

Regional Sustainable Management Pathways to Carbon Neutrality

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With the background of global climate change and rapid economic growth, there are increasing problems threatening regional sustainable development [1]. Many global climate actions have been implemented. Carbon neutrality is gradually becoming a common development goal all over the world. Achieving carbon neutrality requires carbon reduction and a carbon sink increase. Carbon reduction is directly closed to the socioeconomic system, involving industrial structure, productive technology, energy consumption, and so on [2]. While carbon sequestration enhancement should improve carbon sink from the perspective of a natural ecosystem, many studies have been carried out centered on carbon emissions. Carbon emission accounting is basic work. Assessing carbon sinks and analyzing carbon balance states can help judge whether ecological objectives can be achieved. Clarifying the relationship between carbon emissions and socioeconomic systems and assessing the socioeconomic impacts of carbon reduction are crucial for upgrading industrial structures, optimizing energy consumption structures, and so on. Carbon emission prediction is the key to exploring the future realization path to carbon neutrality, such as target planning scenario analysis. Comprehensive management plans and frameworks need to be further and supplemented and improved, including promoting nature-based solutions, establishing ecological product realization mechanisms, standardizing carbon trading markets, and improving negotiation and compensation mechanisms.

This Special Issue, entitled “Regional Sustainable Management Pathways to Carbon Neutrality”, presents 13 high-quality original research papers, covering the cascade framework of “spatiotemporal variations–balance analysis–socioeconomic impacts–scenario analysis–policy recommendations” centered on carbon emissions.

Carbon emissions accounting can be based on sector classification or administrative boundaries. Yang and Yan (2024) assessed and analyzed the characteristics of transportation CO₂ emissions and revealed their influencing factors. They classified thirty Chinese provinces into six characteristic types (Types I to VI) and proposed priority control directions and indicators for carbon reduction as well as typological strategies and key performance indicators (KPIs) for each type. The periodic development characteristics of carbon emissions were further explored. Lu et al. (2023) revealed the carbon emission development stage of three urban agglomerations in the Yangtze River Economic Belt. At the same time, the impacts of influencing factors were analyzed. Moreover, the preparation method of carbon emission spatial data was also innovated and developed [3]. Liu et al. (2023) established a carbon emission assessment model based on the “NPP–VIIRS-like” nighttime light data. The spatiotemporal variation of carbon emissions at three different levels and the spatial correlation at the county level were analyzed in the nine provinces along the Yellow River.

Carbon sequestration, as a typical regulation service that can absorb CO₂ and release O₂, becomes a key element in exploring how natural ecosystems contribute to carbon



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neutrality. Yang et al. (2024) used the carbon absorption coefficient method to estimate the carbon sink in the Beijing–Tianjin–Hebei Region and explored the carbon sink enhancement potential based on different land use scenarios. They found that the expansion and optimization of arable land, garden land, and forest can effectively enhance carbon sinks. Based on the assessment of carbon source and carbon sink, carbon balance analysis can help with spatial zoning and optimization management. Fan et al. (2024) estimated the grid-scale net ecosystem productivity (NEP), explored the spatiotemporal evolution of carbon budgets, and conducted carbon balance zoning for the 31 cities in the middle reaches of the Yangtze River urban agglomerations (MRYRUA). They found that carbon sink functional zones were distributed in areas with rich ecological resources and proposed specific regional collaborative reduction policies.

The generation of carbon emissions is closely related to socioeconomic system. Most processes of economic production are accompanied by the generation of carbon emissions and pollutants. Many representative indexes have been established to assess environmental performance. Wang et al. (2024) assessed the carbon emission efficiency (CEE) and identified the main influence factors in the Beijing–Tianjin–Hebei Urban Agglomeration (BTHUA). They found that the input-related factors (carbon emissions per capita, employment per ten thousand people, total assets per capita, and energy intensity) had a negative effect on CEE, DP per capita, urbanization level, and proportion of the tertiary sector's GDP had positive impacts on CEE. Xue et al. (2023) considered various environmental pollutants into eco-efficiency (EE) assessment and established an index system to evaluate urbanization efficiency, aiming at analyzing the correlation between EE and urbanization efficiency in the 64 cities in China. Besides efficiency assessment, the impacts of carbon neutrality on land use were also investigated. Yang et al. (2023) analyzed the characteristics and driving mechanism of urban construction land under rapid urbanization and carbon neutrality targets.

The forecast of carbon emission trends can be used as an effective reference for policy-making. Meng et al. (2023) employed an extended STIRPAT model and ridge regression to simulate the projections of carbon peaks under different development scenarios. Moreover, Yang et al. (2024) also used scenario analysis to explore the carbon sink enhancement potential.

As the ultimate export of scientific research, this Special Issue published several papers on policy recommendations. Aligning with the Kunming-Montreal Global Biodiversity Framework (GBF) and other frameworks that support nature-based solutions, the policies and strategies should conform to the correct laws of nature, have a certain priority, and pay attention to harmony between nature and the socio-economy. The articles include carbon compensation zoning, carbon emission trading, ecological products, and synergistic carbon reduction policies. Chen et al. (2023) constructed a more comprehensive per capita carbon compensation zoning model, divided Chinese counties into per capita carbon compensation-type zones, and put forward the suggestions for optimizing low-carbon development. Li and Liu (2023) used a difference-in-differences model and verified that China's carbon emissions trading policy and the horizontal mobility experience of the provincial governors exert a significant positive effect on carbon emission reduction. Moreover, they identified the correlation between political factors and carbon emissions and provided specific suggestions for carbon reduction policy formulation. Wang et al. (2023) focused on the realization mechanism of ecological products and considered conversion efficiency as a convincing method to present the transformation degree of ecological production into economic benefits and the degree of eco-economic synergy. Forest Ecological Products (FEPs) value was evaluated to analyze the conversion efficiency in the Pearl River Delta (PRD). Chen et al. (2023) integrated the game model and general spatial equilibrium model, revealing the formation of regional comparative advantages in emission reductions and their impacts on synergistic emission reductions. Moreover, a form of synergy was proposed to provide trade, industry, and economic growth policies, which complement emission reduction policies.

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