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Characteristics of Environmental Change and Sustainable Development Ways in the Urbanization Process

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Abstract: As time elapses, a growing number of countries have either experienced urbanization or are currently in the process of it. Urbanization is a process typified by the growth of economic activities and the increase in population density within urban areas.This transformation can significantly drive economic growth, foster innovation, and promote societal progress. However, it also brings about various environmental impacts, both positive and negative. Sustainable management of these changes is necessary to maintain a balance between urban expansion and ecological preservation. Although urbanization is an unavoidable and frequently advantageous process, its long-term viability hinges on people's capacity to manage it responsibly. This study analyzes the multifaceted environmental changes accompanying urbanization, focusing on aspects such as air quality, water resources, land use, and biodiversity. By embracing sustainable development pathways, policymakers, planners, and communities can forge resilient, equitable, and eco-friendly cities in an era of accelerating urbanization.

Keywords: Urbanization process, environmental change, sustainable development, biodiversity, low-carcon development

1. Introduction

Urbanization has a huge impact on economies, society, and landscapes. It can reshape the way people live, work, and interact with their environment. Cities become centers of opportunity as they expand to handle growing populations and economic activity [1]. However, this rapid growth also brings about significant environmental changes that pose challenges to sustainability. The expansion of urban areas changes ecosystems, increases resource consumption, and contributes to climate change, pollution, and biodiversity loss [2]. These shifts pose serious challenges to sustainability, emphasizing the need for development paths that balance urban growth with ecological integrity and social well-being. Understanding the characteristics of environmental change in the urbanization process is also important for developing sustainable development strategies. Urbanization can be reconciled with the global sustainable development goals through the adoption of clean energy, low-carbon development and other solutions [3]. This study provides insights into the interactions between urbanization and environmental change, highlighting the challenges and potential solutions for ensuring a sustainable future for urban environments. This study also reveals the intricate relationships between urbanization and environmental change. This study has research implications. First of all, it provides people with a clearer understanding of the drivers behind resource depletion, pollution, and habitat loss in rapidly

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expanding cities. Policy - makers or urban planners can then formulate and implement targeted strategies to avoid negative ecological impacts. Secondly, this study promotes public participation and cross - sector collaboration. Different sectors, such as governments, communities and corporations, should collaborate to protect the environment, which will enhance the quality of life for current and future generations.

2. Environmental change in urbanization

Rapid urbanization has a profound impact on the environment. It affects the climate system, natural resources and ecosystems. As cities expand to accommodate growing populations and economic activities, vast amounts of land are consumed, often at the expense of forests, wetlands, and agricultural areas. This transformation alters local and global climate patterns by replacing natural vegetation with heat-absorbing concrete and will contribute to the urban heat island effect. At the same time it aggravates to climate change through increased greenhouse gas emissions from industries, transportation, and energy use. Cities can generate significant air, water, and soil contaminants. Urbanization poses severe threats to biodiversity, disrupting ecosystems and accelerating species extinction. Challenges such as climate change, pollution, resource degradation and biodiversity loss are becoming increasingly prominent.

2.1. Climate change

There are two main ways that urbanization considerably exacerbates climate change: increased greenhouse gas emissions and the creation of urban heat islands. The vulnerability to climate change will rise as a result of urbanization. Trends in exposure and vulnerability to climate extremes have been influenced by urbanization, changes in socioeconomic situations, and settlement patterns [4]. The temperatures are higher in cities compared to rural areas, a phenomenon known as the “urban heat island” [5]. Dense impervious surfaces, such as concrete and asphalt, absorb and re-radiate solar energy, and then elevate urban temperatures by up to 5°C [6]. Figure 1 illustrates the impact of urbanization on temperature. This feedback loop between energy use and temperature rise further entrenches urban vulnerability to climate change. Dense infrastructure, like buildings and roads, absorbs and retains heat, thereby leading to localized temperature increases. This phenomenon not only increases cooling energy demand but also disrupts regional weather patterns. In addition, the urban heat island effect interacts with global climate trends and may exacerbate risks such as extreme precipitation events and prolonged droughts. The concentration of populations and economic activities in urban areas amplifies fossil fuel consumption. Therefore, it directly contributes to atmospheric warming and global climate destabilization [8].

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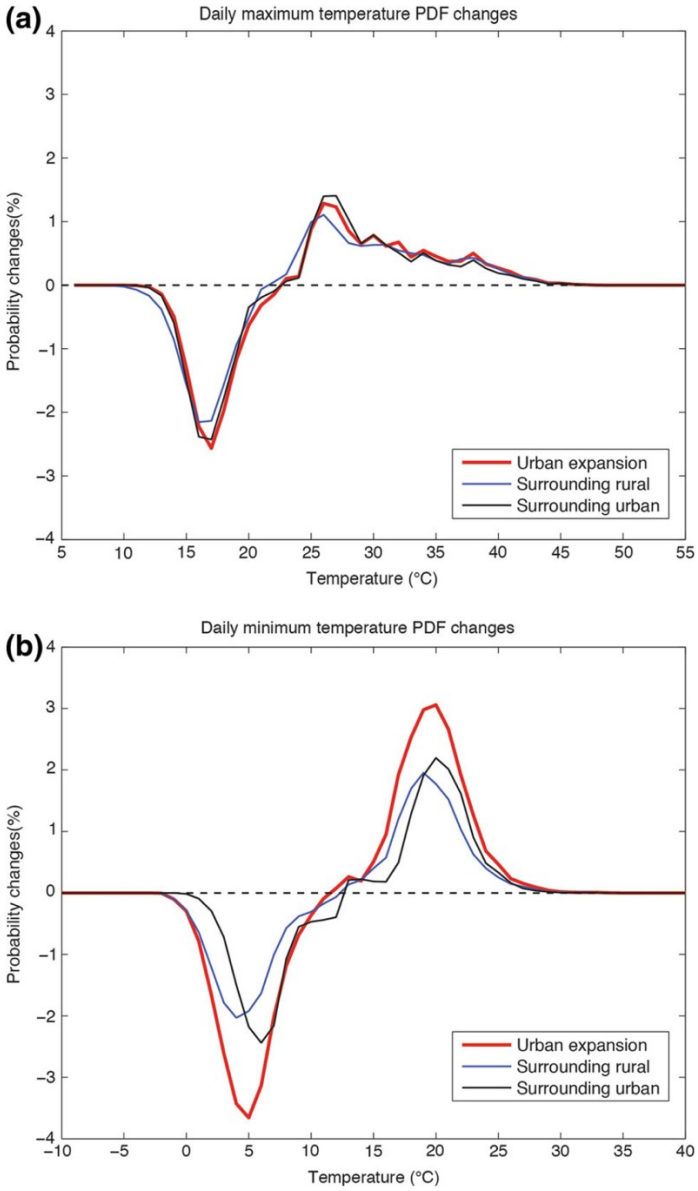

Figure 1: Changes in the probability distribution for daily maximum (a) and minimum (b) temperature over areas with projected land use changes (red) and the surroundings with no land use changes: urban (black) and rural (blue) [7]

2.2. Pollutants (air, soil, water resources)

Urban areas are significant sources of pollutants, generating vast amounts of waste, industrial emissions, and vehicular exhaust. These pollutants severely degrade air, soil, and water quality, and pose substantial risks to both the environment and human health. As seen in Table 1. The rapid pace of urbanization has intensified these issues, as cities expand to accommodate growing populations and economic activities. Both generators and receivers of air and water pollution are urban areas. In urbanized and urbanizing areas, combustion sources (such as vehicles and power plants) release nitrogen oxides, ozone, volatile organic compounds, other reactive gases, and aerosols [9]. The expansion of transportation networks in cities further exacerbates pollution levels, as increased vehicular traffic emits carbon monoxide (CO), hydrocarbons, and nitrogen oxides, contributing to

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smog and poor air quality [10]. Industrialization is a core component of urban development. It releases large quantities of chemical waste, heavy metals, and toxic substances into the environment. These pollutants often exceed the natural capacity of ecosystems to absorb and degrade them and then lead to persistent environmental pollution. For example, industrial activities such as manufacturing, mining, and energy production emit sulfur dioxide (SO2), nitrogen dioxides (NO2), and tropospheric ozone (O3), which contribute to air pollution and respiratory diseases [11]. Industrialization is also a major source of soil contamination. Factories and manufacturing plants release heavy metals and toxic chemicals into the soil through improper waste disposal, accidental spills, and emissions. The prevalence of heavy metal (loid) pollution in soils at industrial sites varies depending on the type of industry. It can result from emissions from high-temperature processes, accidents, and fires, as well as from the dust and spills of raw materials, wastes, finished products, and fuel ash [12]. Improper disposal of solid waste can be a significant source of pollution. Pesticides seep into water bodies via surface runoff from agricultural fields and residential lawns. Meanwhile, industrial plants and chemical processing facilities discharge wastewater that contains toxic metals like lead, mercury, and chromium, which further aggravates environmental pollution [13].

Table 1: Pollutants in air, soil and water

Air	Soil	Water
Particulate matter	Heavy metal	Heavy metal
Nitrogen oxides and sulfur oxides	Toxic chemals	Microplastic
Volatile organic compound	Organic pollutants	Pathogens
Carbon monoxide and carbon dioxide	Microplastic and plastic	Phosphates and nitrates

2.3. Biodiversity

Biological diversity is the variety of life and refers to the diversity of biological organization at all levels [14]. It is essential for maintaining ecological balance and providing critical services such as pollination, water purification, and climate regulation. Rapid urbanization threatens biodiversity by upsetting ecosystems and hastening the extinction of species. As cities expand, natural habitats such as forests, wetlands, and grasslands are fragmented or destroyed to make way for infrastructure, housing, and industrial zones. One of the main causes of the decline in biodiversity is habitat loss, which displaces local species and lowers genetic diversity. For instance, in New England, forest habitats that were lost due to logging and farming are being restored through biological succession. However, the majority of the urbanized areas in this region not only still remain but are also expanding and threatening other local ecosystems[15]. Urbanization negatively affects mainly plants. This is because fragmentation due to land cover change has reduced the species richness of plant communities. Low habitat fragment connectivity also leads to less diverse and less efficient insect pollination and because of this, plants showed a decrease in reproductive success [16].

3. Introduction of measures for sustainable development

3.1. Adoption of clean energy

As cities grow, their energy demands grow exponentially, and their reliance on fossil fuels intensifies pollution and accelerates climate change. The concept of clean energy emerged in response to the environmental and economic challenges posed by fossil fuels. Transitioning to clean energy—renewable and sustainable energy sources such as solar, wind, hydropower, and geothermal—offers

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a viable solution to reduce carbon footprints, mitigate environmental degradation, and ensure long-term energy security. Clean energy is derived from natural processes that are replenished continuously. It is an environmentally friendly alternative to finite fossil fuels like coal, oil, and natural gas. Clean energy encompasses a range of renewable sources: solar energy, wind energy, hydropower, geothermal energy and so on. In order to solve the world's energy problems, clean energy systems are expected to have no negative impacts on the economy, ecology, future generations' resources, or sustainability [17]. Clean energy technologies have advanced significantly in recent decades. Solar energy, in particular, has witnessed growth in electricity generation, water desalination, and heat production. The advantages of solar energy technology are that it is a clean, renewable energy source, which is abundant, less costly, requires less maintenance, and is environmentally friendly[18]. Hydropower remains the largest source of renewable electricity globally. Geothermal resources are considered for Iceland’s energy system [19]. However, there are still some barriers to clean energy systems such as a lack of cooperation with political authorities and enterprises, low energy density, lack of affordability, high initial investment and installation [17]. Additionally, some regions lack the natural resources or technological capacity to develop certain types of clean energy.

3.2. Low carbon development

Low-carbon development is another important strategy for sustainable urbanization, focusing on minimizing carbon emissions from all aspects of urban life. It includes energy production, transportation, infrastructure, industrial activities and a range of practices and policies designed to reduce carbon footprints.

The adoption of clean energy and low-carbon development are closely linked. Renewable energy is the foundation of low-carbon strategies, powering cities with minimal environmental impact. At the same time, low-carbon urban planning optimizes energy use and maximizes the efficiency of clean energy systems. These approaches create a virtuous cycle of long-term sustainability. In order to promote the growth of non-carbon-intensive modes of mobility, such as walking, bicycling, and public transportation, low-carbon governance zoning calls for diverse land uses and equitable density. Denser development also reduces the amount of energy required for heating. To aid in cooling and lessen the urban heat island effect, low-carbon zoning must also include open space [20].

4. Conclusion

Urbanization brings both challenges and opportunities. It can reshape the environment while driving economic and social growth. Its environmental impacts, such as climate change, pollution, resource depletion and biodiversity loss, have shown the necessity for sustainable development strategies. By implementing sustainable urban development measures (for example, cutting down carbon emissions and using clean energy), cities can be turned into centers of environmental resilience and innovation.

As cities expand, the transformation of natural landscapes into urban areas disrupts soil ecosystems and introduces a variety of contaminants. These pollutants degrade soil quality, threaten biodiversity, and pose risks to human health through the food chain.

The link between urbanization and pollution lies in the transformation of land use and economic activities. As rural areas transition into urban centers, industrialization becomes a dominant force, driven by the need for economic growth and job creation. However, this industrial growth often prioritizes productivity over environmental sustainability, leading to the release of untreated or inadequately treated waste into the environment.

This study highlights the complex interplay between urbanization and environmental change, emphasizing the need for integrated, sustainable solutions. Adopting clean energy and low-carbon

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development is a global necessity. The amount of literature used in this paper is limited, and this paper discusses only a few of these problems and solutions to urbanization and environmental change. There are some barriers to measuring of sustainable development. Future research could incorporate more literature and use empirical studies to explore integrated, sustainable solutions to make the Earth a more livable place.

References

[1] Sukanya, R. and Tantia, V. (2023). Urbanization and the Impact on Economic Development. [online] www.igi-global.com. Available at: https://www.igi-global.com/chapter/urbanization-and-the-impact-on-economic-development/327396.

[2] Zeng, C., Deng, X., Dong, J. and Hu, P. (2016). Urbanization and Sustainability: Comparison of the Processes in 'BIC' Countries. Sustainability, 8(4), p.400. doi:https://doi.org/10.3390/su8040400.

[3] Cui, L., Weng, S., Nadeem, A.M., Rafique, M.Z. and Shahzad, U. (2022). Exploring the role of renewable energy, urbanization and structural change for environmental sustainability: Comparative analysis for practical implications. Renewable Energy, [online] 184, pp.215–224. doi:https://doi.org/10.1016/j.renene.2021.11.075.

[4] Garschagen, M., & Romero-Lankao, P. (2013). Exploring the relationships between urbanization trends and climate change vulnerability. Climatic Change, 133(1), 37–52. https://doi.org/10.1007/s10584-013-0812-6

[5] Chapman, S., Watson, J. E. M., Salazar, A., Thatcher, M., & McAlpine, C. A. (2017). The impact of urbanization and climate change on urban temperatures: a systematic review. Landscape Ecology, 32(10), 1921–1935. https://doi.org/10.1007/s10980-017-0561-4

[6] Oke, T.R. (1982). The energetic basis of the urban heat island. Quarterly Journal of the Royal Meteorological Society, [online] 108(455), pp.1–24. doi:https://doi.org/10.1002/qj.49710845502.

[7] Argüeso, D., Evans, J.P., Fita, L. and Bormann, K.J. (2013). Temperature response to future urbanization and climate change. Climate Dynamics, 42(7-8), pp.2183–2199. doi:https://doi.org/10.1007/s00382-013-1789-6.

[8] Intergovernmental Panel on Climate Change (2021). Climate Change 2021: The Physical Science Basis. [online] IPCC. Available at: https://www.ipcc.ch/report/ar6/wg1/.

[9] Grimm, N.B., Foster, D., Groffman, P., Grove, J.M., Hopkinson, C.S., Nadelhoffer, K.J., Pataki, D.E. and Peters, D.P. (2008). The changing landscape: ecosystem responses to urbanization and pollution across climatic and societal gradients. Frontiers in Ecology and the Environment, 6(5), pp.264–272. doi:https://doi.org/10.1890/070147.

[10] Gurjar, B.R., Butler, T.M., Lawrence, M.G. and Lelieveld, J. (2008). Evaluation of emissions and air quality in megacities. Atmospheric Environment, 42(7), pp.1593–1606. doi:https://doi.org/10.1016/j.atmosenv.2007.10.048.

[11] A. Nakhjiri and A.A. Kakroodi (2024). Air pollution in industrial clusters: A comprehensive analysis and prediction using multi-source data. Ecological informatics, 80, pp.102504–102504. doi:https://doi.org/10.1016/j.ecoinf.2024.102504.

[12] Alloway, B.J. (2012). Sources of Heavy Metals and Metalloids in Soils. Environmental Pollution, [online] 22, pp.11–50. doi:https://doi.org/10.1007/978-94-007-4470-7_2.

[13] Saxena, V. (2025). Water Quality, Air Pollution, and Climate Change: Investigating the Environmental Impacts of Industrialization and Urbanization. Water, Air, & Soil Pollution, 236(2). doi:https://doi.org/10.1007/s11270-024-07702-4.

[14] Gaston, K.J. and Spicer, J.I. (2012). Biodiversity : an introduction. Malden: Blackwell Publishing.

[15] McKINNEY, M.L. (2002). Urbanization, Biodiversity, and Conservation. BioScience, [online] 52(10), pp.883–890. doi:https://doi.org/10.1641/0006-3568(2002)052[0883:ubac]2.0.co;2.

[16] Ruas, R. de B., Costa, L.M.S. and Bered, F. (2022). Urbanization driving changes in plant species and communities – A global view. Global Ecology and Conservation, [online] 38, p.e02243. doi:https://doi.org/10.1016/j.gecco.2022.e02243.

[17] Dincer, I. and Acar, C. (2015). A review on clean energy solutions for better sustainability. International Journal of Energy Research, 39(5), pp.585–606. doi:https://doi.org/10.1002/er.3329.

[18] Maka, A.O.M. and Alabid, J.M. (2022). Solar energy technology and its roles in sustainable development. [online] Oup.com. Available at: https://academic.oup.com/ce/article/6/3/476/6606003.

[19] Spittler, N., Davidsdottir, B., Shafiei, E., Leaver, J., Asgeirsson, E.I. and Stefansson, H. (2020). The role of geothermal resources in sustainable power system planning in Iceland. Renewable Energy, 153, pp.1081–1090. doi:https://doi.org/10.1016/j.renene.2020.02.046.

[20] Feng, X., Wang, S., Wu, N., Li, Y. and Yang, J. (2024). Urban low-carbon governance zoning coupled with urban attributes and spatial networks: Theoretical framework and practical path. Journal of Environmental Management, [online] 373, p.123865. doi:https://doi.org/10.1016/j.jenvman.2024.123865.