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What is the peri-urban area, and how can it effectively be delineated? A synthesis and analysis from a literature review

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Abstract:	Peri-urban areas are neither urban nor rural in the conventional sense; and their conditions and issues are different from urban and rural areas, which mix both with complexities. Nowadays, there is no uniform definition for these areas, nor an unequivocal method for delineating them. It is therefore essential to define the peri-urban areas, in order to develop appropriate policies to manage and address these complicated issues. Hence, this paper reviews and evaluates the literature and applications which encompass fundamental theories to answer the critical questions. The article finds that the peri-urban area is a transition zone between urban and rural elements and mainly has transitional, "vacuum" or complex characteristics. It confirms that quantitative delineation has become the primary means for defining the ranges of peri-urban areas. The research suggests that the data and appropriate analytical methods of quantitative delineation should be selected, to refer to the local characteristics of peri-urban areas. Furthermore, the ranges of peri-urban areas can be delineated based on data collection and integrated analysis from the dimensions of social order, economic development, environmental resource and administrative governance. Appropriate methods help improve the accuracy of defining these peri-urban areas, helping to supplement development strategies and decision-making processes.
Corresponding Author:	lanxin li University of Nottingham NOTTINGHAM, UNITED KINGDOM
Corresponding Author E-Mail:	lanxin.li@nottingham.ac.uk
Order of Authors:	Lanxin Li
	Amy Tang, Doctor
	Nicole Porter, Doctor
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What is the peri-urban area, and how can it effectively be delineated? A synthesis and analysis from a literature review

Lanxin Li[a] *, Amy Tang[b] and Nicole Porter[c]

Abstract:

Peri-urban areas are neither urban nor rural in the conventional sense; and their conditions and issues are different from urban and rural areas, which mix both with complexities. Nowadays, there is no uniform definition for these areas, nor an unequivocal method for delineating them. It is therefore essential to define the peri-urban areas, in order to develop appropriate policies to manage and address these complicated issues. Hence, this paper reviews and evaluates the literature and applications which encompass fundamental theories to answer the critical questions. The article finds that the peri-urban area is a transition zone between urban and rural elements and mainly has transitional, "vacuum" or complex characteristics. It confirms that quantitative delineation has become the primary means for defining the ranges of peri-urban areas. The research suggests that the data and appropriate analytical methods of quantitative delineation should be selected, to refer to the local characteristics of peri-urban areas. Furthermore, the ranges of peri-urban areas can be delineated based on data collection and integrated analysis from the dimensions of social order, economic development, environmental resource and administrative governance. Appropriate methods help improve the accuracy of defining these peri-urban areas, helping to supplement development strategies and decision-making processes.

[a] *PhD student, Department of Architecture and Built Environment, Faculty of Engineering, University of Nottingham, Nottingham, NG7 2RD, United Kingdom;*

[b] *Assistant Professor, Department of Architecture and Built Environment, Faculty of Engineering, University of Nottingham, Nottingham, NG7 2RD, United Kingdom;*

[c] *Chair of the University of Utah's Division of Multi-Disciplinary Design, College of Architecture and Planning, University of UTAH, East Salt Lake City, UT, 84112, United States*

Keywords: peri-urban area, characteristics, quantitative method, delineation dimension

1. Introduction

Urban expansion has profoundly affected peri-urban areas. The intersection of urban and rural areas is where the initial expansion occurs, in which urban and rural forces strongly interact (Thomas, 1990). Globally, urban expansion occurs at a high rate and on a large scale. According to the United Nations (2018), the percentage of the population living in urban areas of the world increased from 29.6% to 56.2% between 1950 and 2020; the number will increase to 68.4% in 2050. Hence, peri-urban areas, as the most extreme areas where urban and rural elements are intertwined, have become more noteworthy.

Peri-urban areas reveal prominent negative and positive influences between villages and cities. With the continuous urban expansion referred to above, the population, industry, commerce and residential areas sprawl into the surrounding areas, which tends to squeeze the environments in peri-urban areas bringing with it considerable pollution, such as sewage, garbage and waste (Howard, 1919; Thomas, 1990; Zhong and Yang, 2004; Li and Zhang, 2008; Wang, 2008; Gu and Zhang, 2009; Tan et al., 2010; Zhang, 2011). It may cause a reduction in agricultural production and public space (Huang et al., 2006; Honda et al., 2010; Randhawa and Marshall, 2014; Buxton et al., 2016; Singh et al., 2016; D'Alessandro et al., 2018; Fan and Wang, 2021; Kassis et al., 2021; Spyra et al., 2021; Torre and Fonseca, 2023); deterioration of the ecological environment (Randhawa and Marshall, 2014; Singh et al., 2016; Walters et al., 2016; Amirinejad et al., 2018; Kalfas et al., 2020; Fan and Wang, 2021; Yang, 2021; Aziz et al., 2023); and destruction of landscape and cultural heritage in peri-urban areas (Darwin et al., 2019; Fan and Wang, 2021; Li and Chen, 2021; Yang, 2021).

As a result of the complication of demographic composition in peri-urban areas, social conflicts may readily arise (Thomas, 1990; Errington, 1994). It often tends to be mixed,

including urban and rural residents, and even floating populations (Ren et al., 2009; Hudalah et al., 2016; Petrovici et al., 2023). The economic income and cultural backgrounds among different groups may lead to economic segregation (Ren et al., 2009; Mortoja et al., 2020; Melo and Jenkins, 2021; Gottero et al., 2023); cultural shock (Dadashpoor and Ahani, 2019); social isolation (Pan, 2012; He, 2014); and threatening social stability (Randhawa and Marshall, 2014; Cheng et al., 2018; Wubie et al., 2020; Narain, 2021).

When the urban sprawl of peri-urban areas is ahead of planning, and peri-urban areas often are the "vacuum zones" of urban and rural management (Amirinejad et al., 2018; Yang, 2021; Shao and Zhang, 2022), it results in the development of peri-urban areas lacking supervision or any management mechanism. Therefore, peri-urban areas are constantly subject to a great deal of non-conforming development (Ren et al., 2009; Ingwani, 2019; Nguyen, 2023), often triggering an uncoordinated relationship between supply and demand of infrastructure (Allen et al., 2006; Amirinejad et al., 2018; Yang, 2021); scattered residential, commercial, and workspace development (Amirinejad et al., 2018); random industrial structures (He et al., 2014; Yang, 2021); and inefficient land use and substandard activities in peri-urban areas (Park, 1915; Thomas, 1990; Zhong and Yang, 2004; Zhuang et al., 2016; Tian et al., 2017; Amirinejad et al., 2018; Li and Chen, 2021). The three key negative impacts have shown that urban development potentially threatens the ecosystem, landscape, cultural heritage, agricultural output, industrial structure, infrastructure supply and social stability.

While there are these negative impacts, peri-urban areas act as liaisons between urban and rural areas. They bring together the benefits from urban and rural areas and play their role in coordinating the urban-rural relationship. Economic resources and high living standards have been introduced into rural and peri-urban areas from urban areas through urbanisation, increasing the economic development opportunities and living quality in peri-urban areas themselves (Fan and Wang, 2021). Conversely, rural and peri-urban areas provide resources

and environment for the ecology and culture of the city and as a destination for urban residents to experience the vernacular culture and enjoy nature during their leisure time (Snep et al., 2006; Fan and Wang, 2021). Therefore, managing peri-urban areas is essential to easing the conflicts between urban-rural elements and to adjusting the urban-rural relationship (Huang and Tian, 2021).

For understanding and managing change in peri-urban areas, the first question is: "What is the peri-urban area, and how can it be delineated?' A clear concept of and scope for peri-urban areas are fundamental to forming management strategies (Randhawa and Marshall, 2014; Amirinejad et al., 2018). Successful management of peri-urban areas has great significance. It can optimise industrial structures (He et al., 2014); infrastructure supply (Mortoja et al., 2020; Yang, 2021); and land-use patterns. It can protect the ecological environment (Randhawa and Marshall, 2014; Kalfas et al., 2020; Ouyang, 2023); landscape (Fan and Wang, 2021); cultural heritage (Fan and Wang, 2021; Li and Chen, 2021; Yang, 2021); and agricultural production (Buxton et al., 2016; Mortoja et al., 2020; Fan and Wang, 2021). It also can help coordinate people's cultural and economic social relations (Randhawa and Marshall, 2014; Ouyang, 2023) and narrow the economic and living gaps between urban and rural areas. Further, it will promote the achievement of long-term coordination of urban-rural relationships and sustainable development (Yan and Zhou, 2005; Randhawa and Marshall, 2014; Jin et al., 2018; Mortoja et al., 2020; Ge and Lu, 2021; Mortoja and Yigitcanlar, 2022; Li, 2022; Ouyang, 2023).

However, no unified definition or delineation method exists in the current literature (Gonçalves et al., 2017a). This study explores the possibility of unifying the definition and aims to discover the appropriate delineation methods for peri-urban areas. It examines the literature developments synthesised with the concept and characteristics of peri-urban areas. It reviews the issues of modernisation and urbanisation and evaluates the conflicts in this massive

development process. It discusses suitable delineation methods and factors in delineating the scope of peri-urban areas. Finally, it suggests improving existing delineating factors for a more precise assessment.

2. Concept and Characteristics of the Peri-urban Area

The concept and characteristics of the peri-urban area have been continuously enriched by considerable research, but as yet there has been no uniformity in academic circles. This section reviews the primary literature on the topic, leading to a summary of the definitions of peri-urban areas.

2.1. Concept of the Peri-urban Area

Early scholars in the field defined peri-urban areas as land-use transition areas between urban and agricultural land (Louis, 1936; Wehrwein, 1942), in which the combination of urban and rural elements in land use, production methods, culture and interpersonal relationships (Robin, 1968; Fesenmaier et al., 1979; George, 1994; Countryside Agency and Groundwork, 2005) and urban and rural elements gradually shift, interact and penetrate each other (Gu et al., 1993; Chen, 1995). As a result of this interaction (Conzen, 1960; Golledge, 1960; Glaeser and Kahn, 2004; de las Rivas Sanz and Fernández-Maroto, 2019), the boundaries of the areas are often fluctuating, or "fuzzy" (Jones, 1988; Amirinejad et al., 2018), and are not necessarily coterminous with political boundaries (Whitehand, 1967). Moreover, urban expansion contains a certain degree of randomness, so peri-urban areas are often discontinuous land-use areas, in which commerce, industries, urban service facilities and farm areas are discontinuous (Wissink, 1962). Furthermore, Qviström (2007) proposed that peri-urban areas should be depicted as a phase rather than a place; rural activities are interpreted as about to disappear in a few years' time, whereas urban activities are simply understood as forerunners of the city.

2.2. Characteristics of the Peri-urban Area

There are numerous research studies on the characteristics of peri-urban areas. The majority of researchers state that the urban-rural transition is their primary characteristic (Gu et al., 1993; Mark, 2000; Qviström, 2007; Tian, 2015; de las Rivas Sanz and Fernández-Maroto, 2019). These studies show that the transition is generally one of three types, defined by the number of urban and rural elements and the degree of transition characteristics (see Figure 1).

In the first type, the number of elements in peri-urban areas is medium and shows a smooth transition between urban and rural features. For example, the population density is often medium from urban to rural areas (Golledge, 1960; Desai and Gupta, 1987). The second type is where there are fewer urban and rural elements, thus forming areas with "vacuum" characteristics (Jacobs, 1962). In such circumstances, there is often a sparsity and deconcentration in people, facilities, retail activities and intensive agricultural production (Golledge, 1960; Friedrichs and Rohr, 1975), and an imperfection of public services and public facilities (Golledge, 1960). The third type is where those urban and rural elements are high and interacting extremely. This interaction tends to bring a mix of urban-rural economic development, which often leads to mixed and complex land use (Li, 2005; Yong et al., 2011). Moreover, population mobility is often high due to urban-rural interaction (Yan and Zhou, 2005; Xing, 2006), which also leads to mixed cultures, income levels, activities and so on (Zhang and Xu, 1999). Hence, these areas often display complex and mixed characteristics.

2.3. Overview of the Concept and Characteristics of Peri-urban Area

Although the current interpretations of the concept of peri-urban areas are limited to partial characteristics of these areas, these interpretations are often one-sided and incomplete. Its concepts and characteristics have been thoroughly studied in academic circles, resulting in a relatively unified definition: *Peri-urban areas are a phase, rather than a place where urban*

elements gradually transit into rural elements. This formation often results from urban-rural interaction and has a discontinuous, fluctuating and dynamic evolution. The boundaries of the areas are often blurred and may not be coterminous with political boundaries. Peri-urban areas are considered those areas with *high transitional, vacuum or complex characteristics,* including but not limited to their economy, population, culture, activities and land use. Hence, the concept and characteristics of peri-urban areas influence the method of delineating them.

3. Methods of Delineation of the Range of the Peri-urban Area

The fluctuating development and blurred boundaries of peri-urban areas determine that methods of delineating their range become difficult and crucial. The two main methods currently applied in this research field are therefore both qualitative and quantitative. This section reviews the key literature and evaluates the delineating methods of peri-urban areas to establish their advantages and disadvantages. It also summarises the appropriate conditions for applying such methods in practice.

3.1. Qualitative Delineation Methods

Early attempts at delineation found in the literature relied mainly on qualitative methods based on practical experience and intuitive judgment to describe peri-urban areas' ranges fuzzily. For example, the first researchers qualitatively delineated peri-urban areas' range by depicting the areas as the zone where the city's edge expands outward (Louis, 1936; Conzen, 1960; Carter and Wheatley, 1979). Carter and Wheatley (1979) considered that peri-urban areas are the administrative boundary of a city, where urban sprawl maintains a static nature. Gu et al. (1993) described peri-urban areas as mixed areas, with both urban and rural land use. In this early literature, only Pryor (1968) made an attempt to quantify their size, stating that peri-urban areas are the areas where the percentage of urban and rural land use is equal.

3.2. Quantitative Delineation Methods

With technological development from the 1970s onwards, scholars have used fewer and fewer qualitative delineation methods and have gradually been able to move to quantitative methods. These methods include using statistical indices and satellite imagery to collect data. Delineation by statistical index, essentially inserting a series of indices obtained by statistical methods into a map, often generated by Geographic Information System (GIS) data, emerged as a significant method of defining the range of peri-urban areas. These indices are mainly related to population transition (Russwurm, 1975; Bryant and Russwurm, 1982; Gu et al., 1993; Zhao and Chen, 1996; Lincaru and Atanasiu, 2014; Merciu et al., 2019a); the economy (Zhao and Chen, 1996; Liu, 2006; Lin et al., 2007; Merciu et al., 2019); public services (Merciu et al., 2019; Yan et al., 2021); and amalgamated sprawl (Kew and Lee, 2013). Compared with qualitative methods, using statistical indices is more comprehensive, objective and accurate. However, it is more challenging to collect reliable data. With the development of Remote Sensing (RS) and other supplementary technologies, scholars have begun to use satellite imagery to collect image data effectively for delineating areas; the image data can then be input into GIS for analysis, to determine the range of peri-urban areas.

The essential methods for data analysis of statistical indices and satellite imagery include the Threshold Method (Sutton et al., 2006; Sutton et al., 2010; Mustak et al., 2018; Yan et al., 2021); the Fuzzy Set Method (Heikkila et al., 2003; Mustak et al., 2018; Mortoja and Yigitcanlar, 2022); the Breaking Point Method (MacGregor-Fors, 2010; Zhang et al., 2010; Paul, 2017); the Cluster Analysis Method (Gonçalves et al., 2017b); and the Shannon Entropy Method (Cheng and Zhao, 1995; Chen et al., 2001; Qian et al., 2007; Wang et al., 2010b; Chai, 2011; Li et al., 2012; Bian and Wang, 2015).

The principles applied in each method are different. The Threshold Method, as its name implies, uses a threshold of factors to delineate the ranges of peri-urban areas, such as the

number of public services and the brightness of nighttime light. Shannon (1948) proposed the Shannon Entropy Method to obtain the degree of information disorder: the more chaotic the system content, the higher the information entropy values; the more stable the system content, the lower the entropy value. Shannon's method delineates the ranges of peri-urban areas based on setting a threshold entropy value of the disorder degree of landscapes. Converse (1949) proposed the Breaking Point Method to explore the most striking breaking point of factors. The delineation principle here is to determine influential radiation of the urban centre on the surrounding area to identify significant changes in radiation (mutation points); these changing points can then outline circles. The area between these two circles is the delineated range of peri-urban areas. Zadeh (1965) created the Fuzzy Set Theory to explain fuzzy phenomena in the objective world. The attributes of an object are determined by assigning a certain degree of membership. Using the Fuzzy Set Method to delineate the range of peri-urban areas is derived by judging the degree of subordination of factors to the city and the village. It then uses a threshold of subordination to determine the ranges. The Cluster Analysis Method is used to perform a clustering and dimensionality reduction analysis of parishes based on various factors; then, certain clustered regions with peri-urban area characteristics are delineated as peri-urban areas.

In the 21st century, many scholars have carried out dynamic delineation by comparing maps of the same area at different times with the quantitative method (Heikkila et al., 2003; Bian and Wang, 2015; Qiao et al., 2017). The advantage of quantitative methods is that they make it possible to uncover the evolution of peri-urban areas, which can then become an aid in managing the decision-making process in urban and rural development.

In general, in contemporary times, quantitative delineation methods have gradually taken over as the primary tool for delineating the range of peri-urban areas. They break the constraints of administrative boundaries in a dynamic way, which helps achieve results that are

closer to reality. Further, the dynamic outlining of the range of peri-urban areas can reflect the dynamic delineation at different times. Significantly, when delineating peri-urban areas of multiple regions, specific analytical methods (threshold, Shannon Entropy, Breaking Point, Fuzzy Set and Cluster Analysis) need to be selected according to local characteristics.

3.3. Comparison Study of Quantitative Analytical Delineation Methods

Quantitative delineation methods are the most frequently applied in practice, because of their accuracy and suitability for visualisation. There is no one analytical method suitable across the board to meet every challenge (Mortoja et al., 2020). In order to find appropriate analytical methods adapted to comprehensive coverage of all conditions, it is crucial to understand the differences between the various methods, which can be compared through the results of their delineation, prevailing factors, analytical principles and suitable areas (see Table 1).

The prevailing factors used in the Threshold Method, the Fuzzy Set Method, the Breaking Point Method and the Cluster Analysis Method demonstrate both statistical and image aspects. The Shannon Entropy Method uses various land function factors to deal with graphical data, rather than statistics. All the influential factors used in these methods vary widely, which increases the representativeness of the results of their delineation.

The delineated results (see Figure 2) from the Threshold Method, the Shannon Entropy Method, the Fuzzy Set Method and the Cluster Analysis Method show more accurately the discontinuous characteristics of peri-urban areas in reality. As a result, the ranges of peri-urban areas obtained by these methods present a common characteristic: they are a discontinuous closed loop with changes in width, which confirms the features of peri-urban areas.

The results of delineation with the Breaking Point Method tend to display as a closed loop with various widths. It cannot, however, reflect the discontinuous characteristics of the areas under study. Nevertheless, it demonstrates the evolution of these areas through the

changes in their widths, thus reflecting the situation on the ground relatively more accurately. The Breaking Point Method also has the advantage of not relying on thresholds, which reduces the subjectivity of the delineated results.

Hence, all these methods share their suitability for obtaining more accurate ranges of peri-urban areas. However, how the specific method should be applied under various conditions needs to be further analysed in detail.

The transition threshold and subordination can reflect the transitional character of peri-urban areas. The Threshold Method and the Fuzzy Set Method are especially suitable for delineating peri-urban areas with high transitional characteristics. These two refer to the transition threshold of the number of factors from city to rural and the subordination degree of factors in the cities or villages to delineate the peri-urban area. The Breaking Point Method and the Cluster Analysis Method are more suitable for delineating the peri-urban areas with vacuum characteristics, where elements tend to show distinctly distinguished from urban and rural areas. With no statistical factors in the Shannon Entropy Method, because of the consideration of disordered and mixed threshold of land factors, it has an unparalleled advantage for delineating peri-urban areas with complex characteristics.

Significantly, the peri-urban areas of a city may contain all three characteristics in different regions (high transition, vacuum or complex). Hence, when high accuracy is required in delineating results, these methods can be separately used in different regions of the city to obtain a more comprehensive picture overall of peri-urban ranges. In short, the analytical method to be adopted needs to be determined according to the specific characteristics of peri-urban areas. If an unsuitable analytical method is used, the delineated scope may seriously deviate from their scope in reality.

4. Factors in Delineating Peri-urban Areas' Ranges

Whether using qualitative or quantitative analytical methods, researchers should purposely select specific analytical dimensions or factors and consider the potential social, environmental, economic and administrative variables which may affect the ranges. As discussed above, scholars have adopted several methods to delineate peri-urban areas. However, they have chosen a range of differing input factors (specific data) when applying these methods, resulting in varying conclusions. This section reviews these delineating factors, summarises the dimensions of delineation, and analyses the strengths and limitations of the various factors in play.

The current delineation factors can be classified into social order, economic development, environmental resource and administrative management, resulting in four dimensions of delineation results. Significantly, there is no overlap between these dimensions (see Table 2).

Social order factors represent different perspectives on ethnicity, religion, occupation, status, income, lifestyle and relationships in urban centres, peri-urban areas and rural areas (Chen, 1995; Yan and Zhou, 2005; Li, 2005; Yong et al., 2011). The current social order factors involve the size of the peri-urban area's population, but neglect social relationship factors, which are an essential part of social order. Rural residents tend to settle steadily in an area with familiar neighbours. Hence, the primary relationship is the direct interaction between people cooperating daily (Park, 1915). In cities, the population structure is often unstable, because of large-scale communities and frequently changing neighbours. Instead of the primary relationship, urban areas mainly show the secondary indirect relationship (Park, 1915). Peri-urban areas, as the transition zone, present both primary and secondary relationships (Park,

1915). Hence, social relationship factors should be included and adopted to delineate peri-urban areas from the perspective of social order.

Economic development factors reflect the land-value differentiation between urban and rural areas. The closer to the city centre, the higher the price of housing and rent. Further out of the city, there is an inevitable change in land-use types, and economic activities differ from the urban centres, through the peri-urban areas, to the rural areas (Park, 1915; Jiang et al., 2003; Li, 2005; Yong et al., 2011; Yan and Zhou, 2005). Various industrial and commercial factors contribute to the delineation of peri-urban areas by measuring activity levels. It is worth considering whether economic development factors should include land values, which contribute to economic distribution.

Environmental resources factors relate to physical settings, landscaping, and promoting and restricting the development of peri-urban areas. Environmental resources are the underpinning of developing a civilisation, containing the necessary resources for human development, and directly reflecting the needs of a peri-urban area's development. Existing research has focused on many artificial environmental factors (public facilities, traffic conditions) and eco-environmental factors (eco-land, ecosystem) to delineate the areas. These factors reflect the natural environmental resources for peri-urban development and the degree of the built environment of these areas. However, the delineation should also take account of topography, landforms and environmental pollution as relevant factors within the environmental resource dimension. Topography and landforms impact the shaping process of peri-urban development; environmental pollution also shows a transitional trend from cities to the countryside and particularly in changes in the peri-urban areas (Zhang and Xu, 1999). Adopting relevant factors such as these can contribute to establishing an integrated delineation method for considering environmental resources.

Administrative management factors are associated with regional legal content, resulting in binding boundaries of cities. Administrative decisions restrict the division of urban, peri-urban and rural areas. Some researchers have used administrative governance boundaries to delineate peri-urban areas, but these applications lack scientific evidence. At the same time, governance model factors have not tended to be considered in the administrative dimension. The administrative management and governing structure change from city to village with various social elements. The governance model mainly adopted by cities depends on the coexistence of law governance and public opinion (Park, 1915) while, on the other hand, the governance model of villages is based mainly on law and etiquette (Park, 1915; Fei, 1992). Etiquette governance refers to the maintenance of a stable social order by disciplining the behaviour norm among primary groups (Fei, 1992). As a transitional zone between urban and rural areas, the peri-urban area has a governance model composed of law, etiquette and public opinion, which can act as administrative management factors when considering their delineation.

When selecting factors for delineating peri-urban areas, there is a need for accuracy that can facilitate the formation of scientific strategies for developing and managing the areas (Gross et al., 2014). Multiple social dimension factors can be introduced to delineate the areas where there are conflicts between social groupings. By changing these social dimension factors, suitable management strategies can be proposed to deal with such conflicts. Economic dimension factors can be used to formulate strategies for managing issues related to the widened economic gaps and uncoordinated industrial structures often found in peri-urban areas. Environmental dimensions can be adopted to delineate the area where the problems caused by environmental destruction and lack of facilities. Environmental protection and infrastructure supply decisions are up for discussion. Administrative management criteria can be selected to delineate the areas that lack sufficient governance in peri-urban areas. Governance strategies

can be formed in terms of the local governance model. With such applications, situating scientific development and management strategies of peri-urban areas can be formulated specifically for peri-urban areas. Selecting appropriate factors to delineate the areas from multiple dimensions, while taking into account the complexities of local situations, can lay a relatively accurate foundation to support developing and managing such peri-urban areas with complicated issues.

5. Conclusion

This paper aims to define the concept of the peri-urban area and determine the most suitable method for its delineation by reviewing the relevant literature and evaluating the popular application methods. Clearer delineating ranges are conducive to defining peri-urban areas more accurately. Scientifically-based delineation is beneficial to the formulation of strategies targeting such areas accurately, both to resolve issues and to achieve smart growth, urban-rural coordination and sustainable development (Randhawa and Marshall, 2014; Jin et al., 2018; Mortoja et al., 2020; Ge and Lu, 2021; Mortoja and Yigitcanlar, 2022).

- The peri-urban area can be defined as a phase, rather than a place, in which urban elements gradually transition to rural elements. They tend to contain transitional, vacuum or complex characteristics.
- Although the quantitative delineation method has become the primary means for delineating the ranges with timelessness and visualisation, the selection of data analysis methods needs to take into account the local conditions and the availability and limitations of data. The Threshold and the Fuzzy Set Methods are appropriate for delineating those peri-urban areas with evidently transitional characteristics. The Breaking Point and the Cluster Analysis Methods are more advisable for delineating

the peri-urban areas with distinct vacuum characteristics. The Shannon Entropy is more suitable for delineating peri-urban areas with complex characteristics.

- The selection of delineating factors needs to take into consideration the situations of peri-urban areas from the dimensions of social order, economic development, environmental resources and administrative management, or a combination of these. The delineation of the range of peri-urban areas, based on local conditions and accounting for the appropriate dimensions, helps in the formulation of scientific development strategies and decision-making processes.

To conclude, the paper reviews and evaluates the current definitions and methods of delineation for peri-urban areas. It compares the advantages and disadvantages of the qualitative and quantitative methods. It has examined the implementation of multiple delineating quantitative methods and suggested their application where appropriate. It also encourages including more delineating elements that have a significant impact on peri-urban areas. Notably, no absolute correct methods or factors exist for delineating peri-urban areas. Only relatively appropriate ones have been suggested, according to the main characteristics and conditions of different peri-urban areas (Mortoja et al., 2020). Advisable methods and factors can delineate peri-urban areas' ranges close to reality, but with social, economic and technological development, new characteristics and factors may necessitate altering the method of delineation. Appropriate methods and factors for delineating peri-urban areas may evolve accordingly, hence the examination and evaluation of delineating methods and factors should be carried out regularly. When possible, such methods should be explored further, with a view to increasing their accuracy in the future.

Data availability statement

No data, models or code were generated or used during the study.

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Table 1 The comparison of different analytical methods for quantitative delineation

		The Threshold Method	The Shannon entropy method	The breaking point method	The fuzzy set method	The cluster analysis method
Factor type	Image information	√	√	√	√	√
	Statistical information	√	N/A	√	√	√
Factors	Nighttime light	√	N/A	√	√	√

Built-up land	N/A	√	N/A	N/A	N/A
Arable land	N/A	√	N/A	√	√
Water body	N/A	√	√	√	N/A
Woodland	N/A	√	N/A	N/A	N/A
Meadow	N/A	√	N/A	√	N/A
Vegetation land	N/A	N/A	√	N/A	N/A
Urban land	N/A	N/A	√	N/A	√
Greenbelt	N/A	N/A	N/A	√	N/A
Bare land	N/A	√	√	√	N/A
Transport land use	N/A	√	N/A	√	√
Urban elevation	N/A	N/A	N/A	N/A	√
Commuting range	N/A	N/A	√	N/A	N/A
Population density	√	N/A	N/A	√	N/A
Population growth	√	N/A	N/A	√	N/A
Population mobility	√	N/A	N/A	√	√
Non-agricultural workers	√	N/A	N/A	√	N/A
Population of no van	√	N/A	√	N/A	N/A
Gender ratio	N/A	N/A	N/A	√	N/A
The single rate	N/A	N/A	√	N/A	N/A
Lifestyle	N/A	N/A	N/A	N/A	√
Literacy and qualification rate	N/A	N/A	√	√	N/A
Christian	N/A	N/A	√	N/A	N/A
Poor health rate	N/A	N/A	√	N/A	N/A
Dependent children	N/A	N/A	√	N/A	N/A
Aged population rate	N/A	N/A	√	N/A	N/A
Unemployed rate	N/A	N/A	√	N/A	N/A
Per capita living space	√	N/A	√	N/A	N/A
The white British rate	N/A	N/A	√	N/A	N/A
Per capita income	√	N/A	N/A	√	N/A
The occupational structure	N/A	N/A	N/A	√	N/A
Public facilities	N/A	N/A	N/A	√	√
Open space distribution	N/A	N/A	N/A	N/A	√
Water supply	N/A	N/A	N/A	N/A	√
Water risk	N/A	N/A	N/A	N/A	√
Water management capacity	N/A	N/A	N/A	N/A	√
Industry	N/A	N/A	√	N/A	N/A
The economic connection strength degree between city and county	N/A	N/A	√	N/A	N/A
The distance from CBD	N/A	N/A	N/A	N/A	√
Economic activities	√	N/A	N/A	N/A	√
Vegetable delivery radius	N/A	N/A	√	N/A	N/A
Commodity supply flow	√	N/A	√	N/A	N/A
Passengers flow	N/A	N/A	N/A	√	N/A

	Cargo flow	N/A	N/A	N/A	√	N/A
	Climate change pressure	N/A	N/A	N/A	N/A	√
	Biodiversity and ecosystem services	N/A	N/A	√	N/A	√
	Natural elements	N/A	N/A	N/A	N/A	√
Analytical principle	Determining the range of peri-urban areas based on the thresholds of factor's number	√	N/A	N/A	N/A	N/A
	Determining the range of peri-urban areas based on the thresholds of the land type distribution's disorder degree	N/A	√	N/A	N/A	N/A
	Determining the range of peri-urban areas based on the connection line of the factor's mutation points	N/A	N/A	√	N/A	N/A
	Determining the range of peri-urban areas based on the subordination thresholds of factors to urban and rural areas	N/A	N/A	N/A	√	N/A
	Clustering some regions into a few larger regions; then, certain clustered regions with peri-urban area characteristics are delineated as peri-urban areas.	N/A	N/A	N/A	N/A	√
Advantage	Result is visualization	√	√	√	√	√
	Cover many factors increasing the accuracy of delineation	√	√	√	√	√
	Delineated ranges reflect the relatively real changes of peri-urban areas	√	√	√	√	√
Suitable peri-urban areas	Method is more suitable for peri-urban areas with high transitional characteristics	√	N/A	N/A	√	N/A
	Method is more suitable for peri-urban areas with mixed characteristics	N/A	√	N/A	N/A	N/A
	Method is more suitable for peri-urban areas with vacuum characteristics	N/A	N/A	√	N/A	√

Table 2 Current factors

Dimensions	Types of factors	Factors
Social order	Population	Population density (Desai and Gupta, 1987; Gu et al., 1993; Chen, 1995; Zhao and Chen, 1996; Heikkila et al., 2003; Li and Bai, 2005; Wang et al., 2010a; Liu and Jin, 2013; Paul, 2017; Zhou et al., 2017; Mustak et al., 2018; Merciu et al., 2019)
		Population mobility (Li and Bai, 2005; Gonçalves et al., 2017b)
		Population growth (Mustak et al., 2018)
	Urban and rural population	The ratio of non-agricultural population to agricultural population (Robin, 1968; Russwurm, 1975; Bryant and Russwurm, 1982)
		Non-agricultural workers (Mustak et al., 2018)
		Villagers (Li et al., 2012)
	Demographic structure of population	Aged population (Paul, 2017)
		Dependent children (Paul, 2017)
		Christian believers (Paul, 2017)
		White British rate (Paul, 2017)
		Lifestyle (Gonçalves et al., 2017b)
		Single rate (Paul, 2017)
		Gender ratio (Gonçalves et al., 2017b)
		Poor health rate (Paul, 2017)
		Population without car or van (Paul, 2017)
		Per capita living space (Paul, 2017)
		Occupational structure (Mustak et al., 2018)
		Qualifications rate (Paul, 2017)
		Literacy (Mustak et al., 2018)
		Unemployed rate (Paul, 2017)
Economic development	Economic situation	Economic activities (Gonçalves et al., 2017b; Yan et al., 2021)
		Per capita income (Li and Bai, 2005)
		Distance from the CBD (Robin, 1968; Russwurm, 1975; Desai and Gupta, 1987; Bartelmus, 1994; Wang et al., 2010a)
		Commodity supply flow (Chen, 1995; Merciu et al., 2019a)
		Basic vegetable delivery radius (Zhao and Chen, 1996)
		Economic connection strength degree between city and county (Liu, 2006)
	Industry	Service industry (Chen, 1995; Zhang et al., 1999b; Chao et al., 2009)
		Manufacturing industry (Chen, 1995; Zhang et al., 1999b; Chao et al., 2009)
		Industry density (Li, 2005)
		Production value density (Chen, 1995)
Environmental resources	Construction development	Nighttime light (Sutton et al., 2006; Zhuang et al., 2016; Lu, 2019)
		Urban land (Mustak et al., 2018)
		Rural residential land (Wang et al., 2010b; Li et al., 2012)
		Impervious surface coverage (Zhou et al., 2017)
		Built-up land (Cheng and Zhao, 1995; Chen et al., 2001; Qian et al., 2007; Wang et al., 2010b; Chai, 2011; Li et al., 2012; Mortoja and Yigitcanlar, 2022)
		Construction density (Lin et al., 2007; Zhang et al., 2010; Li et al., 2012; Bian and Wang, 2015; Merciu et al., 2019b)
		Building heights (Heikkila et al., 2003)
		Building density (Chen, 1995; Li and Bai, 2005)
		Location of new consumer homes (LeSage and Charles, 2008)
		Open space distribution (Danielaini et al., 2018)
		Land ownership (Lin et al., 2007)
	Traffic	Bus departure frequency (Desai and Gupta, 1987)
		Daily commuting range (Friedmann and Miller, 1965; Zhang et al., 1999a; Paul, 2017)
		Daily commuters (Desai and Gupta, 1987; Chen, 1995)
		traffic accessibility (Merciu et al., 2019a)
		Transport land use (Chai, 2011; Li et al., 2012; Yan et al., 2021)
		Urban elevation (Wang et al., 2010a)
	Public facility and utility	Public service power (Chen, 1995; Li and Bai, 2005; Wang et al., 2010a; Merciu et al., 2019a)
		Water supply (Chen, 1995; Danielaini et al., 2018)
		Water risk (Danielaini et al., 2018)
		Water management capacity (Danielaini et al., 2018)
	Eco-land	Forest land (Chen et al., 2001; Wang et al., 2010b; Li et al., 2012; Bian and Wang,

		2015; Danielaini et al., 2018)
		Water body (Cheng and Zhao, 1995; Chen, 1995; Chen et al., 2001; Wang et al., 2010b; Chai, 2011; Li et al., 2012; Bian and Wang, 2015; Gonçalves et al., 2017b; Danielaini et al., 2018; Mortoja and Yigitcanlar, 2022)
		Semi-natural area (Danielaini et al., 2018)
		Agricultural lands (Chen et al., 2001; Li and Bai, 2005; Qian et al., 2007; Wang et al., 2010b; Li et al., 2012; Bian and Wang, 2015; Danielaini et al., 2018)
		Meadow (Zhang et al., 1999b; Wang et al., 2010b; Bian and Wang, 2015)
		Woodland (Chen et al., 2001; Qian et al., 2007; Wang et al., 2010b)
		Vegetation (Zhang et al., 1999b; Mortoja and Yigitcanlar, 2022)
		Bare land (Chen et al., 2001; Wang et al., 2010b; Li et al., 2012; Mortoja and Yigitcanlar, 2022)
	Ecosystem	Climate change pressure (Danielaini et al., 2018)
		Bird diversity (MacGregor-Fors, 2010)
Administrative management	Administrative boundary	Administrative boundary of a city where urban sprawl maintains a static phase (Carter and Wheatley, 1979)

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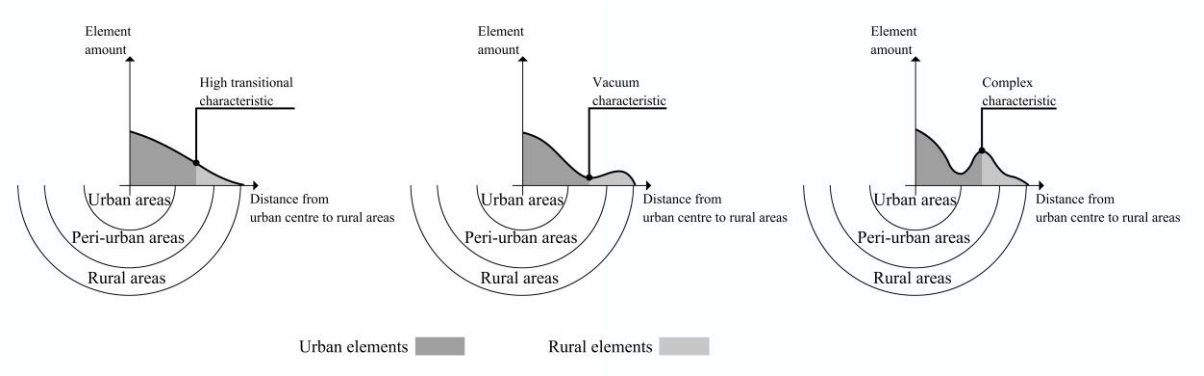

Figure 1 Characteristic types of peri-urban areas

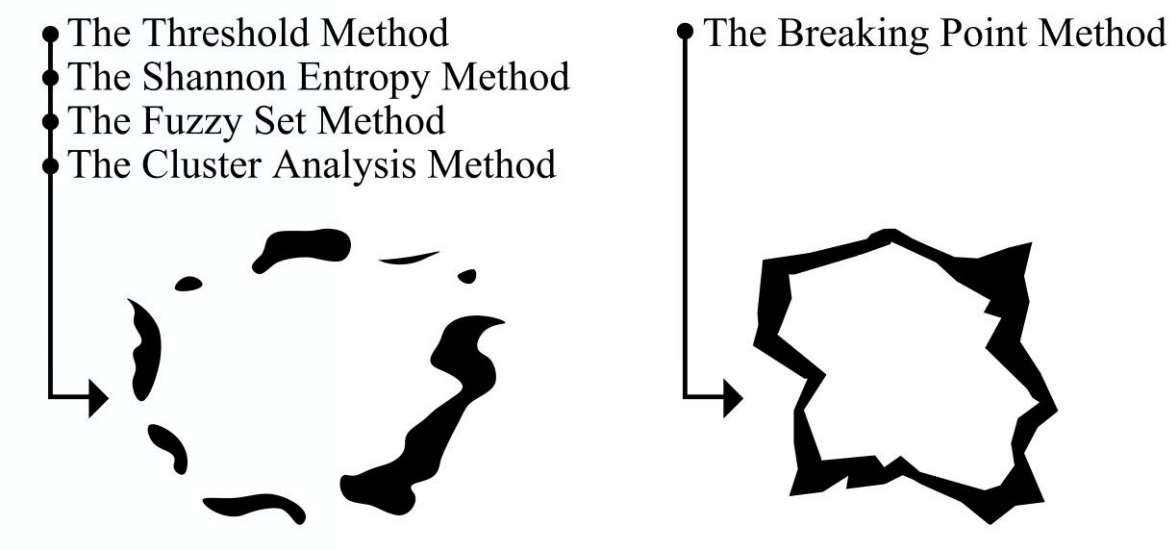

Figure 2 Diagrams of delineated results of each method

Figure Caption List

Dear Editors and Reviewers:

Thank you for giving me the opportunity to submit a revision of my manuscript, titled

"What is the peri-urban area, and how can it effectively be delineated? A synthesis and analysis from a literature review" to Journal of Urban Planning and Development. We are grateful to the reviewers for their insightful comments on the manuscript. We have been able to incorporate changes to reflect suggestions provided by the reviewers. We have highlighted the changes below.

Response to Reviewer #1

Comment 1: *The authors declare that there is no uniform definition for the peri-urban area before. But, why it needs a strict definition is unclear to me. What negative thing will happen if we define it in an inaccurate way. And how should we know if it is defined right?*

Response: Thank you for pointing this out. We agree with this comment. Therefore, we have further explained the positive and negative influence of urban-rural interaction force on peri-urban areas in detail. Based on these influences, we disguised the possibility of coordinating the urban-rural interaction force by managing peri-urban areas to achieve sustainable development. Then, we disguised the role of defining and delineating peri-urban areas in forming scientific strategies to manage peri-urban areas. If the delineated result largely deviates from reality, it is hard to form targeted strategies to manage peri-urban areas to achieve sustainable development.

1. Introduction

(Negative influence on peri-urban areas brought by urban-rural interaction:) … Peri-urban areas reveal prominent negative and positive influences between villages and cities. With the continuous urban expansion referred to above, the population, industry, commerce and residential areas sprawl into the surrounding areas, which tends to squeeze the environments in peri-urban areas bringing with it considerable pollution, such as sewage, garbage and waste (Howard, 1919; Thomas, 1990; Zhong and Yang, 2004; Li and Zhang, 2008; Wang, 2008; Gu and Zhang, 2009; Tan et al., 2010; Zhang, 2011). It may cause a reduction in agricultural production and public space (Huang et al., 2006; Honda et al., 2010; Randhawa and Marshall, 2014; Buxton et al., 2016; Singh et al., 2016; D'Alessandro et al., 2018; Fan and Wang, 2021; Kassis et al., 2021; Spyra et al., 2021; Torre and Fonseca, 2023); deterioration of the ecological environment (Randhawa and Marshall, 2014; Singh et al., 2016; Walters et al., 2016; Amirinejad et al., 2018; Kalfas et al., 2020; Fan and Wang, 2021; Yang, 2021; Aziz et al., 2023); and destruction of landscape and cultural heritage in peri-urban areas (Darwin et al., 2019; Fan and Wang, 2021; Li and Chen, 2021; Yang, 2021).

As a result of the complication of demographic composition in peri-urban areas, social conflicts may readily arise(Thomas, 1990; Errington, 1994). It often tends to be mixed, including urban and rural residents, and even floating populations (Ren et al., 2009; Hudalah et al., 2016; Petrovici et al., 2023). The economic income and cultural backgrounds among different groups may lead to economic segregation (Ren et al., 2009; Mortoja et al., 2020; Melo and Jenkins, 2021; Gottero et al., 2023); cultural shock (Dadashpoor and Ahani, 2019); social isolation (Pan, 2012; He, 2014); and threatening social stability (Randhawa and Marshall, 2014; Cheng et al., 2018; Wubie et al., 2020; Narain, 2021).

When the urban sprawl of peri-urban areas is ahead of planning, and peri-urban areas often are the "vacuum zones" of urban and rural management (Amirinejad et al., 2018; Yang, 2021; Shao and Zhang, 2022), it results in the development of peri-urban areas lacking supervision or any management mechanism. Therefore, peri-urban areas are constantly subject to a great deal of non-conforming development (Ren et al., 2009; Ingwani, 2019; Nguyen, 2023), often triggering an uncoordinated relationship between supply and demand of infrastructure (Allen et al., 2006; Amirinejad et al., 2018; Yang, 2021); scattered residential, commercial, and workspace development (Amirinejad et al., 2018); random industrial structures (He et al., 2014; Yang, 2021); and inefficient land use and substandard activities in peri-urban areas (Park, 1915; Thomas, 1990; Zhong and Yang, 2004; Zhuang et al., 2016; Tian et al., 2017; Amirinejad et al., 2018; Li and Chen, 2021). The three key negative impacts have shown that urban development potentially threatens the ecosystem, landscape, cultural heritage, agricultural output, industrial structure, infrastructure supply and social stability.

(Positive influence on peri-urban areas brought by urban-rural interaction:) While there are these negative impacts, peri-urban areas act as liaisons between urban and rural areas. They bring together the benefits from urban and rural areas and play their role in coordinating the urban-rural relationship. Economic resources and high living standards have been introduced into rural and peri-urban areas from urban areas through urbanisation, increasing the economic development opportunities and living quality in peri-urban areas themselves (Fan and Wang, 2021). Conversely, rural and peri-urban areas provide resources and environment for the ecology and culture of the city and as a destination for urban residents to experience the vernacular

culture and enjoy nature during their leisure time (Snep et al., 2006; Fan and Wang, 2021). Therefore, managing peri-urban areas is essential to easing the conflicts between urban-rural elements and to adjusting the urban-rural relationship (Huang and Tian, 2021).

(Contribution of defining and delineating peri-urban areas:) For understanding and managing change in peri-urban areas, the first question is: "What is the peri-urban area, and how can it be delineated?' A clear concept of and scope for peri-urban areas are fundamental to forming management strategies (Randhawa and Marshall, 2014; Amirinejad et al., 2018). Successful management of peri-urban areas has great significance. It can optimise industrial structures (He et al., 2014); infrastructure supply (Mortoja et al., 2020; Yang, 2021); and land-use patterns. It can protect the ecological environment (Randhawa and Marshall, 2014; Kalfas et al., 2020; Ouyang, 2023); landscape (Fan and Wang, 2021); cultural heritage (Fan and Wang, 2021; Li and Chen, 2021; Yang, 2021); and agricultural production (Buxton et al., 2016; Mortoja et al., 2020; Fan and Wang, 2021). It also can help coordinate people's cultural and economic social relations (Randhawa and Marshall, 2014; Ouyang, 2023) and narrow the economic and living gaps between urban and rural areas. Further, it will promote the achievement of long-term coordination of urban-rural relationships and sustainable development (Yan and Zhou, 2005; Randhawa and Marshall, 2014; Jin et al., 2018; Mortoja et al., 2020; Ge and Lu, 2021; Mortoja and Yigitcanlar, 2022; Li, 2022; Ouyang, 2023).

However, no unified definition or delineation method exists in the current literature (Gonçalves et al., 2017a). This study explores the possibility of unifying the definition and aims to discover the appropriate delineation methods for peri-urban areas. It examines the literature developments synthesised with the concept and characteristics of peri-urban areas. It reviews the issues of modernisation and urbanisation and evaluates the conflicts in this massive development process. It discusses suitable delineation methods and factors in delineating the scope of peri-urban areas. Finally, it suggests improving existing delineating factors for a more precise assessment.

Comment 2: *The authors discuss the factors and methods of delineation of the range of the peri-urban area in the major body of the manuscript. However, they are still open-loop analyses. Like the last comment, how should we know if the delineation is right?*

Response: We agree with the assessment of delineation results is an essential part of delineation. We found no absolutely correct methods and factors for delineating peri-urban areas, only relatively more appropriate methods and factors for delineating the areas with different characteristics and situations (Mortoja et al., 2020). And we suggested suitable methods and factors for delineating different peri-urban areas.

5. Conclusion

…

- Although the quantitative delineation method has become the primary means for delineating the ranges with timelessness and visualisation, the selection of data analysis methods needs to take into account the local conditions and the availability and limitations of data. The Threshold and the Fuzzy Set Methods are appropriate for delineating those peri-urban areas with evidently transitional characteristics. The Breaking Point and the Cluster Analysis Methods are more advisable for delineating the peri-urban areas with distinct vacuum characteristics. The Shannon Entropy is more suitable for delineating peri-urban areas with complex characteristics.
- The selection of delineating factors needs to take into consideration the situations of peri-urban areas from the dimensions of social order, economic development, environmental resources and administrative management, or a combination of these. The delineation of the range of peri-urban areas, based on local conditions and accounting for the appropriate dimensions, helps in the formulation of scientific development strategies and decision-making processes.

To conclude, the paper reviews and evaluates the current definitions and methods of delineation for peri-urban areas. It compares the advantages and disadvantages of the qualitative and quantitative methods. It has examined the implementation of multiple delineating quantitative methods and suggested their application where appropriate. It also encourages including more delineating elements that have a significant impact on peri-urban areas. Notably, no absolute correct methods or factors exist for delineating peri-urban areas. Only relatively appropriate ones have been suggested, according to the main characteristics and conditions of different peri-urban areas (Mortoja et al., 2020). Advisable methods and factors can delineate peri-urban areas' ranges close to reality, but with social, economic and technological development, new characteristics and factors may necessitate altering the method of delineation. Appropriate methods and factors for delineating peri-urban areas may evolve accordingly, hence the examination and evaluation of delineating methods and factors should be carried out regularly. When possible, such methods should be explored further, with a view to increasing their accuracy in the future.

Comment 3: *More publications should be considered. For a research topic started before 1950, this review paper only has <100 references. The conclusions are not convincing enough.*

Response: Agree. We have broadened the reading and referencing range while revising and improving the content accordingly; more than 120 references have been cited by the paper in order to generate a more solid conclusion.

Comment 4: *The authors cite limited literature to argue that rural populations here often lack the competitiveness to accumulate wealth more than urban populations. Whether such a conclusion is universal in most countries needs further discussion.*

Response: We agree with this and have incorporated your suggestion throughout the

Manuscript. We revised the sentence to say that the demographic composition in peri-urban areas tends to be mixed. Cultural shock, economic segregation, and social isolation may easily occur in peri-urban areas due to differences in culture and income among different groups.

1. Introduction

… As a result of the complication of demographic composition in peri-urban areas, social conflicts may readily arise (Thomas, 1990; Errington, 1994). It often tends to be mixed, including urban and rural residents, and even floating populations (Ren et al., 2009; Hudalah et al., 2016; Petrovici et al., 2023). The economic income and cultural backgrounds among different groups may lead to economic segregation (Ren et al., 2009; Mortoja et al., 2020; Melo and Jenkins, 2021; Gottero et al., 2023); cultural shock (Dadashpoor and Ahani, 2019); social isolation (Pan, 2012; He, 2014); and threatening social stability (Randhawa and Marshall, 2014; Cheng et al., 2018; Wubie et al., 2020; Narain, 2021).

Response to Reviewer #2

Comment 1: *From the perspective of the article as a whole, although the induction and collation of literature research are relatively comprehensive, there is a lack of in-depth summary of literature, and the innovation of the article needs to be improved.*

Response: Thank you for pointing this out. We agree with this comment. In-depth summary and innovation are a benefit to clear the contribution of the research. We further discussed the suitable methods and factors for delinting peri-urban areas with different characteristics and situations in-depth. It is the main innovation of the research and lays a clear foundation for

managing peri-urban areas for achieving urban-rural coordination and sustainable development.

3.3 Comparison Study of Quantitative Analytical Delineation Methods

…

The transition threshold and subordination can reflect the transitional character of peri-urban areas. The Threshold Method and the Fuzzy Set Method are especially suitable for delineating peri-urban areas with high transitional characteristics. These two refer to the transition threshold of the number of factors from city to rural and the subordination degree of factors in the cities or villages to delineate the peri-urban area. The Breaking Point Method and the Cluster Analysis Method are more suitable for delineating the peri-urban areas with vacuum characteristics, where elements tend to show distinctly distinguished from urban and rural areas. With no statistical factors in the Shannon Entropy Method, because of the consideration of disordered and mixed threshold of land factors, it has an unparalleled advantage for delineating peri-urban areas with complex characteristics.

Significantly, the peri-urban areas of a city may contain all three characteristics in different regions (high transition, vacuum or complex). Hence, when high accuracy is required in delineating results, these methods can be separately used in different regions of the city to obtain a more comprehensive picture overall of peri-urban ranges. In short, the analytical method to be adopted needs to be determined according to the specific characteristics of peri-urban areas. If an unsuitable analytical method is used, the delineated scope may seriously deviate from their scope in reality.

4. Factors in Delineating Peri-urban Areas' Ranges

… When selecting factors for delineating peri-urban areas, there is a need for accuracy that can facilitate the formation of scientific strategies for developing and managing the areas (Gross et al., 2014). Multiple social dimension factors can be introduced to delineate the areas where there are conflicts between social groupings. By changing these social dimension factors, suitable management strategies can be proposed to deal with such conflicts. Economic dimension factors can be used to formulate strategies for managing issues related to the widened economic gaps and uncoordinated industrial structures often found in peri-urban areas. Environmental dimensions can be adopted to delineate the area where the problems caused by environmental destruction and lack of facilities. Environmental protection and infrastructure supply decisions are up for discussion. Administrative management criteria can be selected to delineate the areas that lack sufficient governance in peri-urban areas. Governance strategies can be formed in terms of the local governance model. With such applications, situating scientific development and management strategies of peri-urban areas can be formulated specifically for peri-urban areas. Selecting appropriate factors to delineate the areas from multiple dimensions, while taking into account the complexities of local situations, can lay a relatively accurate foundation to support developing and managing such peri-urban areas with complicated issues.

5.Conclusion

…

- Although the quantitative delineation method has become the primary means for delineating the ranges with timelessness and visualisation, the selection of data analysis methods needs to take into account the local conditions and the availability and limitations of data. The Threshold and the Fuzzy Set Methods are appropriate for delineating those peri-urban areas with evidently transitional characteristics. The Breaking Point and the Cluster Analysis Methods are more advisable for delineating the peri-urban areas with distinct vacuum characteristics. The Shannon Entropy is more suitable for delineating peri-urban areas with complex characteristics.
- The selection of delineating factors needs to take into consideration the situations of peri-urban areas from the dimensions of social order, economic development, environmental resources and administrative management, or a combination of these. The delineation of the range of peri-urban areas, based on local conditions and accounting for the appropriate dimensions, helps in the formulation of scientific development strategies and decision-making processes.

Comment 2: *According to the summary of the article, it is suggested that the future research direction can be put on the land space planning and other aspects, and the following documents are recommended:*

[1] Spatiotemporal patterns in urbanization efficiency within the Yangtze River Economic Belt between 2005 and 2014 [J].Journal of Geographical Sciences,2018,28(08):1113-1126.

[2]A strategy of the rural governance for territorial spatial planning in China[J]. Journal of Geographical Sciences, 2021, 31(9) : 1349-1364.

Response: Agree. We have, accordingly, referenced the two important publications to emphasise the significance of defining and delineating peri-urban areas in achieving long-term urban-rural coordination and sustainable development.

1. Introduction

… Further, it will promote the achievement of long-term coordination of urban-rural relationships and sustainable development (Yan and Zhou, 2005; Randhawa and Marshall, 2014; Jin et al., 2018; Mortoja et al., 2020; Ge and Lu, 2021; Mortoja and Yigitcanlar, 2022; Li, 2022; Ouyang, 2023).

Comment 3: *In the introduction section, "It treats the ecological environment and landscape*

of peri-urban areas." is inconsistent with the previous and subsequent contents. Should "treats" be changed to "threats".

Response: Thank you for helping us to find the problems. It is 'threats', and we have corrected the spelling and proofread all content of the paper.

Comment 4: *Part 3.2 of the article has missing references, and the author is suggested to supplement or replace them.*

Response: Thank you for helping us to find the problems. We have corrected the missing and proofread all content of the paper.

Comment 5: *The article should pay attention to the unity of the content format. In the Factors of Delineation of the Range of the Peri-urban Area, the first sentence of the second paragraph is bolded to see if there is any special meaning.*

Response: Thank you for helping us to find the problems. We have proofread the format and revised the sentence in an unbolded format.

Comment 6: *The language expression of the full text should be further refined and improved, and attention should be paid to language simplification, semantic accuracy, fluent sentences and cohesion and logic between contexts.*

Response: Thank you for helping us to find the problems. We have further proofread the language expression throughout the full paper and made language become more simplification, accurate, and logical.

Response to Chief Editor

Comment: *In view of the remaining comments, I would like the authors to prepare a revised version, and address all concerns as well as suggestions raised by the reviewers. The manuscript would be accepted for publication only if all critical issues have been taken care properly or explained convincingly. An itemized response report shall also be included to expedite the re-review process.*

Most importantly, the contributions of this study to the urban planning community should be highlighted clearly. The revised version will be re-reviewed by the same reviewers.

Response: Thank you for providing the revisors' comments and highlighting the most important suggestions. We have revised the paper according to all revisors' comments. Significantly, we have to pay much attention to clear the contribution of the paper. We further explained the urban-rural interaction forces in peri-urban areas and pointed out the possibility of mange these interaction forces to coordinate urban-rural relationships and achieve suitable development. The clear definition and suitable delineation of peri-urban areas according to the situation of different peri-urban areas contribute to laying a foundation to form strategies for scientifically managing the areas. (the specific contribution and innovation can be seen in the responses for comment 1 of reviewer 1 and comment 1 of reviewer 2)

Additional clarifications

In addition to the above comments, the expression for improving the accuracy of the paper has been improved, and all spelling and grammatical errors pointed out by the reviewers have been corrected.

We look forward to hearing from you in due time regarding our submission and to respond to any further questions and comments you may have.

Sincerely,

Lanxin Li

27 March 2023