

Abstract

As global urbanization progresses rapidly, more than half of the world's population now resides in urban areas, a number that is expected to increase in the future. This rapid urbanization poses multiple challenges for city managers, including resource reutilization, environmental protection, sustainable economic construction, and social welfare. In this context, the quick and efficient assessment and optimal management of building stocks become crucial for ensuring sustainable urban development. Building stocks not only impact resource utilization during construction and energy efficiency in operation but also have implications for environmental benefits and social welfare. Traditional research often faces challenges in accurate building attribute assessment and effective analysis methods, leading to inadequate resource allocation and inefficient policies for city managers. However, with the rapid development and widespread adoption of machine learning and remote sensing technologies, we now have ample data and efficient methods to address these challenges. These technologies assist urban planners in more accurately understanding the distribution and composition of urban stocks, thereby effectively enhancing urban resource utilization and energy efficiency, and ultimately promoting sustainable development of the entire city.

This dissertation aims to explore the distribution and composition of urban building stocks in different regions and their role in global sustainable development using machine learning and remote sensing technologies. Through three specific case studies, the dissertation showcases the tremendous potential of emerging technologies and data in exploring regional building stocks. The application of these technologies is intended to address significant challenges in urban planning and resource management, particularly in improving resource utilization efficiency and reducing environmental impacts.

Firstly, we utilize nighttime light data and machine learning to explore the spatiotemporal distribution of key construction materials such as steel, aluminum, and cement globally from 2000 to 2019. The analysis reveals spatial patterns of material accumulation in the urbanization process, providing a comprehensive picture of global anthropogenic stocks. The refined results can assist in systematically revealing the spatiotemporal dynamics of materials accumulation worldwide, including discrepancies in distribution between and within cities. This database serves as a reliable source of spatial information to support waste management, circular economy, spatial planning, urban sustainability, and climate change mitigation on different geographical levels.

Then, shifting to a more microscopic perspective, we explore using deep learning and remote sensing technologies to identify exterior wall and roofing materials in four major cities in Denmark. This part aims to deconstruct specific attributes of building stocks, aiming to furnish more intricate and detailed insights for the formulation of policies geared towards sustainable urban development. Additionally, we delineate a methodological framework for identifying building material, encompassing research background, data preparation, model development, and expansion, and address challenges encountered in the development and deployment of sophisticated models. These case studies are designed to illustrate the transformative impact of emerging technologies on traditional methods of data acquisition and analysis, thereby tackling the challenges of the future.

Finally, leveraging comprehensive cadastral data from Denmark, we conduct an integrated analysis of stocks with economic and environmental indicators. The analysis focuses on the role of building stocks in promoting urban mining and sustainable development, combining technical analysis with practical urban policy development. This part showcases how emerging technologies offer valuable data resources and novel analytical perspectives and creative approaches to urban managers in the pursuit of green and sustainable urban progress.

In summary, this dissertation demonstrates through three specific case studies the application of machine learning and remote sensing technologies in global sustainable development, highlighting the potential of these technologies in improving urban planning efficiency and promoting material recycling. The dissertation aims to discuss how these technologies can more effectively manage urban building stocks, thereby promoting regional and global urban sustainable development.