

# Urban Development and Sustainable Land Resource Management: An Ecological Geological Perspective

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**Abstract:** This paper delves into the crucial role of ecogeology in urban development and land resource management. Ecogeology integrates principles of geology, ecology, and urban planning to achieve a balance between urban growth and the preservation of the natural environment. The article emphasizes the core principles, methods, and applications of ecogeology in urban planning to foster sustainable urban development. The section on challenges in urban development and sustainable land resource management highlights issues such as rapid global urbanization, land fragmentation, and ecosystem degradation. Urbanization trends place significant demands on land resources, but they also come with resource scarcity, environmental burdens, and social issues. Land fragmentation results in the fragmentation of natural landscapes, while ecosystem degradation threatens biodiversity and ecosystem services. These challenges require comprehensive approaches, and ecogeology provides a promising avenue. The paper further explores successful cases and best practices, including projects in Singapore, Kutzbachstadt (Germany), Shenzhen, and others. These cases demonstrate how ecogeology successfully enhances urban environmental quality and improves the quality of life for urban residents through measures such as wetland restoration, green infrastructure, nature conservation, and urban green spaces. The future outlook section emphasizes the importance of sustainable urban planning, climate change adaptation, and technological innovation. Cities will continue to expand, climate change will persist in affecting the environment, and technological innovation will drive modern urban management.

**Keywords:** Urban Development; Land Utilization; Ecological Geology; Development Planning.

## 1. Introduction

Urbanization is one of the prevailing trends in today's world. According to the United Nations' estimates, the global urban population is expected to comprise 70% of the total population by 2050 (Figure 1). This rapid growth of urban populations implies increased demands for land, resources, and infrastructure in urban areas to meet the needs for housing, food, water, and energy [1,2]. However, urban expansion and land development have also given rise to a series of significant challenges, including land fragmentation, ecosystem degradation, climate change, and resource waste. As cities expand, land resources become increasingly scarce. Land fragmentation is a severe issue, as agricultural land, forests, and wetlands in peri-urban areas are continuously divided and developed, resulting in ecosystem degradation, loss of biodiversity, and increased natural disasters[3-5]. These problems not only impact the health of ecosystems but also have adverse effects on the quality of life for urban residents[6]. Moreover, unsustainable urban sprawl leads to the wastage of significant resources, including land, water, energy, and materials. This not only results in resource shortages but also exacerbates environmental issues such as air and water pollution and climate change. Therefore, a comprehensive approach is required to balance the demands of urban development and sustainable land resource management, precisely what an ecogeological perspective offers.

Ecogeology, as a comprehensive approach, integrates the principles of geology, ecology, and urban planning. It aids in better understanding the urban geological environment, ecosystem services, and the sustainable management of land resources. Through the lens of ecogeology, we can identify the connections between the potential value of land resources, the health of ecosystems, and sustainable urban development.

Ecogeology provides a holistic approach to introducing the concept of ecosystem services in urban planning and land resource management to achieve sustainable development goals.

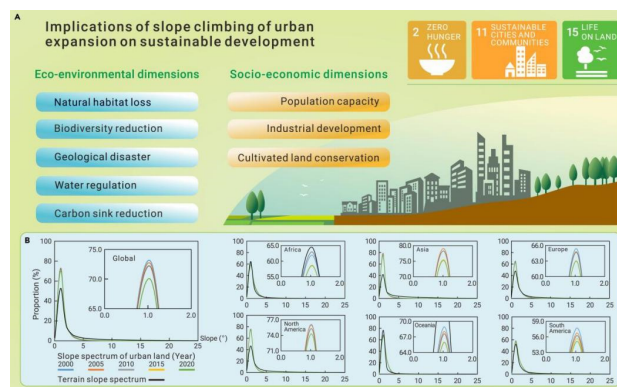


Figure 1. Implications of slope climbing of urban expansion on sustainable development [7]

## 2. Challenges in Urban Development and Sustainable Land Resource Management

### 2.1. Urbanization Trends

The continuous global growth of urbanization is one of the most significant challenges facing society today. The trend of urbanization not only accelerates the expansion of urban areas but also results in population reduction in rural areas, the conversion of agricultural land, and increased infrastructure demands. This rapid urbanization can lead to several issues, including land resource scarcity, traffic congestion, housing shortages, and ecosystem degradation[8]. Taking China as an example, China has experienced an unprecedented wave of

urbanization, with the urbanization rate increasing from less than 20% in the 1980s to nearly 60% at present. This has led to significant land use changes, including the conversion of agricultural land into urban use, the loss of forests and wetlands, and an increase in air and water pollution.

## 2.2. Land Fragmentation

Rapid urban expansion is often accompanied by land fragmentation, which refers to the division of natural areas such as farmland, forests, and wetlands into smaller, separate parcels due to urban development, road construction, and infrastructure projects[9]. Land fragmentation not only results in the wastage of land resources but also has a destructive impact on ecosystems, including biodiversity loss, interruptions in ecosystem services, and an increase in natural disasters. Urban expansion in the United States typically goes hand in hand with suburban land fragmentation[10]. This leads to the division of once-continuous natural landscapes by roads, residential areas, and commercial zones, disrupting wildlife migration corridors, increasing the risk of wildfires, and impeding the protection and restoration of natural habitats.

## 2.3. Ecosystem Degradation

Urban development often involves land clearing and construction, which has adverse impacts on the surrounding natural ecosystems. Ecosystem degradation includes wetland filling, deforestation, soil erosion, among others, which disrupt ecosystem services such as water purification, climate regulation, and food supply. Urbanization in regions like the Amazon rainforest has resulted in extensive deforestation[11], causing severe damage to the ecosystem. The loss of forests not only affects regional biodiversity but also leads to increased carbon emissions, exacerbating global climate change issues.

# 3. Successful Cases and Best Practices

## 3.1. Singapore - Eco-City Planning

Singapore is widely regarded as a model of eco-city planning. The country actively employs the principles and methods of eco-geology to enhance the quality of the urban environment. By protecting and restoring natural habitats and developing green infrastructure, such as urban parks and wetland reserves, Singapore has successfully improved air and water quality, elevating the quality of life for its residents[12]. Moreover, Singapore actively adopts water-saving and energy-efficient technologies to reduce resource wastage and carbon emissions. Notable examples include the Sungei Buloh Wetland Reserve, a wetland conservation area that provides a habitat for rare wildlife and attracts ecotourism, offering urban residents a peaceful escape from the hustle and bustle of the city.

## 3.2. Kuttigen, Germany - Sustainable Urban Development with Eco-Geology

Kuttigen, a city in Germany, is renowned for its sustainable urban development that incorporates eco-geological principles, merging urban planning with natural environment preservation. By optimizing land use and waste management, Kuttigen has successfully reduced energy and resource wastage while improving energy efficiency. Additionally, the city's green infrastructure network, including urban gardens and bike paths, enhances the quality of life for its residents, promoting both health and sustainable mobility. Kuttigen's

example demonstrates how urban planning guided by eco-geological principles, including the creation of green infrastructure and sustainable transportation systems, can enhance the urban environment, foster residents' well-being, and encourage sustainable lifestyles.

## 3.3. Calgary, Canada - Balancing Natural Habitat Preservation with Urban Expansion

Calgary, a Canadian city, embraces eco-geological principles to balance urban expansion with the preservation of natural habitats. Urban planners collaborate with conservation organizations to protect wetlands and wildlife habitats in the city's surrounding areas. This not only contributes to the maintenance of ecosystem health but also enhances the quality of life for urban residents by providing opportunities for enjoying nature and outdoor activities. Calgary's wetland preserves, such as Fish Creek Provincial Park, offer the city a valuable oasis, attracting residents and tourists to experience nature. This successful practice emphasizes the balance between urban development and nature conservation to achieve sustainable urban development.

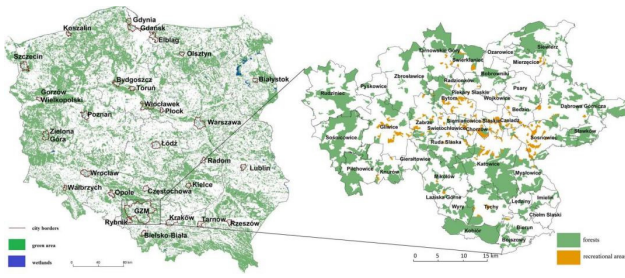
## 3.4. Shenzhen - Green City Demonstration Zone

Shenzhen, as a rapidly developing city in China, has taken proactive measures to promote eco-geology and sustainable urban development. Shenzhen's Green City Demonstration Zone project aims to integrate urban planning with ecosystem protection and restoration through eco-geological principles. Key focuses of this project include wetland restoration, increased green spaces, waste sorting, and wastewater treatment. Shenzhen's success illustrates how cities can protect and improve the natural environment throughout the urbanization process through eco-geological approaches.

# 4. Future Outlook

The future trends of eco-geology will emphasize sustainable urban planning, including increasing urban density, improving transportation systems, promoting energy-efficient buildings, expanding the use of renewable energy, and reducing waste generation[13,14] (Figure 2). These efforts will help reduce the carbon footprint of cities, improve air and water quality, and enhance the quality of life in urban areas. Eco-geology can assist urban planners and policymakers in better addressing climate change, including rising sea levels, extreme weather events, and temperature increases. Future cities will need to adopt more green infrastructure, such as coastal protection projects, urban forests, and stormwater management systems, to mitigate the adverse impacts of climate change[15].

Technological innovation will continue to play a crucial role in eco-geology. Smart city technologies, big data analytics, artificial intelligence, and the Internet of Things will be used to enhance the efficiency of urban planning and resource management. For example, smart sensors can be employed to monitor environmental quality in cities and automate waste management and energy consumption. These innovative technologies will provide more data and insights to help cities better understand and address their challenges.



**Figure 2.** Poland's largest cities against green areas based on Corine Land Cover 2018 land cover database [16].

## 5. Conclusion

Eco-geology, as a comprehensive approach that combines principles from geology, ecology, and urban planning, has played a crucial role in urban development and land resource management. This article delves into the fundamental principles and methods of eco-geology and how it is applied in urban planning and land management. By analyzing successful case studies and best practices, we can clearly see how eco-geology helps cities achieve sustainable development goals.

Regarding the challenges in urban development and land resource management, the rapid growth of urbanization, land fragmentation, and ecosystem destruction are the real issues we must confront. Cities need more land and resources, but this also brings threats to ecosystems and environmental degradation. However, eco-geology offers a comprehensive approach that can balance the demands of urban development with sustainable land resource management. It does so by utilizing the concept of ecosystem services, helping us better understand the value of land resources and promoting sustainability in urban planning and resource management.

In terms of future outlook, we see the potential and significance of eco-geology. Cities will continue to expand, climate change will continue to threaten our environment, and technological innovation will provide new tools for urban management. In the future, there is a need to focus on sustainable urban planning, emphasize environmental protection, address the challenges of climate change, and place public education and engagement at the forefront of the agenda.

## Acknowledgments

This work was funded by the project of Shaanxi Province Land Engineering Construction Group (DJNY-YB-2023-20).

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