

Spatiotemporal dynamics of urban expansion in 13 cities across the Jing-Jin-Ji Urban Agglomeration of China from 1978 to 2015

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To understand the profound impacts of urban expansion on ecological processes, socioeconomics and human life, it is the fundamental first step to quantify spatiotemporal patterns of urbanization. Spatially explicit studies with consistent data sets of high time frequency over a relatively long timeframe across large geospatial extents are lacking. We quantified and compared the magnitude, rates, forms, and their dynamics of urban expansion for 13 cities across the Jing-Jin-Ji Urban Agglomeration, and examined the invariant relationship of urban patch structure and hierarchical structure of urban growth. We used multi-temporal Landsat data of circa 1978, 1990, 1995, 2000, 2005, 2010, and 2015, and performed patch structure and patch-based urban growth analyses. Rates and composition of urban expansion forms (i.e. infilling, edge-expansion and leapfrogging) varied considerably across cities and over time, due to national and regional policies, physical features and the urban administrative hierarchy. The overall annual urban expansion rate for 13 cities was $5.5 \pm 2.0\%$ between 1978 and 2015. Leapfrogging was the dominant urban expansion form in early period then edge-expansion took the leading role since 1990 and the contribution of infilling was generally less than 40% across cities and over time. However, the composition of three urban growth types for two typical mountainous cities (i.e. Chengde and Zhangjiakou) was largely diverged from that of other cities, which might be related to the fact that topography tends to limit urban expansion and the constraint can be relaxed because of technology development or people's preferences for living environment or both. Patch analysis results showed that relationship between patch number and patch size, derived from 32 major cities of China, can be extrapolated to the Jing-Jin-Ji Urban Agglomeration despite the discrepancies in temporal scale and urban administrative hierarchy. Our results generally supported the applicability of converged urban patch structure across time and space but revealed the considerable differences in urbanization level and urban growth trajectory for those 13 cities over the past 37 years. Further research is needed to shed light on the driving forces behind observed similarity and differences of urban expansion across cities in the Jing-Jin-Ji Urban Agglomeration and their possible consequences.