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Climate Change Adaptation through Smart Cities in Developing Countries: A Review

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ABSTRACT

Significant problems are presented by climate change for developing nations, especially in metropolitan areas where vulnerabilities are increased by population growth and scarce resources. By utilizing data-driven strategies and technology breakthroughs, smart cities present viable alternatives for adapting to climate change. This study explores the idea of smart city adaptation to climate change in poor nations. It examines the body of research on the effects of climate change in urban settings, considers how smart cities might help address these issues, and suggests successful adaptation tactics. The study also includes case studies from developing nations that have adopted smart city programs in an effort to adapt to climate change, including the precise actions done and their results. The study further outlines obstacles to implementing climate change adaptation in developing nation contexts, such as difficulties with governance and policy as well as technology constraints. Developing nations may increase their resilience, manage resources better, and lessen the effects of climate change on urban populations by utilizing the potential of smart cities.

Keywords: Climate Change, Smart Cities, Technology, Adaptation

INTRODUCTION

Climate change presents enormous issues for developing countries, particularly in metropolitan areas where population increase, limited resources, and insufficient infrastructure heighten vulnerability. Smart cities have emerged as viable solutions for climate change adaptation due to their combination of modern technologies and data-driven techniques. The purpose of this literature review is to investigate the existing body of knowledge on climate change adaptation via smart cities in poor countries, with an emphasis on identifying tactics, difficulties, and possibilities.

Urban regions in developing nations are particularly vulnerable to the effects of climate change, such as extreme weather, rising sea levels, heat waves, and water scarcity. Infrastructure, human health, food security, and economic livelihoods are also impacted by these effects (Cai & Tang, 2021).

The main objective of this research is to assess the potential of smart cities in developing countries as a means of climate change adaptation and identify key strategies and principals for effective implementation.

Role of Smart Cities in Climate Change Adaptation

Utilizing technologies and data analytics, smart cities improve resource management, infrastructure, and urban planning. They combine real-time data collecting, analysis, and decision-making processes to provide viable solutions for adapting to climate change (Siano *et al*., 2018). Smart city efforts can help with adaptive governance, sustainable urban design, efficient energy management, resilient infrastructure, and public engagement in climate action (Nam & Pardo, 2011; Siano *et al*., 2018). Smart cities should focus on Resilience and Infrastructure, Sustainable Resource Management and Decision-Making and Citizen Engagement systems (Simonofski *et al*., 2019). Sensors and data analytics are used by intelligent waste management systems to improve waste collection routes, lowering greenhouse gas emissions and raising recycling rates (Meijer & Bolívar, 2015). For data driven decision making process Based on real-time data and estimates, policymakers can evaluate and rank adaption solutions using sophisticated analytics and modeling tools. (Anthopoulos, 2017).

Case Studies and success stories on Climate Change Adaptation in Developing Countries through Smart Cities

Numerous developing nations have created smart city programs to tackle the issues posed by climate change. For instance, the Smart Cities Mission in India seeks to build sustainable and climate-resilient cities by implementing strategies including the integration of renewable energy, intelligent waste management, and effective water resource management (Kundu, 2020). Similar to this, the Tianjin Eco-City initiative in China emphasizes low-carbon transportation, green infrastructure, and sustainable urban development to improve climate resilience (Cai & Tang, 2021). The second-biggest city in Colombia, Medellin, is confronted with issues including rising temperatures, landslides, and water scarcity as a result of climate change. The city incorporated mitigation and adaptation strategies for climate change under the "Medellin Smart City Strategy," a smart city program. The plan put a lot of emphasis on sustainable mobility, urban greening, and the management and monitoring of water resources through digital technology (Smith *et al*., 2022). Similarly, the extended drought brought on by climate change in 2018 triggered a serious water issue in Cape Town. The city created the "Smart Cape Water Meter," a smart water management system, to increase its resilience (Parks et al., 2019; Angelidou, 2015).

CHALLENGES AND OPPORTUNITIES

Many obstacles must be overcome before climate change adaptation through smart city implementation can be implemented in underdeveloped nations. These obstacles include lack of funding, technological limits, insufficient ability and experience, weak governance frameworks, and socioeconomic inequities. But there are also chances for creativity, teamwork, and information sharing because of these difficulties. These obstacles can be addressed and the potential of smart cities for climate change adaptation unlocked with the aid of public-private partnerships, global cooperation, and capacity-building initiatives.

DISCUSSION

Adapting to climate change in developing countries necessitates strategic approaches and technologies, and smart cities emerge as vital entities in this endeavor. Categorized across the capacity building, management, planning, practice, information, and financing domains, current adaptation initiatives focus on multifaceted resilience. Smart cities can significantly impact adaptation through sustainable urban planning, incorporating green spaces, and fostering eco-friendly practices. Deploying smart infrastructure and energy management technologies enhances efficiency, while resilient transportation systems ensure connectivity during climate extremes. Water management, conservation practices, citizen engagement, and social inclusion constitute key strategies for effective adaptation. The synergy of informed policies, technological innovation, and community involvement positions smart cities as crucial contributors to building resilient urban environments in the face of climate uncertainties.

PROPOSED TECHNOLOGIRS FOR CLIMATE CHANGE ADAPTATIONS

Climate change adaptation in smart cities comprises a variety of techniques and technology aimed at increasing resilience and mitigating the effects of climate change (Schaffers et.al, 2011; Parks et al., 2019; Komninos, 2013).

1. IoT Sensors: In order to gather real-time data on a variety of environmental characteristics, including temperature, humidity, air quality, water levels, and energy consumption, Internet of Things (IoT) sensors should be installed throughout the city (Bibri, 2018).
2. Big Data Analytics: The enormous volume of data that is gathered from multiple sources in smart cities is processed and analyzed using big data analytics techniques for real-time decision making.
3. Real-time Monitoring and Control Systems: Climate-related factors, infrastructure performance, and resource consumption are tracked using real-time monitoring systems. These systems give real-time notifications and allow for quick reactions to climate-related catastrophes such as floods, heatwaves, or spikes.
4. Geographic Information System (GIS): GIS are used to map and visualize spatial data about climate change risks, such as infrastructure networks, green spaces, and flood-prone areas. It facilitates risk

assessment, spatial planning, and the selection of appropriate sites for initiatives aimed at adapting to climate change.

5. Renewable Energy Systems: Renewable energy technologies including solar panels, wind turbines, and energy storage devices are frequently integrated into smart cities. In the face of climate change, these technologies assist lower greenhouse gas emissions and improve energy efficiency.
6. Intelligent Transportation Systems: Intelligent transportation systems make use of technology including smart mobility solutions, real-time data processing, and traffic sensors.
7. Water Management Technologies: Several technologies are used by smart cities to effectively manage their water supplies such as Smart irrigation systems, leak detection systems and IoT based water sensors (Yang et al., 2022).

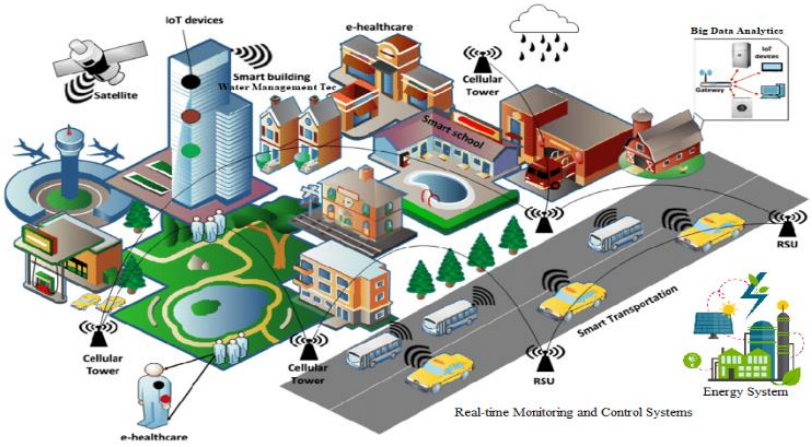

Figure 1Technologies for Smart City

PROPOSED PRINCIPLES FOR CLIMATE CHANGE ADAPTATION VIA SMART CITIES

Strategic Principles for Climate-Smart Cities include increasing citizen engagement through programs for and with citizens, assisting vulnerable groups in participating, and allowing a broader range of experiences and knowledge to work together to develop solutions to harness collective wisdom. To address local climate concerns, the strategy focuses on citizen-identified and scenario-based challenges, gathering and compiling data for designing adaption strategies, and guiding urban infrastructure resilience. Activities include aligning with current urban planning procedures, correcting data gaps, and connecting with existing information systems. Local co-creation is encouraged, harnessing local innovation ecosystems and skills and facilitating social adoption of collaboratively designed measures. Sustainability planning involves short-term actions, stakeholder engagement, and clear communication while aligning with local, regional, and national strategies. Transferability and upscaling are facilitated through knowledge management, documentation of good practices, feedback loops, and knowledge dissemination. Responsible data use includes compliance with standards, addressing cybersecurity and data protection risks, and enhancing citizens' digital competencies. Open source solutions are prioritized to reduce dependencies, foster collaboration, and customize existing tools (GIZ,2023).

Figure 2Principles for Climate Change Adaptation

CONCLUSION

This study draws attention to the increased interest and possibilities for smart city adaptation to climate change in developing nations. It highlights the significance of context-specific tactics, taking into account the particular difficulties that developing-nation cities face. climate change adaptation through smart cities presents a promising approach for developing countries. By leveraging innovative technologies and data-driven solutions, smart cities have the potential to enhance resilience and mitigate the impacts of climate change. These cities can efficiently manage resources, optimize energy consumption, and improve infrastructure to withstand extreme weather events. Understanding the role of smart cities in climate change adaptation and tackling implementation challenges can help to construct more resilient and sustainable urban settings and encourage citizen engagement in the face of climate change. In addition to investigating novel strategies that incorporate social, economic, and environmental concerns, more study is required to evaluate the efficacy and long-term effects of smart city projects in developing nations. It is crucial for policymakers, urban planners, and communities to work together to harness the full potential of smart cities and create a sustainable future in the face of climate change.

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