

Review Article

Artificial Intelligence on Civil and Environmental Processes for Sustainable Urban System

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Abstract

Urban areas are very fragile for sustainable development. In this regard, this review article aims to examine how artificial intelligence (AI) can be integrated with the skills of civil and environmental engineers to make the process more efficient for smart urbanization for future generations. Prior to sustainable urban planning, several requirements must be met, including adequate political will, institutional capacity, pertinent laws or regulations, accurate and up-to-date maps, basic data and information availability, mechanisms for civil society and public participation, creative ways to increase the visibility and voice of women and youth, clearly defined roles of public and private sectors, and plans tailored to local conditions. Without AI, civil and environmental engineers who construct and implement urban planning are unable to provide a clear future vision. AI can reduce traffic jams and lower emissions, enhance safety and reduce human errors, prevent failures and extend infrastructure's lifespan, improve efficiency and reliability of services, ensure public health and safety, increase efficiency and reduce environmental impact by increasing recycling rates, and reduce landfill of water reservoirs for sustainable urban systems. AI also has the capacity to completely transform urban administration for energy-efficient building design and intelligent material selection, promoting creative, long-term answers to urban problems.

Keywords

Artificial Intelligence, Civil and Environmental Processes, Traffic Management, Sustainable Urban System

1. Introduction

Due to rapid urbanization, the pattern of land use is being changed in the fast-growing cities, especially in the developing countries [22]. In most cases, development is taking place without proper guidance; increasing disaster risk may arise from different hazards. As a result of haphazard development, damage and loss increased gradually, and a number of cities in the developing countries had to face adverse situations. Urban growth brings a potential increase in conflict between envi-

ronmental, economic, political, social, and cultural interests as well as between the public and private sectors. Cities in developing countries experiencing economic and population growth will inevitably confront a physical expansion of the informal areas in particular, where the majority of the population is very poor. If current trends continue, the urban areas of developing countries will contain large unplanned areas with informal or illegal slums, characterized by unhealthy,

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poor- quality housing and lacking basic infrastructure, services, and adequate transport systems. Poor living conditions have a particularly negative impact on women, children, young people, and persons with illnesses [19]. Figure 1 also shows the adverse consequences of rapid unplanned urbanization in the world. Rapid urbanization increases temperature, water runoff, deforestation, and disease infestation as well as decreases air quality, natural beauty, quality of runoff water, farmland reduction, food shortage, and altered weather patterns and threatens built-in system, which leads to a vicious circle of poverty. So, long-term sustainable development is an important factor for urban planning. By planning infrastructure, tackling environmental issues, and creating sustainable urban settings, civil and environmental engineers play vital roles in urban development [16].

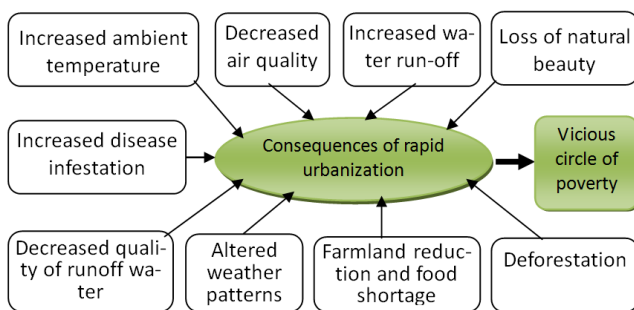


Figure 1. Consequences of unplanned rapid urbanization.

Environmental engineers are experts in reducing pollution and managing resources for a healthy urban environment, whereas civil engineers concentrate on the physical infrastructure, such as buildings, roads, and water infrastructure. Urban development outlines strategies for land use, infrastructure, and services to ensure sustainable and orderly development [7]. These plans address critical aspects of a city, including housing, transportation, and environmental protection. It is essential to involve them all in the planning process. Urban planning differs from country to country, but it generally encompasses controlling and enabling tools. Controlling tools include spatial plans, zoning and land subdivision regulations, building codes and standards, while enabling tools include public land acquisition and allocation, investment in public infrastructure, green spaces and service facilities, and stimulation of public-private partnerships. It is important to keep in mind that much city growth in developing countries happens outside authorized planning. Most of the capital and other cities are the central place for the activities of the government. People from different sectors come to the capital city for their official business purposes. Without artificial intelligence (AI), civil and environmental engineers who construct and implement urban planning are unable to provide a clear future vision. For sustainable urban growth, planning tools must be multidisciplinary. In this regard, artificial intelligence (AI) is the simulation of human intelligence in machines

programmed to think and teach [18]. It includes technologies like machine learning, deep learning, and neural networks used to analyze data and make decisions and optimizations in the built environment. Creating buildings and urban spaces that meet present needs without compromising the ability of future generations to meet their own needs. This approach focuses on minimizing environmental impact and optimizing resources, which enhances quality of life. AI can surely enhance the skills of civil engineers and make the process more efficient for smart urbanization for the future generation. Artificial intelligence (AI) can also assist in gathering information on future predictions for sustainable urban systems, something that environmental and civil engineers are unable to achieve. Still now the combined use of AI and civil and environmental engineers' knowledge in urban planning systems is scanty. Realistic urban development planning requires an integrated approach to cope with the complex reality and fast-changing conditions. These studies show how AI has a big impact on the built environment and how it may improve sustainability, efficiency, and the quality of life in cities.

2. Methodology

This study has been conducted based on secondary data. Necessary data has been collected from a large number of books, journals, online lectures, and databases of various government and nongovernment institutions along with international organizations. The collected information has been compared and analyzed to find out the development processes for an inclusive smart urban planning system.

3. Results and Discussion

3.1. Preconditions for Sustainable Urban Development

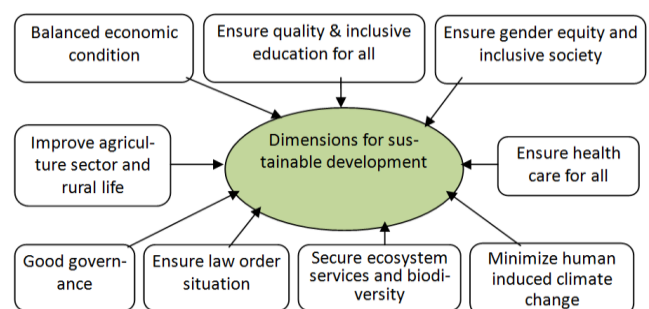


Figure 2. Factors affecting for sustainable development.

A few prerequisites need to be fulfilled for sustainable urban planning (Figure 2). Balanced economic conditions achieve sustainable urban growth; economic conditions must be improved in a balanced manner. According to [23], one of

the requirements for a sustainable urban system is economic restructuring. This entails setting up a system in which social justice, environmental preservation, and citizens' general quality of life are all bolstered by economic prosperity. Long-term resilience, resource efficiency, and equitable growth should be given top priority in a comprehensive strategy for urban economic development.

In respect of quality and inclusive education focuses on ensuring that everyone has fair access to high-quality education, especially for vulnerable populations, and incorporates sustainable development principles into the curriculum in order to promote sustainable urban development. SDG objective 4.7 emphasizes the importance of incorporating fundamental knowledge into education to promote diversity, respect for human rights, and sustainable development [12]. This entails advancing pertinent information and abilities, increasing civic participation, and supporting sustainable urban behaviors. On the other hand, ensure healthcare for all affects social justice, economic productivity, and general well-being in a city; universal access to healthcare is essential for sustainable urban development. The goal of universal health coverage (UHC) is to protect people from threats to their public health and financial hardship brought on by disease by ensuring that everyone has fair access to high-quality medical care. Achieving the Sustainable Development Goals—especially SDG 3, which focuses on promoting well-being and guaranteeing healthy lives for all—requires this strategy [11]. In order to ensure gender equity and inclusivity in sustainable urban development, it is necessary to address gender-specific needs and vulnerabilities, ensure that all inhabitants have equal access to resources and opportunities, and incorporate gender perspectives into all phases of planning, design, and implementation. Everyone benefits from more resilient, just, and sustainable cities created with this strategy [1]. Good governance refers to how public institutions manage resources and conduct public affairs in a way that respects the rule of law and human rights. It involves making sure those procedures and establishments produce outcomes that satisfy the demands of society and make effective use of resources, including in a sustainable manner. A country's affairs should be managed in an open, transparent, responsible, and equitable manner in order to promote growth and guarantee the implementation of human rights. This is the essence of good governance [13]. Good governance also can ensure sustainable urban planning for developing countries. Local authorities are the key actors in planning, but they need capacity development and institutional strengthening in order to use democratic planning tools such as participatory planning models, urbanization statistics, multi-sector approaches, legislative tools, environmental assessment, and public-private partnerships. Civil society has a central role in planning by expressing people's needs and demands, mobilizing communities to participate in planning processes, and monitoring service delivery, observance of laws, and systems for legal appeal. Equal participation of women and men is

fundamental, as is participation of different interest or ethnic groups. Likewise, the private sector, including the informal sector, should have a more instrumental role in urban planning. The media is important for information dissemination and public debate. Political commitment plays a significant role. Governments are rarely prepared for the ongoing urban growth, as the planning horizon of politicians is often too short. The distribution of responsibility and authority between levels of government is often ineffective, and fiscal systems often need reforming. The earth's surface is anticipated to be affected by a set of meteorological parameters. The meteorological parameters include temperature, pressure, humidity, wind, precipitation, solar radiation, etc. [9], which are interdependent in terms of magnitude in the atmosphere. Soil temperature is deemed a key climatic factor influencing ecosystem processes, specifically below the ground surface [5]. Soil temperature plays an important role in aiding decision-making for many processes like soil respiration, crop production, pest growth, germination, pavement design, etc. [2]. So, optimum vegetation can ensure a reduction in air and soil temperature to reduce the bad effects of environmental consequences. To ensure a law and order situation for sustainable urban development, maintaining law and order is essential. Infrastructure development, economic activity, and general societal well-being are all made possible by a stable environment. Without a safe environment, development initiatives may be thwarted, which could result in a rise in crime, social discontent, and a general decline in living standards [4]. For sustainable urban growth, biodiversity and ecological services must be protected. Benefits of incorporating biodiversity into urban planning include greater climate regulation, increased resilience, and better air and water quality. Green infrastructure and urban greening are examples of nature-based solutions that can enhance biodiversity and provide ecosystem services [8]. A number of sustainable development goals, such as those pertaining to water, health, and sustainable cities, depend on this strategy. Sustainable urban development must place a high priority on waste reduction, energy efficiency, renewable energy adoption, and sustainable mobility in order to reduce human-induced climate change. A comprehensive strategy involving community involvement, policy execution, and urban planning is needed for this.

3.2. Responsible of Civil and Environmental Engineers

Figure 3 shows the responsibility of civil and environmental engineers for a sustainable built environment.

By implementing eco-friendly designs, using sustainable materials, and emphasizing waste reduction, water conservation, and energy efficiency, civil engineers help create sustainable structures. They are also essential to the development and execution of sustainable infrastructure projects, the control of air and water pollution, and the management of municipal trash [10]. In order to preserve building codes and

standards, civil engineers develop structures in accordance with pertinent requirements, keep abreast of legislative changes, and make sure that codes are followed during the design and construction phases. They are in charge of comprehending, implementing, and upholding these regulations to guarantee secure and useful structures. Civil engineers must take social and environmental factors into account while designing infrastructure in order to combine sustainable urbanization with law enforcement. This entails creating environmentally friendly infrastructure, improving water management, encouraging intelligent technology, and making sure stakeholders are working together effectively. Law enforcement should also make sure that zoning and environmental laws are followed. With features like parks, green roofs, and sustainable drainage systems, civil engineers are essential to the creation of green areas and service facilities in urban settings [21]. By controlling storm water, reducing the urban heat island effect, and improving air quality, these amenities not only benefit aesthetics but also the environment. Additionally, they offer customers basic facilities including water, pathways, seats, shelter, and sanitary facilities.

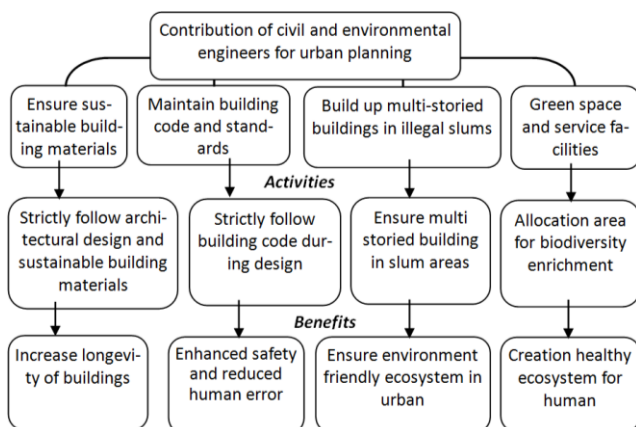


Figure 3. Creation sustainable urban inbuilt environment.

3.3. Artificial Intelligence Application for Smart Urban System

Figure 4 shows the efficiency of AI technologies on traffic and transportation systems. Intelligent traffic management can lower congestion, enhance public transit, and limit environmental effects. Artificial intelligence (AI) may greatly improve traffic management for sustainable urban growth [20]. Travel times are shortened and fuel consumption is decreased when artificial intelligence (AI) algorithms evaluate real-time data from several sources, such as sensors and cameras, to modify traffic signals, forecast congestion patterns, and provide alternate routes. Artificial intelligence (AI)-powered autonomous cars have various advantages for sustainable urban development, such as less traffic, higher efficiency, and enhanced safety. AI technologies can improve

the overall efficiency of urban transportation networks, reduce accidents, and optimize traffic flow [15]. AI-driven predictive maintenance allows cities to proactively maintain their infrastructure, cutting costs and prolonging asset lifespans; it is essential for sustainable urban growth. This method makes use of Internet of Things (IoT) sensors to gather data in real time, which AI algorithms then examine to forecast probable malfunctions and improve maintenance plans. Cities may reduce disturbances, improve public safety, and increase overall efficiency by foreseeing problems before they become more serious. AI is being used to improve public transportation's efficiency, ease traffic, and encourage greener behaviors in order to support sustainable urban growth. By analyzing real-time traffic data, AI can dynamically adjust traffic signals and suggest alternative routes, minimizing congestion and promoting smoother traffic flow. Policymakers, consumers, and regulators are encouraged to learn about the requirements, issues, and uses of artificial intelligence in the burgeoning field of autonomous vehicles.

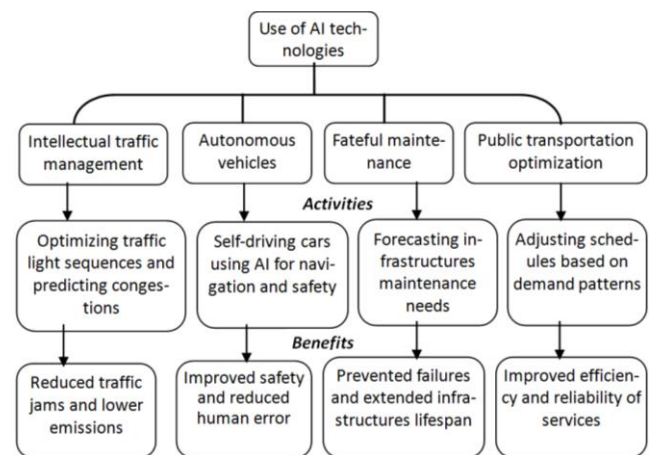


Figure 4. AI Applications in traffic and transportation.

However, societal acceptability, traffic, weather, road conditions, data protection, and cyber security are some of the issues that AI-powered self-driving cars must deal with. Similar findings were reported by [17].

3.4. Waste, Water Management Using AI Technology

Figure 5 shows the efficiency of AI applications in water and waste management. AI technologies such as machine learning and deep learning are used to model and compute water quality classification and water quality indicators (WQIs) [20]. WQIs are employed to evaluate the general condition of water bodies and adherence to environmental standards. Traditional techniques for determining WQIs can be labor-intensive and prone to human error when dealing with significant amounts of monitoring data.

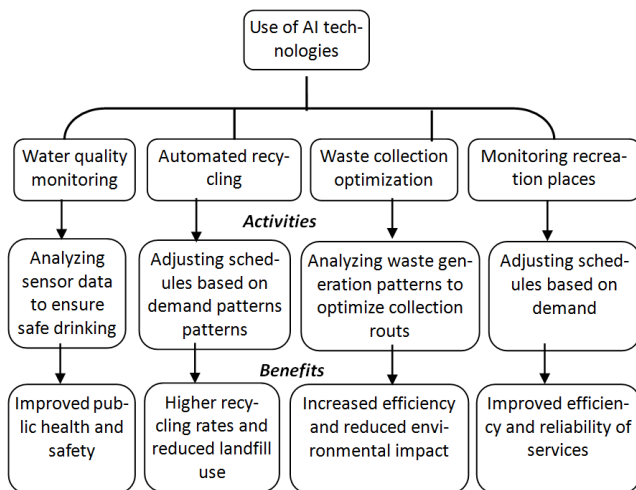


Figure 5. AI applications in water and waste management.

With the ability to improve accuracy, save time, and offer insights into complicated environmental data, artificial intelligence (AI) presents a strong substitute. By automating sorting, anticipating garbage generation, and optimizing routes, artificial intelligence is transforming rubbish collection and promoting more sustainable and effective urban development. This is made possible by technologies that analyze data, automate processes, and optimize waste systems, such as robotics, computer vision, and machine learning. AI-powered recreational space monitoring may greatly support sustainable urban development by maximizing resource allocation, guaranteeing security, and fostering accessibility. In the end, AI-powered systems can create more effective and pleasurable recreational spaces by analyzing data from multiple sources, including sensors, cameras, and social media, to track occupancy, spot possible safety risks, and forecast future requirements [6].

3.5. Strategic Areas Supporting for Sustainable Urban System

Figure 6 shows the support of strategic areas for sustainable urban systems. By evaluating vast datasets, forecasting trends, and allocating resources as efficiently as possible, artificial intelligence (AI) can assist in tracking population inflow and outflow to promote sustainable urban growth. This makes cities more livable and efficient by empowering urban planners to make better-informed choices on infrastructure, transit, and land use. AI may also optimize resource utilization, boost production, and generate new economic opportunities in rural areas, all of which can support sustainable urban development by improving rural agriculture practices and lifestyles. Consequently, this can ease the strain on metropolitan areas and encourage equitable regional development. Numerous advantages and opportunities, such as rich data collection, sustainable assessment, and productivity, have been made available to

civil engineers by the extensive application of artificial intelligence (AI) in this field. With the help of digital technologies, the construction industry is shifting toward sustainability. In order to advance digitization and intelligence in civil engineering, artificial intelligence (AI) is essential. It enables significant improvements in automation, performance, and dependability and actively connects digital and physical construction [14, 3]. Civil engineers build a sustainable society for the present and future, comply with legislation and codes, use resources efficiently and effectively, seek multiple options to solve sustainability challenges, manage risk to minimize adverse impact on people or the environment, apply professional and responsible judgment, and take a leadership role. In developing nations like Bangladesh, construction projects must be developed sustainably in order to minimize downtime and prevent maintenance expenses. These include preventing early concrete structure deterioration, considering the durability of the structures, conducting additional research on concrete structure durability to comprehend the deterioration process in our hot and humid nation, controlling cement brand quality for the sustainable development of concrete construction projects, and similar abrasion value. More courses on recently developed technologies should be added to undergraduate programs, professional organizations should produce skilled workers, and more seminars and symposiums should be organized to discuss the knowledge related to the sustainable development of construction works.

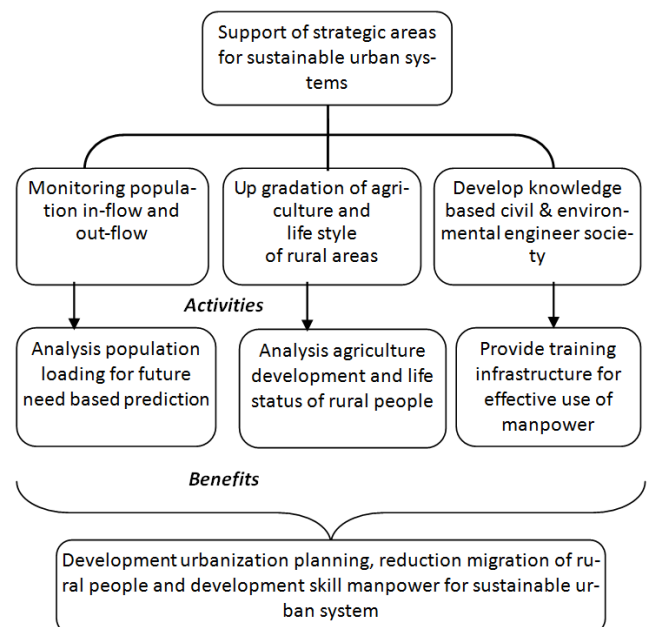


Figure 6. AI Applications in water and waste management.

As key areas for a sustainable urban system, improved urban plans, decreased rural migration, and enhanced skilled

labor are established by monitoring and improving rural life and agriculture and creating knowledge-based engineering societies.

Abbreviations

AI	Artificial Intelligence
SDG	Sustainable Development Goal
UHC	Universal Health Coverage
IoT	Internet of Things
WQIs	Water Quality Indicators
FAO	Food and Agriculture Organization

Author Contributions

Rukaiya Ferdous: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Resources, Validation, Writing – original draft, Writing – review & editing

Mahmud Hasan: Conceptualization, Formal Analysis, Funding acquisition, Methodology, Software, Validation, Writing – original draft, Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

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