frontiers | Frontiers in Environmental Science

TYPE Editorial
PUBLISHED 13 August 2025
DOI 10.3389/fenvs.2025.1669726

OPEN ACCESS

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RECEIVED 20 July 2025
ACCEPTED 01 August 2025
PUBLISHED 13 August 2025

CITATION
Lombardi M (2025) Editorial: Urban carbon emissions and anthropogenic activities. *Front. Environ. Sci.* 13:1669726. doi: 10.3389/fenvs.2025.1669726

Editorial: Urban carbon emissions and anthropogenic activities

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KEYWORDS

environmental policy, digitalization, low-carbon development, China, urbanization, emissions, land use, green transformation

Editorial on the Research Topic
Urban carbon emissions and anthropogenic activities

1 Introduction

The following ten scientific articles have provided robust, data-driven insights into how China can achieve its "dual carbon" goals (carbon peak and neutrality).

They highlight that:

- Digital infrastructure, green innovation, and policy experimentation are critical drivers.
- Policies must be regionally differentiated and technology-driven.
- Effective climate action depends on multi-level coordination, integrating local, regional, and national strategies.

In summary, these studies suggest that China's environmental transition must be smart, digital, inclusive, and tailored to local contexts, leveraging both market-based tools and technological advancement to build a sustainable future.

Specifically, the papers in this Research Topic can be clustered as follows.

2 Policy-driven corporate green transformation

The study by Qian et al. examines the impact of China's "Zero-Waste City" pilot policy on corporate green transformation. Using double machine learning methods on firm-level data (2016–2023), they find that the policy significantly accelerates corporate environmental upgrading. This happens through three main channels: 1) increased green technology innovation; 2) stronger government oversight; and 3) growing investor environmental awareness. Notably, the policy impact is stronger for non-state-owned firms, non-heavy-polluting sectors, and traditional industries, providing valuable evidence for targeted environmental policy effectiveness.

3 Digitalization and low-carbon governance

Digital transformation plays a central role in environmental governance, as highlighted in multiple studies.

- Hu and Song show that greater government digital attention at the city level helps reduce carbon emissions. This is achieved by improving public low-carbon awareness, enhancing governance capacity, and encouraging corporate low-carbon transitions. The effect is stronger in eastern China and in cities with more developed markets.
- Li and Diao focus on digital infrastructure, showing that it supports simultaneous reductions in pollution and carbon emissions, with a significant synergistic effect. It facilitates labor, capital, and innovation flows across cities. A nonlinear U-shaped relationship was found, suggesting that digital infrastructure must be optimized to maximize environmental gains.
- Sun et al. analyze how the digital economy influences urban carbon emissions. The effect is nonlinear: initially, digital development increases emissions, but once a certain threshold is crossed, it facilitates technological innovation, which offsets those emissions. Thus, green tech R&D is key to aligning digital growth with climate goals.

4 Land use, urban shrinkage, and emissions

Land use and demographic changes significantly affect carbon outcomes.

- Zhang et al. examine land use carbon emissions (LUCE) in shrinking counties in the Beijing- Tianjin-Hebei (BTH) region. They find that although shrinking areas emit less overall, their emissions grow faster, mainly due to inefficient urban land expansion. Severe shrinkage areas have the fastest *per capita* emission growth, stressing the need for differentiated carbon control strategies in shrinking urban regions.
- Chen et al. focus on county-level emissions in the Guanzhong region of Shaanxi. Industrial and residential sectors are the largest contributors. The spatial pattern shows a core-edge structure, with urban centers emitting more, while rural areas (like Qinling National Park) have significant carbon sink potential. This highlights the importance of localized strategies for rural low-carbon development.

5 Urbanization, agglomeration, and emissions

Urbanization and industrial agglomeration present both challenges and opportunities.

- Zhu and Lin investigates producer services agglomeration and finds it reduces local urban carbon intensity by enhancing energy efficiency and industrial structure upgrading. However, it has limited spillover effects on surrounding areas. Its benefits are stronger in non-resource-based cities and mid-sized urban areas.
- Conversely, Zhang et al. highlight a paradox: rising urbanization tends to decrease carbon emission performance per unit space. They show strong spatial autocorrelation and spillover effects, especially linked to industrial and energy structure. Therefore, urbanization without structural reforms may hinder carbon efficiency.

6 Policy innovation for pollution and carbon reduction

Innovative environmental policies are a key lever for emissions control.

- Wang et al. assess the impact of Energy-Consuming Rights Trading (ECRT) as a quasi-natural experiment. Their findings show that ECRT significantly improves pollution and carbon reduction, particularly in central and western regions and in resource-based cities. The mechanism relies on green innovation and industrial upgrading. The authors recommend expanding ECRT's coverage and flexibility.
- Jiang and& Wu analyze the environmental impact of the Belt and Road Initiative (BRI). Since 2014, BRI has reduced PM2. 5 levels in key provinces along the route, mainly by fostering technological innovation and industrial restructuring. However, the effect is stronger in areas along the Silk Road Economic Belt, suggesting regional disparities. BRI also improved green total factor productivity, supporting a greener "Belt and Road."

Finally, across these ten studies, it has been possible to reveal a number of cross-cutting insights and policy implications, some of which are outlined below.

✓ Digitalization as a Double-Edged Sword Digital technologies and infrastructure support emissions reduction, but only when paired with technological innovation and regulatory adaptation. Without green innovation, digital development may initially worsen emissions.

✓ Importance of Tailored Regional Policies Geographic and economic differences matter: shrinking cities, mid-sized cities, resource-based regions, and rural counties exhibit distinct emissions patterns. As such, one-size-fits-all approaches are inadequate.

✓ Role of Structural Transformation Structural reforms—especially in industrial upgrading, energy restructuring, and land-use efficiency—are essential complements to any policy aimed at decarbonization.

✓ Synergy between Pollution Control and Carbon Goals Multiple studies confirm that policies promoting air quality improvement (e.g., PM2.5 reduction) often align with carbon reduction goals, offering co-benefits that enhance policy efficiency.

Author contributions

ML: Supervision, Validation, Writing – review and editing.

Funding

The author(s) declare that no financial support was received for the research and/or publication of this article.

Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Generative AI was used in the creation of this manuscript.

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