advances in urban resilience and sustainable city design
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Policy Frameworks and Governance Structures Supporting Green City Movements

Saaif Rasul
Bangladesh University of Professionals
saaifrasul39@gmail.com
Aw Yoke Cheng
BERJAYA University College
https://orcid.org/0000-0001-8254-8384
ycaw@yahoo.com

abstract

Green city movements are gaining momentum worldwide as cities strive to become more sustainable, resilient, and environmentally friendly. To support these movements, various policy frameworks and governance structures have been implemented. Here are some examples: Sustainable Development Goals (SDGs): The United Nations' SDGs provide a comprehensive framework for countries and cities to work towards a sustainable future. Many green city movements align their goals and initiatives with the SDGs, which address various aspects of sustainability, including clean energy, sustainable infrastructure, climate action, and more. National and Local Climate Action Plans: Many countries and cities have developed climate action plans to address the challenges of climate change. These plans typically include targets and strategies for reducing greenhouse gas emissions, increasing energy efficiency, promoting renewable energy, improving public transportation, and enhancing urban resilience. Urban Planning and Zoning Regulations: City governments can implement urban planning and zoning regulations that support green city initiatives. These regulations may include requirements for green building standards, the preservation of green spaces, the promotion of mixed land-use development, and the prioritization of pedestrian and cycling infrastructure. Incentive Programs and Financial Mechanisms: Governments can establish incentive programs and financial mechanisms to encourage green practices and investments. This can include tax incentives for energy-efficient buildings, subsidies for renewable energy installations, low-interest loans for sustainable infrastructure projects, and grants for green innovation and research. Public-Private Partnerships (PPPs): Collaboration between governments and the private sector is essential for the success of green city movements. PPPs can facilitate the implementation of sustainable infrastructure projects, such as renewable energy installations, waste management systems, and smart city technologies. These partnerships often involve shared investment, expertise, and risk. Civic Engagement and Participation: Green city movements thrive when there is active civic engagement and participation. Governments can create platforms for public consultation, involve citizens in decision-making processes, and support community-led initiatives. This ensures that the voices and ideas of residents are considered in the development and implementation of green city policies.

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Monitoring, Reporting, and Accountability: Effective governance structures for green city movements include monitoring, reporting, and accountability mechanisms. Governments can establish systems to track progress towards sustainability goals, regularly report on key indicators, and establish mechanisms for public scrutiny. This promotes transparency and ensures that actions are aligned with the intended objectives.

Keywords: *Green city movements, Policy frameworks, Governance structures, Sustainable development goals (SDGs), Climate action plans*

introduction

Growing global awareness of environmental sustainability in urban areas has become a pressing issue as the world grapples with the challenges posed by rapid urbanization and climate change [1], [2]. With more than half of the world's population living in cities, the impact of urban areas on the environment cannot be ignored [3], [4]. The growing awareness of environmental sustainability in urban areas stems from the recognition that cities are major contributors to greenhouse gas emissions, resource consumption, and waste generation. The negative consequences of these activities, such as air and water pollution, loss of biodiversity, and urban heat island effect, have necessitated a shift towards more sustainable practices.

The Green City Movement is a collective effort that aims to address the environmental challenges faced by urban areas and promote sustainable development. It encompasses a range of strategies and initiatives aimed at creating environmentally friendly and livable cities. At its core, the Green City Movement seeks to integrate ecological principles into urban planning and design, transportation systems, energy infrastructure, waste management, and green spaces. The movement recognizes that achieving sustainability in cities requires a holistic approach that considers the interconnections between various aspects of urban life and the natural environment.

The core principles of green cities revolve around urban planning and design that prioritizes sustainability. One of the key aspects is promoting mixed-use developments and compact urban form. By integrating residential, commercial, and recreational spaces within the same area, cities can reduce the need for long-distance commuting and encourage a more efficient use of resources [5]. This approach minimizes the environmental impact associated with transportation and promotes social cohesion by creating vibrant, diverse neighborhoods where people can live, work, and play in close proximity [6].

Another crucial principle is prioritizing pedestrian and cyclist-friendly infrastructure. Green cities aim to reduce reliance on cars and promote active modes of transportation such as walking and cycling. This involves designing and implementing safe, well-connected networks of sidewalks, bike lanes, and greenways. By providing convenient and accessible infrastructure for pedestrians and cyclists, cities can improve air quality, reduce traffic

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congestion, and enhance the overall health and well-being of their residents [7]. Additionally, this approach encourages physical activity and fosters a sense of community engagement within the urban environment [8].

Emphasizing green spaces and biodiversity conservation is also essential in the development of green cities. These cities recognize the importance of preserving and enhancing natural ecosystems within urban areas. By integrating green spaces, such as parks, gardens, and urban forests, cities can provide numerous benefits. Green spaces contribute to improved air quality, mitigate the urban heat island effect, and provide recreational opportunities for residents. Furthermore, biodiversity conservation efforts within urban environments help protect native species, promote ecological balance, and create habitats for wildlife [9]. Green cities recognize the interconnectedness of humans and nature and strive to create harmonious environments where both can thrive [10]. The core principles of green cities revolve around urban planning and design that promotes sustainability [11]. This includes advocating for mixed-use developments and compact urban form to minimize environmental impact and foster vibrant communities. Prioritizing pedestrian and cyclist-friendly infrastructure encourages active transportation, reduces congestion, and enhances the health and well-being of residents [12]. Lastly, emphasizing green spaces and biodiversity conservation preserves and enhances natural ecosystems within urban environments, providing numerous ecological and social benefits. By adhering to these principles, cities can create sustainable, livable environments that prioritize the needs of both people and the planet.

Sustainable transportation and mobility play a crucial role in the core principles of green cities. One of the key strategies is encouraging public transportation and reducing reliance on private vehicles. By providing efficient and accessible public transit systems, cities can decrease traffic congestion, reduce greenhouse gas emissions, and improve air quality. This includes developing comprehensive networks of buses, trains, trams, and subways, as well as implementing innovative solutions like bus rapid transit (BRT) systems [13]. Additionally, green cities prioritize the integration of multimodal transportation options to provide seamless connectivity between different modes, making it easier for residents to choose sustainable transportation alternatives [14].

Another important aspect of sustainable transportation is promoting the use of electric vehicles (EVs) and supporting infrastructure [15]. Green cities recognize the environmental benefits of EVs, such as reduced carbon emissions and improved air quality. To encourage their adoption, cities implement policies and incentives, such as financial incentives for EV purchases, the installation of EV charging stations in public spaces and residential areas,

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and the development of EV-friendly parking infrastructure [16]. By providing a reliable charging infrastructure and promoting EV usage [17], cities can accelerate the transition to cleaner transportation and contribute to the overall sustainability goals [18].

In addition to public transportation and electric vehicles, green cities prioritize the implementation of bike-sharing programs and pedestrian-friendly initiatives. By creating a safe and interconnected network of bike lanes, bike-sharing systems, and pedestrian-friendly infrastructure, cities promote active transportation modes and reduce the dependence on motorized vehicles for short-distance travel. This approach not only reduces traffic congestion and carbon emissions but also contributes to the health and well-being of residents by encouraging physical activity and creating more livable, vibrant urban spaces [19].

Energy efficiency and renewable energy are vital components of the core principles of green cities. One key strategy is promoting energy-efficient buildings and green building certifications. Green cities incentivize and mandate the use of energy-efficient technologies, materials, and design principles in new constructions and renovations. This includes features like efficient insulation, smart lighting systems, high-performance windows, and energy-efficient appliances. Green building certifications, such as LEED (Leadership in Energy and Environmental Design), provide a framework for evaluating and recognizing buildings that meet specific sustainability criteria. By promoting energy-efficient buildings, cities can significantly reduce energy consumption, lower greenhouse gas emissions, and create healthier indoor environments for residents [20].

Another critical principle is encouraging the use of renewable energy sources like solar and wind power. Green cities understand the importance of transitioning to clean, renewable energy to mitigate climate change and reduce reliance on fossil fuels. They support the installation of solar panels on rooftops, public buildings, and parking structures to generate clean electricity. Wind power is harnessed through the installation of wind turbines in suitable locations [21]. Additionally, cities promote community solar initiatives and encourage the integration of renewable energy technologies into the urban landscape, such as solar-powered streetlights and charging stations. By prioritizing renewable energy, cities can significantly reduce their carbon footprint and contribute to a more sustainable energy future [22].

Green cities also focus on implementing smart grid technologies and energy management systems. Smart grids enable efficient distribution of electricity, optimizing the use of energy resources and reducing waste. They incorporate advanced metering systems, real-time monitoring, and demand-response mechanisms to balance energy supply and demand, improve grid reliability, and support the integration of renewable energy sources [23]. Energy management systems provide tools for

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residents, businesses, and city authorities to monitor and control energy usage, identify areas for improvement, and make informed decisions to optimize energy efficiency [24]. By leveraging smart grid technologies and energy management systems, green cities enhance their energy resilience, reduce energy costs, and enable more effective management of energy resources [25].

Waste management and the adoption of a circular economy are fundamental principles of green cities. One key strategy involves implementing comprehensive recycling and waste reduction programs. Green cities prioritize the establishment of efficient and accessible recycling systems that encompass various materials, such as paper, plastics, glass, and metals. This includes providing recycling bins in public spaces, residential areas, and businesses, as well as educating residents about proper recycling practices. By diverting waste from landfills and promoting the recycling of materials, cities can conserve resources, reduce environmental pollution, and decrease the need for raw material extraction.

In addition to recycling, green cities encourage composting and promote organic waste management. Composting is the process of decomposing organic waste, such as food scraps and yard trimmings, into nutrient-rich soil amendments. Cities implement composting programs and provide composting facilities or services to residents, businesses, and community gardens. By diverting organic waste from landfills and converting it into compost, cities can minimize methane emissions, improve soil quality, and close the nutrient loop. This approach supports sustainable agriculture, urban greening, and local food production [26].

Emphasizing the concept of the circular economy is another key aspect of waste management in green cities. The circular economy aims to minimize waste generation and maximize resource efficiency by promoting the reuse, repair, and recycling of products. Green cities encourage businesses and consumers to adopt circular economy practices, such as implementing take-back programs for electronic waste, supporting the sharing economy models, and promoting product design that facilitates easy disassembly and recycling. By embracing the principles of the circular economy, cities can reduce waste, conserve resources, and create economic opportunities through the development of sustainable industries and business models.

discussion

Sustainable Development Goals (SDGs) serve as a global roadmap for promoting sustainable development across various sectors. With 17 interlinked goals and 169 targets, the SDGs provide a comprehensive framework to address pressing environmental, social, and economic challenges. When it comes to green city movements, aligning their goals and initiatives with the SDGs enables them to contribute towards the achievement of these global objectives

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[27]. By incorporating the SDGs into their strategies, cities can focus on key areas such as clean energy, sustainable infrastructure, climate action, affordable and clean transportation, and more, thus fostering a sustainable future for their residents [28].

National and local climate action plans play a pivotal role in mitigating the impacts of climate change. These plans are designed to address the specific challenges faced by countries and cities, considering their unique circumstances and vulnerabilities. Typically, these plans outline ambitious targets for reducing greenhouse gas emissions, which serve as a foundation for transitioning to a low-carbon economy. They also emphasize the importance of increasing energy efficiency to minimize energy waste and promote sustainable consumption patterns.

Furthermore, climate action plans prioritize the adoption of renewable energy sources to reduce reliance on fossil fuels and mitigate greenhouse gas emissions. By promoting the deployment of solar, wind, hydro, and other forms of renewable energy, these plans aim to foster a transition towards a more sustainable and climate-resilient energy system. Additionally, they focus on improving public transportation systems, encouraging the use of electric vehicles, and enhancing accessibility to sustainable mobility options. These measures not only help reduce carbon emissions but also contribute to creating cleaner, more efficient, and inclusive transportation networks.

Urban resilience is another critical aspect addressed by climate action plans. With the increasing frequency and intensity of climate-related events, cities need to enhance their resilience to withstand and recover from such shocks. Climate action plans include strategies to improve infrastructure resilience, strengthen disaster preparedness, and enhance adaptive capacity to protect communities and critical systems from climate risks. By integrating climate resilience into urban planning and design, cities can ensure the long-term sustainability and livability of their environments [29]. Sustainable development goals provide a holistic framework for countries and cities to work towards a sustainable future. When green city movements align their goals and initiatives with the SDGs, they can effectively address various aspects of sustainability. National and local climate action plans play a crucial role in this process, as they outline strategies and targets for reducing greenhouse gas emissions, promoting renewable energy, improving public transportation, and enhancing urban resilience [30]. By implementing these plans, cities can contribute to mitigating climate change, improving quality of life, and creating a more sustainable and resilient future for their residents.

Urban planning and zoning regulations play a crucial role in shaping the development of cities and promoting sustainable practices. City governments can utilize these regulations to support green city initiatives and create a more sustainable urban environment. For

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instance, implementing requirements for green building standards ensures that new constructions adhere to energy-efficient and environmentally friendly design principles. These regulations may include guidelines for energy and water efficiency, the use of sustainable materials, and the integration of renewable energy systems [31].

Preserving green spaces is another important aspect of urban planning and zoning regulations. By designating and protecting areas of vegetation, parks, and natural habitats within the city, governments can enhance biodiversity, provide recreational spaces, and improve the overall quality of life for residents. These green spaces contribute to mitigating climate change, improving air and water quality, and creating a healthier and more resilient urban environment [32].

Promoting mixed land-use development is another strategy employed through urban planning and zoning regulations. By encouraging a blend of residential, commercial, and recreational areas within the same neighborhood, cities can reduce the need for long-distance commuting, promote walkability, and enhance access to amenities. This approach not only reduces traffic congestion and carbon emissions but also fosters vibrant and inclusive communities.

Furthermore, urban planning and zoning regulations can prioritize the development of pedestrian and cycling infrastructure. By allocating space for sidewalks, bike lanes, and pedestrian-friendly amenities, cities can encourage active transportation, reduce reliance on cars, and improve public health. These regulations may include requirements for incorporating greenways, bike-sharing programs, and bike parking facilities to create a safe and convenient environment for pedestrians and cyclists.

To further support green city initiatives, governments can establish incentive programs and financial mechanisms. These initiatives provide tangible benefits and incentives for individuals, businesses, and organizations to adopt sustainable practices and invest in green technologies [33]. For example, offering tax incentives for energy-efficient buildings encourages developers and homeowners to incorporate energy-saving measures into their constructions. Similarly, subsidies and grants for renewable energy installations promote the adoption of clean energy sources, contributing to the reduction of greenhouse gas emissions [34].

Additionally, governments can provide low-interest loans and grants for sustainable infrastructure projects. These financial mechanisms enable cities to invest in initiatives such as renewable energy infrastructure, energy-efficient public transportation systems, and green building retrofits. By reducing the financial burden and providing access to capital, these programs facilitate the implementation of sustainable projects that might otherwise be financially challenging [35].

Urban planning and zoning regulations can be leveraged by city governments to support green city initiatives. By

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implementing requirements for green building standards, preserving green spaces, promoting mixed land-use development, and prioritizing pedestrian and cycling infrastructure, cities can foster sustainability and improve quality of life. Furthermore, establishing incentive programs and financial mechanisms, such as tax incentives, subsidies, low-interest loans, and grants, encourages individuals and organizations to adopt green practices and invest in sustainable technologies and infrastructure [36].

Public-Private Partnerships (PPPs) play a vital role in driving the success of green city initiatives. Collaboration between governments and the private sector enables the pooling of resources, expertise, and innovation to implement sustainable infrastructure projects. PPPs can facilitate the development and operation of renewable energy installations, waste management systems, and smart city technologies, among others. By sharing investment costs, risks, and responsibilities, governments and private entities can work together to accelerate the transition towards sustainable urban development [37].

Civic engagement and participation are fundamental to the advancement of green city movements. Governments need to actively involve citizens in decision-making processes and provide platforms for public consultation. By seeking input from residents, policymakers can gain valuable insights, understand local needs and priorities, and ensure that green city policies align with the aspirations of the community. Furthermore, supporting community-led initiatives empowers citizens to take an active role in driving sustainability projects at the local level. This can include grassroots efforts to promote recycling, community gardens, renewable energy cooperatives, and other sustainable practices [38].

Engaging citizens in green city initiatives not only fosters a sense of ownership and pride in the community but also enhances the effectiveness and relevance of sustainability efforts [39]–[41]. By creating opportunities for dialogue, collaboration, and knowledge sharing, governments can tap into the expertise and creativity of their residents [42]. This can lead to innovative solutions, increased public support, and the development of a shared vision for a greener and more sustainable future [43].

Moreover, civic engagement can extend beyond the initial stages of green city planning and continue throughout the implementation and evaluation phases. Regular communication, feedback mechanisms, and transparency in decision-making processes can ensure ongoing engagement and allow for adjustments based on evolving needs and circumstances. By actively involving citizens, governments can build trust, strengthen social cohesion, and create a sense of collective responsibility for the sustainable development of the city.

Public-private partnerships are essential for the success of green city initiatives, as they leverage the

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resources and expertise of both sectors to implement sustainable infrastructure projects [44]. Civic engagement and participation are equally crucial, as they enable governments to incorporate the perspectives and ideas of residents, enhance community-led initiatives, and create a shared vision for sustainable urban development. By fostering collaboration and involving citizens in decision-making processes, governments can tap into the collective wisdom and creativity of their communities, leading to more effective and inclusive green city movements [45].

Monitoring, reporting, and accountability mechanisms are essential components of effective governance structures for green city movements [46]. Governments need to establish robust systems to track progress towards sustainability goals, measure key indicators [47], and report on the outcomes and impacts of their initiatives [48]. This allows for a comprehensive assessment of the effectiveness and efficiency of green city strategies, and provides the necessary information for decision-making and policy adjustments [49].

Monitoring involves the systematic collection and analysis of data to evaluate the implementation and outcomes of green city initiatives. This can include tracking energy consumption, greenhouse gas emissions, waste management practices, air and water quality, and other relevant metrics. By regularly monitoring these indicators, governments can identify trends, measure the success of interventions, and identify areas that require further attention or improvement.

Reporting plays a crucial role in promoting transparency and accountability in green city movements. Governments should establish reporting mechanisms that communicate progress, challenges, and achievements to the public. Regular reports can include information on the status of sustainability goals [50], the implementation of specific projects, financial expenditures, and the overall impact of green city initiatives. Transparent reporting fosters public trust, allows for informed public participation, and facilitates public scrutiny of government actions [51].

Accountability mechanisms are essential to ensure that governments remain committed to their sustainability objectives [52]. This can include establishing clear responsibilities and targets for relevant government agencies, as well as mechanisms for oversight and evaluation. Accountability can be further enhanced through engagement with civil society organizations, independent audits, and public hearings. Holding governments accountable for their actions and progress towards sustainability goals helps maintain momentum, encourages continuous improvement, and reinforces the commitment to creating greener and more sustainable cities.

In addition to government-led monitoring, reporting, and accountability mechanisms, citizen

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engagement can also contribute to the oversight and scrutiny of green city initiatives. By involving the public in the monitoring and reporting process, governments can tap into the collective intelligence and local knowledge of residents. Citizen-generated data, citizen science initiatives, and participatory monitoring can complement official data and provide valuable insights into the lived experiences and perceptions of communities. Monitoring, reporting, and accountability mechanisms are essential for effective governance of green city movements. Establishing systems to monitor key indicators, regularly report progress, and ensure accountability promotes transparency, fosters public trust, and enables evidence-based decision-making. By engaging citizens in the monitoring and reporting process, governments can enhance the accuracy and relevance of data, strengthen community involvement, and create a sense of shared responsibility for achieving sustainability goals.

conclusion

the rapid growth of green city movements worldwide highlights the increasing importance placed on sustainability, resilience, and environmental friendliness in urban development. This research has provided an overview of key policy frameworks and governance structures that contribute to the advancement of green city initiatives. By examining the examples presented, it becomes evident that a multi-faceted approach is necessary to achieve sustainable urban environments.

The United Nations' Sustainable Development Goals (SDGs) serve as a comprehensive framework that guides countries and cities towards a sustainable future. Many green city movements align their goals and initiatives with the SDGs, addressing various aspects of sustainability, including clean energy, sustainable infrastructure, and climate action. By adopting the SDGs as a guiding framework, cities can work collectively towards common objectives and benefit from shared knowledge and resources.

Climate action plans developed at the national and local levels are critical in addressing the challenges posed by climate change. These plans encompass specific targets and strategies aimed at reducing greenhouse gas emissions, improving energy efficiency, enhancing public transportation, promoting renewable energy, and strengthening urban resilience. By integrating climate action into urban planning, cities can effectively mitigate and adapt to the impacts of climate change while promoting sustainable development.

Urban planning and zoning regulations play a crucial role in supporting green city initiatives. Through the implementation of regulations that prioritize green building standards, preserve green spaces, promote mixed land-use development, and prioritize pedestrian and cycling infrastructure, cities can create sustainable and livable environments. These regulations shape the physical and social fabric of cities, ensuring that environmental considerations are

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embedded in urban development practices [53].

Incentive programs and financial mechanisms established by governments serve as catalysts for encouraging green practices and investments. By providing tax incentives for energy-efficient buildings, subsidies for renewable energy installations, low-interest loans for sustainable infrastructure projects, and grants for green innovation and research, governments can stimulate the adoption of sustainable technologies and practices. These mechanisms reduce financial barriers and create economic incentives for individuals, businesses, and organizations to pursue sustainable initiatives [54].

Public-Private Partnerships (PPPs) are instrumental in the successful implementation of green city movements. By facilitating collaborative efforts between governments and the private sector, PPPs leverage shared investment, expertise, and risk to realize sustainable infrastructure projects [55]. These partnerships enable the deployment of renewable energy installations, waste management systems, and smart city technologies, fostering innovation and driving sustainable development.

Active civic engagement and participation are crucial components for the success of green city movements. Governments should establish platforms for public consultation, involve citizens in decision-making processes, and support community-led initiatives. By ensuring that residents' voices and ideas are considered, cities can enhance the legitimacy and effectiveness of green city policies, as well as foster a sense of ownership and pride among citizens [56].

Effective governance structures for green city movements require robust monitoring, reporting, and accountability mechanisms. Governments should establish systems to track progress towards sustainability goals, regularly report on key indicators, and provide mechanisms for public scrutiny [57]. These measures promote transparency, enable evidence-based decision-making, and hold stakeholders accountable for their actions, ensuring that green city initiatives remain on track and achieve their intended objectives [58].

The examples of policy frameworks and governance structures presented in this research illustrate the diverse range of approaches cities can take to foster sustainability, resilience, and environmental friendliness. Understanding and implementing these structures are crucial steps towards creating sustainable, resilient, and environmentally friendly cities. As the global population continues to urbanize, it is imperative that cities embrace the principles and practices of green city movements to ensure a sustainable future for generations to come.

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