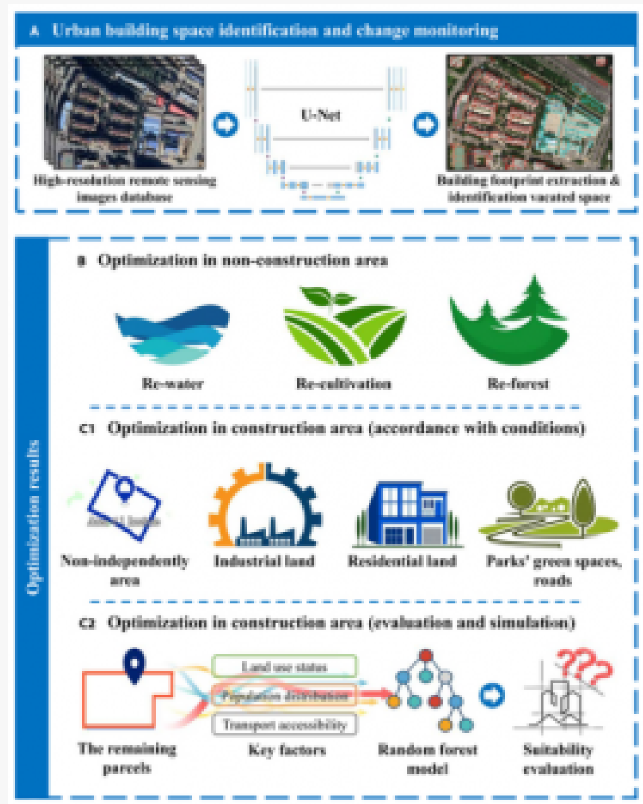
Intelligent planning unlocks sustainable city futures

FAYETTEVILLE, GA, UNITED STATES, October 7, 2025 /EINPresswire.com/ -- Researchers have developed an AI-driven framework to optimize urban space use in megacities. Using deep learning and high-resolution satellite data, the study tracked building dynamics in Beijing and proposed strategies for repurposing vacated areas into farmland, forests, or public facilities.



The proposed framework of urban space monitoring and optimization.

As global urbanization accelerates, megacities face mounting challenges in balancing population growth, land scarcity, and environmental protection. Traditional expansion-oriented planning has given way to strategies emphasizing "Quantity Reduction and Quality Enhancement," aiming to improve urban land quality rather than expand its footprint. However, repurposing vacated or underutilized urban spaces has often relied on qualitative planning rather than quantitative decision-making. Based on these challenges, there is a pressing need for robust, AI-powered methods to dynamically monitor building changes and provide scientific guidance for reusing urban space, ensuring sustainable growth and improved ecological outcomes.

A study (DOI: 10.34133/remotesensing.0748) by Tsinghua University, China Agricultural University, and collaborating institutions, published on July 31, 2025 in the Journal of Remote Sensing, introduces an AI-powered framework for urban space optimization. Focusing on Beijing as a case study, the research applies deep learning and remote sensing to identify building changes between 2018 and 2019, and machine learning to simulate optimal reuse of vacated spaces. This innovation addresses pressing urban challenges such as land scarcity, ecological preservation, and sustainable development by providing actionable insights for policymakers and planners.

The research demonstrated that Beijing's building footprint shrank by 7.2% from 2018 to 2019, equivalent to a net reduction of 76.24 km^2. Most of this decline occurred in ecological and agricultural zones, reflecting successful policy-driven efforts to protect green and arable land. The AI models identified optimal reuse of vacated areas: forests (67.07 km^2), farmland (20.51 km^2), and water bodies (3.63 km^2). In construction zones, simulations proposed reallocating land toward public service facilities (17.40 km^2), industry (13.90 km^2), and residential areas (5.99 km^2). These outcomes align closely with Beijing's master plan, proving that AI-driven urban optimization can support sustainable land management while enhancing urban quality.

The team applied a U-Net deep learning model to ZY-3 satellite imagery, achieving footprint extraction accuracy of 95% (2018) and 90% (2019). Change detection accuracy for new or demolished buildings exceeded 80%. To simulate reuse, the researchers integrated machine learning (random forest regression) with multi-source datasets, including planning approvals, land use records, and demographic data. Suitability indices were established for construction zones, assessing factors like proximity to transport, population distribution, and access to services. In non-construction areas, ecological and agricultural priorities guided reallocation. The optimization models were validated against actual reuse outcomes from 2021, showing consistency above 78% for farmland and forest restoration. This demonstrated the framework's predictive power and adaptability. Importantly, the model also highlighted tensions between policy goals and economic incentives—while simulations favored public facilities and industry, real-world reuse skewed toward residential projects due to market forces and tax policies.

"Our framework demonstrates that artificial intelligence can bridge the gap between policy ambitions and practical urban planning," said Tengyun Hu, lead author of the study. "By combining satellite data, machine learning, and suitability modeling, we provide city planners with a powerful decision-support tool. This approach not only helps optimize current urban layouts but also ensures future developments align with sustainability and ecological preservation goals."

The study combined deep learning and machine learning techniques with multi-source datasets. U-Net models extracted building footprints from ZY-3 high-resolution imagery for 2018–2019, while random forest models simulated reuse scenarios for vacated parcels. Data sources included planning permits, land use surveys, ecological protection zones, and real-time demographic data. Suitability indices integrated land use status, population needs, and transport accessibility. By differentiating strategies for construction and non-construction areas, the framework ensured tailored, functional reuse plans consistent with ecological and urban development policies.

The AI-based framework offers a scalable model for megacities worldwide that face land scarcity, ecological pressures, and urban renewal challenges. Beyond Beijing, it can be adapted to other cities implementing reduction-oriented strategies, guiding the transition toward sustainable, high-quality development. Integrating economic drivers such as investment and taxation into the model could further enhance predictive accuracy. Ultimately, this approach has the potential to transform global urban governance by providing data-driven strategies to repurpose urban space, balance ecological protection, and improve citizens’ quality of life.

References
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