Urban Growth Boundary Delineation for Oasis Cities in Arid Regions Based on Construction and Development Suitability Assessment: A Case Study of Urumqi City (Postprint)

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Abstract

Scientifically and rationally delineating urban growth boundaries constitutes an effective approach for controlling urban sprawl and mitigating inefficient land use, representing a significant focus in China' s current spatial planning explorations. Such delineation should be grounded in regional variations of resource-environmental baseline conditions and construction-development levels, with locally-adapted selection of appropriate indicators and methodologies to more accurately reflect urban development realities and demands, thereby providing substantive guidance. Cities in arid regions are profoundly influenced by oasis-desert ecosystems, where human-land conflicts become particularly pronounced during urban expansion; consequently, urban growth boundary delineation must embody the coordination between resource-environmental constraints and socio-economic development. This study employs Urumqi as a case study, adopting a research framework that integrates resource-environmental bottom-line assessment with urban development potential evaluation to explore viable methodologies for delineating urban growth boundaries in oasis cities within arid regions. The findings demonstrate: (1) the combined approach of restrictive and suitability evaluations effectively delineates urban growth boundaries for oasis cities in arid regions; (2) utilizing oasis areas as evaluation units for land potential is more rational and applicable for boundary delineation in such contexts; and (3) partitioning urban growth boundaries into rigid boundaries and phased boundaries can effectively guide urban land development.

Full Text

Delimitation of Urban Growth Boundaries in Arid Oasis Areas Based on Evaluating the Suitability of Construction and Development: A Case Study in Urumqi City

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Abstract: Scientifically and rationally delimiting urban growth boundaries is an effective way to control disorderly urban expansion and reduce inefficient urban land use, and represents one of the important components of spatial planning exploration in China. Urban growth boundary demarcation should be based on regional resource conditions and construction and development levels of different regions, with appropriate indicators and methods selected according to local conditions to more accurately reflect the actuality and demand of urban development. Urban development in arid areas is significantly affected by the oasis-desert ecosystem, and the contradiction between people and land is more prominent in the process of urban expansion. The delimitation of urban growth boundaries must reflect the coordination of resources, environment, and economic and social development. This paper attempts to carry out the delimitation of urban growth boundaries in Urumqi to explore feasible methods for delimiting urban growth boundaries in arid regions based on the research ideas of resource-environment background and construction and development level. The results showed that: The combination of restrictive evaluation and suitability evaluation could be used to well delimit the urban growth boundary in arid areas; Oasis could be regarded as an evaluation unit of land potential to make the delimitation of urban growth boundary in arid areas more reasonable and applicable; Delimitation of urban growth boundary was divided into the permanent boundary and periodic boundary, which could be used to guide the development of urban land.

Keywords: urban growth boundary; restrictive evaluation; suitability evaluation; periodic boundary; Urumqi

1 Introduction

Controlling urban sprawl and protecting open space are critical policy instruments for sustainable urban development. The delimitation of urban growth boundaries has become an essential tool in urban planning to manage expansion and preserve ecological resources. Previous studies have employed various methods including land ecological suitability evaluation [**?**, **?**, **?**, **?**], artificial neural networks [**?**], and spatial suitability assessment [**?**] to establish urban growth

boundaries. However, these approaches often lack integration with regional resource constraints and development demands specific to arid environments.

The unique characteristics of arid regions, particularly the oasis-desert ecosystem interface, create distinct challenges for urban growth management. The contradiction between population pressure and limited land resources is particularly acute in these areas. Therefore, urban growth boundary delimitation must reflect the coordination among resources, environment, and socio-economic development. This study proposes a comprehensive framework combining restrictive evaluation and suitability assessment, using the oasis as a fundamental evaluation unit to enhance the rationality and applicability of boundary delimitation in arid contexts.

2 Study Area and Methods

2.1 Study Area

Urumqi City, located in an arid oasis region, serves as the study area. The city covers a total area of 20.63 km², with a population of 2.24×10 . The population density reaches 6.16×10 persons per km² in the core urban area. The region faces significant ecological constraints due to its location at the margin of oasis and desert ecosystems, making it representative of urban growth challenges in arid northwestern China.

The evaluation framework incorporates multiple factors: land use status, ecological sensitivity, construction suitability, and development potential. Restrictive evaluation identifies areas prohibited from development based on ecological constraints, while suitability assessment determines the optimal spatial allocation for future urban growth.

2.1.1 Data Sources and Processing

The analysis integrates remote sensing data, land use maps, topographic information, and socio-economic statistics. Spatial analysis employs GIS-based multi-criteria evaluation techniques to generate composite suitability indices. The restrictive evaluation layer identifies ecological redlines including water sources, protected areas, and fragile ecosystems. The suitability evaluation layer considers factors such as terrain slope, soil conditions, infrastructure accessibility, and land use efficiency.

Table 1 Classification system for urban growth boundary delimitation

3 Results and Discussion

3.3 Urban Growth Boundary Delimitation

The delimitation process generated two types of boundaries: permanent boundaries and periodic boundaries. The permanent boundary defines the ultimate limit of urban expansion based on long-term ecological carrying capacity and

resource constraints. The periodic boundary establishes phased development zones that can be adjusted according to changing socio-economic conditions and implementation effectiveness.

The combined approach of restrictive and suitability evaluation provides a robust methodology for arid region urban planning. Using the oasis as an evaluation unit ensures that boundary delimitation respects the fundamental ecological structure of the region. The dual-boundary system offers both long-term guidance and flexibility for adaptive management.

The total area identified for potential urban growth is 2073.34 km^2, accounting for 3.60% of the total oasis area. This allocation balances development needs with ecological preservation, ensuring sustainable urban expansion in the water-scarce environment.

Table 3 Space classification of urban growth boundary

The implementation of these boundaries should be integrated with regional planning policies, including land use regulation, ecological compensation mechanisms, and performance monitoring systems. The periodic boundary should be reviewed and adjusted every 5-10 years to reflect changing conditions and development demands.

4 Conclusion

This study demonstrates that the integration of restrictive evaluation and suitability assessment provides an effective methodology for delimiting urban growth boundaries in arid oasis regions. Key innovations include treating the oasis as a fundamental evaluation unit and establishing a dual system of permanent and periodic boundaries. This approach ensures that urban development respects ecological constraints while maintaining flexibility for future growth.

The methodology is particularly applicable to cities in northwestern China facing similar resource-environment pressures. Future research should focus on refining evaluation indicators, establishing dynamic monitoring systems, and developing policy instruments for boundary implementation.

References

[1] LIU Qiong, DU Xiaohang, SHENG Yexu. Study on the coordination relationship between population urbanization and land urbanization in China based on stage comparison[J]. China Population, Resources and Environment, 2018, 28(1): 26-34.

[2] Myung-Jin Jun. The effects of portland' s urban growth boundary on housing prices[J]. Journal of the American Planning Association, 2006, 72(2): 239-243.

[3] Sybert Richard. Urban Growth Boundaries[R]. Governor' s Office of Planning and Research (California) and Governor' s Interagency Council on Growth Management, 1991.

[4] Bengston DN, Fletcher JO, Nelson KC. Public policies for managing urban growth and protecting open space: Policy instruments and lessons learned in the United States[J]. Landscape and Urban Planning, 2004, 69(2-3): 271-286.

[5] LIU Qiong, DU Xiaohang, SHENG Yexu. Study on the coordination relationship between population urbanization and land urbanization in China based on stage comparison[J]. China Population, Resources and Environment, 2018, 28(1): 26-34.

[8] Bai Yujing. Research on Urban Growth Boundaries in Harbin Based on Ecological Security[D]. Harbin: Institute of Technology, 2013.

[9] FU Ling, HU Yecui, ZHENG Xinqi. The prediction of urban growth boundary based on BP artificial neural networks: An application to Beijing[J]. China Land Sciences, 2016, 30(2): 22-30.

[10] LI Can, TANG Huijun, ZHANG Fengrong. On limitation of urban growth boundary based on construction land suitability evaluation[J]. Journal of Southwest China Normal University (Natural Science Edition), 2017, 42(7): 105-111.

[11] ZHU Zhongwen, MO Bin, XIE Furong. Delimitation of urban growth boundary based on land ecological suitability evaluation: A case of Fangchenggang[J]. Planners, 2009, 25(11): 40-44.

[12] WANG Pei. Study on the Delimitation of Urban Growth Boundary under Ecological Security Pattern[D]. Anhui: Anhui Jianzhu University, 2016.

[13] WANG Yuguo, YIN Xiaoling, LI Guicai. Delimitation of urban growth boundary based on land ecological suitability evaluation: A case of Shenshan special corporation zone[J]. Urban Development Studies, 2012, 19(11): 76-82.

[14] ZHU Shouhong, SHU Bangrong, MA Xiaodong, et al. The delimitation of urban growth boundary based on the idea of "Anti-planning"and FLUS model: A case study of Jiawang District, Xuzhou City[J]. Geography and Geo-Information Science, 2017, 33(5): 80-86, 127.

[15] WANG Ying, GU Chaolin. Grid-based spatial evaluation of establishing urban growth boundary: A case study of Suzhou City[J]. City Planning Review, 2017, 41(3): 25-30.

[16] ZHONG Shan, ZHAO Xiaomin, GUO Xi, et al. Delimitation of urban growth boundary based on spatial suitability evaluation and population carrying capacity in Guixi County[J]. Journal of Natural Resources, 2018, 33(5): 801-812.

[17] ZHU Tianzhu, DU Hongru, ZHANG Xiaolei, et al. Delimitation of Urban Growth Boundary in Arid Oasis Based on Evaluating the Suitability of Construc-

tion and Development: A Case Study in Urumqi City[J]. Arid Zone Research, 2018, 35(2): 436-443.

[18] LI Yonghua. Method of determining urban growth boundary from the view of ecology: A case study of Hangzhou[J]. City Planning Review, 2011, 35(12): 83-90.

[19] CHEN Chunmei, ZHONG Ke, CHEN Yonghang, et al. Effects of clouds on solar radiation over typical city in arid area[J]. Arid Zone Research, 2018, 35(2): 436-443.

Note: Figure translations are in progress. See original paper for figures.