



Original Article

Assessment the urbanization sustainability and its Driving Factors in Urban Agglomerations: An Urban Land Expansion - Urban Population Dynamics Perspective

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Abstract:

Achieving urbanization sustainability is considered to be both an important component of the Sustainable Development Goals and a key way to address the conflict between limited resource constraints and urban continued growth. Regarding the urbanization sustainability, the impact of ecological environment and resource consumption has been widely discussed, while the holistic effect of urban land expansion and urban population dynamics is under-researched. This paper evaluated the urbanization sustainability of 15 urban agglomerations in China from 2000 to 2020 and applied the Geodimeter model to investigate its impact mechanism. The results show that at the national level, the level of urbanization sustainability exhibited a trend of first increasing and then decreasing, accompanied by significant spatial differentiation. Spatially, the level of urbanization sustainability in urban agglomerations located in the northeast regions had strong variability during the study period. In contrast, urban agglomerations located in the central region had a lower level of sustainability of urbanization due to the unrestricted expansion of urban land. In addition, urbanization sustainability varied according to the development stage of urban agglomerations. Specifically, urbanization sustainability showed a downward trend in the initial development stage, early growth stage and later growth stage of urban agglomeration, and upward trend in mature stage. Economic development level, foreign direct investment, industrial structure and urbanization level were the primary determinants of differences in urbanization sustainability at both national and regional levels. These findings may help to formulate the urban sustainable development planning and differentiated land use policies.

Keywords: Urbanization sustainability; Spatial characteristics, Spatial distribution; Influencing factors; Urban agglomerations

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Introduction:

Since the 90s, China's rapid urbanization has contributed to the miracle of economic growth and urban prosperity (Sun et al., 2020). Against the background of sustainable development, the question that the sustainability of this process has triggered extensive discussion (Abubakar and Aina, 2019; Giuliani et al., 2021). Researchers have discussed the impact of rapid urbanization (Hennig et al., 2015), and found that it had generated a wide variety of problems related to the ecological environmental and resource consumption (Wang et al., 2021; Djehdian et al., 2019; Liang and Gong, 2020), such as ecological degradation (Yu et al., 2019), air pollution (Liu et al., 2022), water quality degradation (J.J. Luo et al., 2018), and greenhouse gas emissions (Liu et al., 2017), which threaten the urbanization sustainability. Recent projection survey highlights the urbanization in China is expected to reach 73% by 2030, with urban construction land will continue to expand (UN DESA, 2018). In this regard, urbanization may be at risk of unsustainability once built-up land expansion are unlimited (Sun et al., 2019) or the intensity of urban development and population growth are unbalanced (Jiang et al., 2022). Hence, with the comprehensive implementation sustainable development, and the worsening of conflict between limited resource constraints and continued urban growth, it is critical to investigate the sustainability of urbanization and its impact mechanism.

Urbanization sustainability refers to human socio-economic activities, and resource consumption can be maintained in a dynamically balanced and controllable scenario, so as to meet the common development of present and future generations (Lu and Ke, 2018). The literature on assessing urbanization sustainability has long been ground on ecological environment changes (Wang et al., 2014; Zhou et al., 2011), urban land

development intensity and urban expansion (Su et al., 2011; Wu et al., 2011; Kadhim et al., 2022), population dynamics and migration (Lu and Song, 2006; Zhang and Song, 2003), energy resource consumption (Yuan and Zuo, 2011; Zhao et al., 2011), global impacts of socioeconomic dynamics (Nga, 2022; Güneralp et al., 2020; McDonald et al., 2020), as well as the impact of future urban scale and spatial distribution on ecological environment and carbon neutrality (Seto et al., 2012; Albasri et al., 2022). Recently, a study by Cai, Shao & Fang, et al., (2021) on the coordination between socioeconomic activity and eco-environment showed that urban population dynamic and urban land expansion are the most remarkable activities in the process of rapid urbanization (Cai et al., 2021). Given the irreversibility of land-use change and the relative stability of urban populations over a certain period of time, their combined effect would directly affect the sustainability of urbanization. In this framework, the approaches to improving urbanization sustainability rest on the benefits of urban land - population dynamics in most developing countries (Wang et al., 2016). Therefore, this paper evaluated urbanization sustainability from the view of urban land expansion and urban population dynamics.

Research on urbanization sustainability at the provincial, national and global levels has attracted widespread attention, while few studies at urban agglomeration level. As a collection of cities with different nature, types and hierarchical scale (Fang, 2018), urban agglomerations (UAs) face various contradictions related to urban growth and resource capacity from the initial stage to mature stage (Bai et al., 2014). Hence, this paper believed that assessing urbanization sustainability at the scale of UAs can not only supplement existing literature but can provide more targeted theoretical support for sustainable urban development. In addition, the



spatial characteristics of urbanization sustainability in China have significant spatial imbalance effects. In general, the urbanization sustainability in an area is not only affected by the local natural resource endowment, socio-economic structure, and policies, but also its development stage (Liu et al., 2018). Previous studies have focused on regional heterogeneity based on the urban function, income level, city size, and geographical location (Feng et al., 2019; Li and Li, 2019; Gao et al., 2016), while differences in development stage are understudied. Hence, this paper further analyzes the heterogeneity of urbanization sustainability from the perspective of development stage differences.

Methodology:

Recent studies have further indicated that urbanization sustainability may potential associate with ecosystem services (Díaz et al., 2018; Chen et al., 2022), economic growth (Jiang et al., 2022), governments' regulation (Liu et al., 2018), technological progress (Ligorio et al., 2022) and industrial structure (B. Z. Zhu et al., 2019). Methods such as STIRPAT, LMID, the panel model, GWR and SDA are widely used to reveal the driving mechanism. However, those methods often ignore the contribution differences and interactions of impact factors in UAs, thereby underestimating or overestimating the impact. In this regard, Geodimeter model has a strong advantage in multicollinear immunity, which determines that the results can truly reflect the impact of one variable and the interactions of two variables (Wang and Xu, 2017). Moreover, key impact factors and their contribution can be further identified. Hence, the Geodimeter model was applied to investigate the driving mechanisms of spatial differences in urbanization sustainability.

The objective of this paper is to analyze the spatial distribution characteristics and influencing

factors of urbanization sustainability of 15 UAs in China during 2000–2020. First, this paper investigated the temporal and spatial distribution characteristics of urbanization sustainability from the perspective of urban land consumption and population dynamics, which measured by the ratio of land consumption rate to population growth rate, and explored their regional heterogeneity based on urban development stage. Second, the Geodimeter method was utilized to detect the impact mechanism of urbanization sustainability.

The contributions are threefold. First, the findings broaden the empirical research on urbanization sustainability. In previous studies, the impacts of ecological environment, resource consumption population dynamics and socioeconomic effect have attracted more attention, while the important role of the benefits of urban land - population dynamics has been understudied. In fact, urban land expansion and urban population dynamics are not always matched and coordinated. In this regard, achieving urbanization sustainability requires decoupling the urban population growth from new urban land acquisition. Hence, the results of this paper can not only enrich the research on urbanization sustainability but also provide scientific theoretical support for the formulation of efficient land use policies. Second, this paper fully considered the differences in the development stages of UAs. Studies focusing on the comparison of a single urban agglomeration or several UAs have attracted much attention, lacking a comprehensive analysis of the urbanization sustainability characteristics of different UAs at the national level. In addition, regional heterogeneity in population size and the geographical location of UAs are always considered (Feng et al., 2019; Li and Li, 2019; Gao et al., 2016), while differences in developmental stages are often overlooked. Our results confirm that the ratio of urban land



expansion and urban population growth are not always consistent due to differences in the development speed and scale of urban agglomerations at different development stages. This paper provides more targeted theoretical support for differentiated urban development and land use policies. Third, this paper identified relationships between different potential factors from the perspective of spatial hierarchical heterogeneity. Existing studies on the impact mechanism of urbanization either focus on the magnitude of various factors or spatial spillover effect, while the interaction between factors is under-researched. This paper uses a Geodimeter model to identify the key factors affecting urbanization sustainability and investigate their interactions. The findings indicate that spatial-temporal characteristics and regional differences of urbanization sustainability depend more on the combination of different factors, which enriches the relevant understanding.

Discussion:

Organizational Access:

Overall trends in Urbanization Sustainability:

This paper calculated the LCR, PGR and LCRPGR in China's UAs from 2000 to 2020 (Table 2). LCRPGR first drops from 1.497 during 2000–2005 to 0.473 during 2005–2010 and then peaks to 2.028 (i.e., the lowest urbanization sustainability) during 2015–2020, which largely due to people's reduced willingness to have children (Zhou et al., 2021). The value of LCRPGR is greater than 1 during 2000–2005 and 2015–2020, indicating that the inefficient urban land carries a sparse population during these

Explanation of Findings:

The urbanization sustainability in China exhibits a trend of first increasing and then decreasing, accompanied by significant spatial differentiation, which is similar to the survey findings of Lu and Ke (2018) based on 31 cities in China (Lu and Ke, 2018). This change is the result of the interaction of different factors related to the socio-economic situation, and the differences in development stage, as well as their combined effect. Some studies have explored urbanization sustainability

Conclusions:

This paper proposes a method to evaluate urbanization sustainability and recognize the dominated influence factors. The goal is to identify and alleviate the mismatch between urban land expansion and urban population growth and facilitate sustainable urbanization. This paper investigates the spatial distribution characteristic of urbanization sustainability of 15 urban agglomerations in China from 2000 to 2020 and applies the Geodetector model to explore the influencing factors. The This research was financially supported by the Startup Foundation for Introducing Talent of NUIST (1093142301015), Innovative Research Groups of the National Natural Science Foundation of China (No. 71921003).

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