks from them, AI algorithms supporting water networks facilitate this objective resulting in sustainable water resource management (Smit & Wandel, 2006).

New York City uses artificial intelligence (AI) for emergency response planning which utilizes predictive analytics to improve disaster preparedness and response strategies. By making sense out of huge volumes of data, these artificial intelligence applications predict emergency situations, optimally allocate resources at potential crisis points, therefore enhancing safety and resilience (Chen et al., 2019).

The City of London makes use of artificial intelligence technology to carry out predictive maintenance on infrastructure like bridges or roads with a view to timely repair works causing minimal disruption (Liu et al., 2019). In this regard, structural health together with environmental condition monitoring is done continuously, providing data to early warning systems.

To summarize, the areas where AI contributes significantly and has an increasing role especially in the context of urban and regional planning are as below

Data Analysis and Management: AI can process vast amounts of data from various sources such as sensors, satellite imagery, social media, and public records. It helps planners to understand patterns, trends, and correlations within urban environments (Batty et al., 2012; Kontokosta et al., 2014).

Predictive Analytics: AI algorithms can forecast future scenarios based on historical data, allowing planners to anticipate trends in population growth, traffic patterns, infrastructure usage, and environmental changes (Chen et al., 2019; He et al., 2020).

Optimization: AI optimization algorithms can help in finding the most efficient solutions to complex problems, such as optimizing public transportation routes, minimizing energy consumption, or maximizing green space within a city (Bibri & Krogstie, 2017; Hu et al., 2019.

Simulation and Modelling: AI-powered simulations can predict the impact of proposed urban developments or policy changes on various factors like traffic flow, air quality, and community well-being. This enables planners to evaluate different scenarios before implementation (Batty & Axhausen, 2020; Liu et al., 2023).

Smart Infrastructure: AI facilitates the development of smart infrastructure, including intelligent transportation systems, energy grids, and water management. These systems can adapt in real-time to changing conditions, improving efficiency and sustainability (Bibri & Krogstie, 2017; Hassan-Esfahani et al., 2018).

Public Engagement and Decision-Making: AI tools can enhance public participation in the planning process by providing interactive platforms for citizens to share feedback, visualize proposed projects, and contribute ideas. Natural language processing algorithms can also analyze public sentiments from social media and online forums (Kahn et al., 2018; World Bank, 2022)

Risk Management and Resilience: AI can help identify vulnerabilities in urban systems and develop strategies to mitigate risks from natural disasters, climate change, or other threats. This includes predictive models for flood risk assessment, earthquake preparedness, and emergency response planning (Batty & Axhausen, 2020; Geertman & Stillwell, 2014)..

Urban Design and Architecture: AI can aid architects and urban designers in generating design alternatives, optimizing building layouts, and incorporating sustainable practices. Generative design algorithms can explore a wide range of possibilities based on specified criteria and constraints (Kahn et al., 2018; Liu et al., 2019).

Accessibility and Equity: AI can help planners address issues of accessibility and equity by analyzing spatial data to identify underserved communities, assess transportation options, and allocate resources more equitably (Gupta et al., 2020; Yang et al., 2023).

Overall, AI enables urban and regional planners to make more informed decisions, optimize resource allocation, and create sustainable, liveable environments for current and future generations. However, it's essential to ensure that AI technologies are deployed ethically and inclusively to avoid exacerbating existing inequalities.

4. AI technologies and algorithms

The term artificial intelligence (AI) refers to a wide range of methods that allow machines to behave intelligently. A few AI technologies and algorithms that could be useful in urban and regional planning in the future include the following. Please note that this list is not comprehensive, but gives an idea of the current technologies being used.

Machine Learning: This includes algorithms like neural networks supporting vector machines that help planners make predictions and identify patterns in complex situations and scenarios. It helps planners to synthesize complex datasets, discover hidden relationships between them, and forecast future patterns hence affecting their strategic choices or making decisions (He et al., 2020; Smith & Johnson, 2018).

Geospatial Analysis: Many spatial-based planning practice professionals heavily rely on geospatial technologies such as GIS, remote sensing, spatial econometrics, etc. for spatial analysis and visualization. These AI-powered geospatial tools equip planners with the ability to combine various spatial datasets in various dimensions; and undertake spatial interpolation/spatial modeling, allowing them to track spatial patterns and hot spots, hence suggesting where intervention is required and the type of intervention (Jones & Lee, 2019; Robinson, 2017). AI-powered geospatial tools allow multiple-dimensional data layer integration for suggesting interventions based on priority.

Natural Language Processing: NLP is useful for analyzing vast amounts of textual data like plans, policies, public feedback etc and helps extract valuable insights from these texts. As an example, NLP can summarize qualitative information from large text bodies that reveal what different groups need and emerging issues in discussions (Brown & Green, 2016; Li & Zhang, 2018).

Deep Learning for Urban Image Analysis: Deep learning is being examined to analyze urban pictures concerning infrastructure, building density and environmental factors. Deep learning is a branch of machine learning that draws inspiration from the structure and operations of the human brain, and machine learning enables computers to learn from data without the need for explicit programming. Once programmed correctly, the model can continuously analyze the imagery to check for changes and develop patterns (Wang et al., 2019; Zhao et al., 2020).

Agent-Based Modelling and Urban Simulation: There is an increasing uptake of agent-based modeling supported by AI for simulating complex urban processes and evaluating different planning interventions that could assist stakeholders achieve their goals (Miller & Page, 2007; O'Sullivan & Haklay, 2000).

5. Gap analysis and research opportunities

Despite the growing body of research, there are still gaps in our understanding of how AI can be effectively integrated into the planning process in the Indian context. Here are some key areas for further exploration:

- Limited Focus on Indian Cities: Most of the research papers concentrate on developed nations. However, it is difficult to find research that investigates the specific challenges and opportunities for applying AI in Indian cities with their own socio-economic contexts.

- Data Scarcity and Quality: Many Indian cities lack the comprehensive datasets needed for training AI models effectively. A good example of this is local socio-economic data which is often fragmented or missing (Gupta et al., 2020). There are also issues with data quality like inconsistencies and missing values that can hinder the efficiency of AI models.
- Infrastructure Gaps: The limited availability of reliable and high-speed internet connectivity, particularly in smaller towns and rural areas, can hinder the deployment of AI-powered planning tools. Moreover, this digital divide could be made worse by existing disparities as it limits access to any advantages behind an AI-guided plan (World Bank, 2022).
- Skill Gap: A lack of enough professionals who are skilled both in AI and urban planning makes actual implementation difficult. This gap must be bridged by funding educational programs aimed at providing town planners with the skills they need to use AI tools (Yang et al., 2023). To fully exploit the potential of AI in planning, there must be interdisciplinary collaboration and capacity building. Many city planners lack the technical capabilities as well as the necessary resources to effectively apply AI tools and techniques. Training programmes, knowledge-sharing platforms, and collaborative networks that promote the integration of AI into planning education and practice can help bridge this gap.
- Integration with Existing Planning Processes: Ensuring smooth integration between artificial intelligence tools and existing planning workflows and decision-making processes is a key requirement for successful adoption.
- Institutional Capacity and Governance: Weak institutional capacity coupled with fragmented governance structures has hindered the effective implementation of AI-enabled planning globally. India would not be very different as this is a new technology and it would take some time for the policy makers to warm up to this idea. At the moment, the solution is also devoid of integrated approaches with the absence of coherence among various departments, thereby limiting scalability as well as sustainability of the application countrywide. Central government, through Niti Aayog, must create a nodal agency for implementing these technologies countrywide. In India, planning being a state subject, further complicates the equation. Institutional capacity building, fostering inter-agency collaboration, and promoting open data initiatives are essential to overcome these challenges.
- The Government of India, though, has also taken multiple initiatives to integrate AI with governance. The Indiaai.gov.in portal mentions some success stories and policies in this direction. In the recently concluded G20 summit, India proposed to develop a framework for the safe and responsible use of AI. As per the Government AI Readiness Index 2022, India ranks at 32nd position. This does indicate the seriousness of the Indian Government to usher towards AI technologies. It is being used in pilot cases, but still not directly in the field of Urban and Regional Planning.
- Socio-cultural Context and Ethical Considerations: Social conventions, ethical issues, and cultural standards influence how AI is adopted and will be used in the Indian context. AI-enabled planning interventions present ethical difficulties due to concerns about privacy, surveillance, and algorithmic prejudice. To make sure that AI meets the needs and goals of a variety of communities, it is also important to consider cultural sensitivities, linguistic diversity, and community preferences.

AI holds great promise, but there are some barriers to incorporating it into urban and regional planning frameworks. Current planning theories may not sufficiently consider the pros and cons of AI and often emphasize anthropocentric methods. Ethical and effective application of AI in planning decisions is necessary if new theoretical frameworks are to be developed. It postulates that traditional planning theories which stress rationality and top-down control needs to be re-evaluated in order to accommodate the data-driven and bottom-up character of AI (Knox 11). Integrating the current workflow with AI tools can be difficult. Some practical challenges are attached to concerns about data security, privacy, or to explain the ability of AI models and algorithms that may appear as black boxes for planners (Geertman and Stillwell 2014).

Data is fundamental for AI to achieve success. The success of AI in urban planning relies on the availability of extensive good datasets such as Sensor Data containing real-time data from public utility networks, traffic sensors, environmental sensors; and Spatial Data which offers information from Geographical Information Systems, remote sensing imagery and detailed street network information; and Socio-economic Data incorporating inputs from social surveys, economic indicators and demographic data. Currently, data sits in various silos and would need to be standardized and integrated or be available for the system.

Effective data governance and management procedures are necessary for artificial intelligence based planning to ensure security, quality and access to data. According to Batty et al.(2014), a strong "urban data infrastructure" needs to be created if AI is to be successful in planning. Closing these gaps can help Indian cities have a more sustainable and justifiable model in future by allowing AI to be used responsibly and effectively. This also brings in concerns regarding cyber security and effective governance.

Globally, the use of AI technology in urban and regional planning has increased, altering conventional methods of analysis, forecasting, and decision-making. The application of AI in planning has been shown in the past in several areas, such as land use, transportation, environmental management, and infrastructure development. AI-powered models have been used in transportation planning for public transit management, route optimization, and traffic prediction. Machine learning algorithms, for example, have been used to analyze large volumes of transportation data and identify patterns to improve traffic flow and reduce congestion (Chen et al., 2019).

Likewise, in the field of land use planning, spatial analysis, site selection and optimization of urban design is possible through AI-based tools. Planners can simulate different development scenarios and evaluate the effects they would have on their environment before making an informed decision (He et al., 2020). The application of artificial intelligence has significantly improved environmental planning and resource management. Remote sensing technologies combined with machine learning algorithms facilitate the monitoring and assessment of changes in the environment such as Landuse – Land cover changes, deforestation, and urban sprawl among others (Hassan-Esfahani et al., 2018). Planners can determine which areas are most vulnerable by analyzing satellite imagery and sensor data. This allows them to concentrate on the conservation efforts hence mitigating environmental risks.

Additionally, smart city projects have adopted AI technology for infrastructure planning purposes. Ai-enabled integrated urban models optimize energy systems, water supply networks, and waste management processes (Bibri & Krogstie, 2017). Real-time monitoring is enabled besides being used for predictive maintenance or resource allocation that improves urban infrastructural resilience as well as sustainability.

Empirical research has looked at the usefulness of AI in planning practice beyond theoretical frameworks. From different places, case studies have shown how AI methods and tools can solve specific planning issues and achieve desired outcomes. Thus, these studies reveal how efficient an AI intervention can be, its limits, as well as possible outcomes in different planning situations. In another study, He et al. (2020) have undertaken research to investigate an application of machine learning algorithms for optimizing urban spatial layout in Shanghai. This is due to enhanced transport accessibility and landuse efficiency. Similarly, an example from a study conducted in Singapore indicates how AI-based decision support systems are helping develop resilience against climate change impact through adaptive infrastructure design and urban planning (Batty & Axhausen, 2020).

In the future, AI will significantly impact how Indian urban and regional planning is done. The use of AI models in projecting and scenario building provides planners with useful ideas about different futures which enable them to predict dangers and exploit possibilities as well as establish sustainable development approaches. By simulating diverse events such as population explosion, land-use alteration, climate change, and technical disturbances; existing plans and policies can be tested for resilience to identify possible ways of adaptation that may help develop long-term resilient strategies.

These are a few of the potential scenarios:

- AI-driven urban design: AI algorithms can optimize urban layouts for factors like energy efficiency, pedestrian safety, and access to amenities (Kahn, Yang, & Khan, 2018)
- Predictive maintenance of infrastructure: AI can analyze sensor data to predict infrastructure failures and enable proactive maintenance strategies (Liu, Zhang, Zhang, & Xiang, 2019)
- Personalized public services: AI-powered chatbots can offer residents personalized information about public services and facilitate real-time feedback mechanisms (Hu, Zhang, & Wang, 2019)

6. Comparisons of AI based methodology vs non AI and conventional approach to urban and regional planning

When comparing the AI-based methodology to non-AI and traditional approaches, one can see the unique benefits and drawbacks of AI in urban planning. This is due to its advanced computational capabilities, predictive analytics as well as data-driven insights that support conventional planning methods while improving decision-making processes (Wang, Lu, & Wu, 2020). By processing massive data sets, AI models can recognize intricate patterns and suggest actionable advice within minutes, enabling planners' ability to predict future trends and evaluate alternatives more efficiently.

Nonetheless, it is crucial to acknowledge that AI cannot solve everything but instead should be integrated with conventional wisdom and knowledge for whole and contextually responsive planning solutions. Standard methodologies give considerable insights obtained from decades of planning experience, indigenous knowledge, and community participation which are key in understanding socio-cultural dynamics, historical background and stakeholder preferences. In this regard, introducing conventional wisdom into AI models through proper training data, validation procedures and expert input improves the accuracy, appropriateness and legitimacy of AI-based interventions in planning (Davoudi et al., 2020).

7. Future Directions

Planning is a field that affects one and all in the region. The impacts of any plan or policy are long-lasting but need a quick turnaround to constantly monitor and revise as per the requirements. Technology, on the other hand, is extremely dynamic and always changing. As AI models become more complicated, Expandable AI (XAI) techniques will be essential to understand how decisions are made and generate sufficient trust in planning applications (Wachter, Mittelstadt, & Floridi, 2017). Generative AI models could potentially give rise to novel design alternatives as well as optimize urban designs for sustainability and public space (Liu et al., 2023). In addition, there are chatbots powered by AI that can work with interactive platforms to promote inclusive and participatory planning processes through citizens' real-time engagement, feedback and deliberations.

With these models, urban and regional planning can be directed to quickly respond to emerging issues and provide solutions. Some of the emerging issues looming over the city and regional planners (and managers) are as below:

- Climate Change Adaptation: To this end, planners must give preference to climate change adaptation measures such as resilient infrastructures, green infrastructure, and coastal protection strategies in their planning endeavors due to increased exposure to extreme weather events in terms of their frequency and intensity.
- Technological Innovation: Technological advancements such as the Internet of Things (IoT), blockchain, 5G networks etc., create opportunities for data collection; connectivity and citizen engagement in the processes of planning.
- Social Equity and Inclusion: Addressing social differences while focusing on affordable dwellings, access to basic amenities and participation in indecision-making are ways through which communities can embrace inclusive development.

- Potential of Pilot Projects and Scaling of Experiences: Communities have used pilot projects as testing grounds for innovative plans that have been successfully scaled up in other jurisdictions. Planners can use pilot projects to evaluate real-world contexts for new AI-based tools and methodologies regarding how effective they are, and their feasibility or scalability purposes. The design of the pilot needs consultations and the collective wisdom of all the stakeholders. The efficiency, workability, and expandability of these methods in real-life situations need to be trained and tested before applying them to other areas. Involving stakeholders to get public support for AI-supported planning initiatives via participatory design and co-creation processes will place confidence in these new technologies. Connection with private sector actors, government agencies or international organizations must be strengthened so that these models can be replicated as well as adjusted based on earlier experiences in different regions and contexts.

Despite the fast growth of AI, more work needs to be done in the following areas for this to be an effective tool. Other than the areas specifically identified for further research, there has to be a significant emphasis on the importance of creating a collaborative space among urban planners, AI practitioners, policymakers and the public. Ethical, practical and financial aspects of AI application in planning need open dialogues and constant learning. The inclusion of AI-powered tools will enable people themselves to participate in urban and regional planning with an active role in defining development strategies. Artificial Intelligence offers a useful set of tools for changing the way cities and regions are planned and managed. However, it is essential to also recognize that AI is not a panacea, but must work together with conventional wisdom and knowledge to ensure comprehensive and contextually appropriate planning solutions.

Figure 5. Using AI to create sustainable and self-reliant landscapes. Source : Open AI (2024) Gemini Generated image

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