Understanding the Urbanite-oriented Performance of Ecosystem Service in Peri-urban Areas: An analytical Framework*

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Abstract: Peri-urban area is the transitional territory between rural and urban areas and the most diverse area that the ecosystem confronts the urban development. It is probably one of the fastest growing areas across the world, especially in developing countries, among which China is recognized as one of the most important contributors. Extant research document peri-urban area not only as the most dynamic and growing territories, but also the territories haunted by urban sprawl, environmental pollution, social segregation, etc. Based on the particularity of the ecosystem in the peri-urbanized area, this paper proposes a human-centered analytical framework for assessing ecosystem functions based on the original ecological service value assessment method. First assess the performance of ecosystems (ES), including cultural services, supporting services, regulating services and provisioning services to meet the diverse needs of urban dwellers, rather than equal value or biomass carbon. Further, instead of simply superimposing the four types of ES, clustering analysis is used to classify the ES types of each analysis unit because they differ in the four dimensions of the ES, and finally some scenario predictions were made through the classification results.

Keywords: peri-urban; ecosystem service; people-oriented; developing countries

1 Introduction

Ecosystem services play an indispensable role in the human environment, including supply of food and fresh water, climate and temperature regulation, soil diversity maintenance, spiritual culture and entertainment value (Costanza *et al.*1997; Ma and M. E. A., 2005). Ecosystem services not only play a decision-making tool in the growing urban population and social system, but also an important tool for maintaining human health (Gomez-Baggethun and Barton, 2013). Currently ecosystem system services are still one of the priorities of multidisciplinary research (Seppelt *et al.* 2011, Fisher *et al*. 2009), and the demand for urbanization and other practical applications is becoming more and more obvious (Daily *et al.* 2009, Burkhard *et al*. 2010).

With the rapid urbanization process, urban population expansion and land expansion are also ubiquitous, resulting in rapid and disorderly changes in land use (Haas and Ban, 2014), which gradually destroys natural ecosystems, especially the decline of ecosystem services. At the same time, in the rapid development stage of urbanization, the rapid growth of the built environment and social capital has replaced the natural capital which centered on the value of ecosystem services and become a mainstream value orientation, and the contribution of the ecosystem network to human well-being has been greatly underestimated (Costanza *et al*. 2014a; Costanza *et al.* 2014b). This phenomenon is particularly remarkable in the circle-type and regionalized "peri-urban areas" in the suburbs of megacities.

The peri-urban area is not only one of the most economically active areas (Zhang et al. 2008), but also the frontier areas where the urban built environment and the natural environment face each other. The composition of ecosystem service functions is more diverse and complex, and more Urban planning is urgently needed (Hudalah *et al.* 2007; Webster, 2011; Wu *et a*l. 2008; Tian *et al.* 2013). Studies have shown that urban land use management affects changes in natural ecosystems directly or indirectly, and management policies and planning decisions also largely influence land management practices (Carpenter *et al.* 2009; Maring and Blauw, 2018; Bai *et al.* 2004). Therefore, spatial planning may effectively control the negative effects of semi-urbanized development (LeGates *et al.* 2014; Zhao, 2013; Huang *et al.* 2009). But the planning system itself also needs to make profound changes (Hudalah *et al.* 2007)

Judging from the service value assessment of ecosystems, the traditional performance research is mostly based on the economic value judgments measured in the form of currency, carbon sink or land change, and does not fully consider the real ecological needs of people. In this paper, an ecosystem service evaluation framework is proposed for the peri-urban areas, which based on township streets and human needs. This framework will help bridge the gap between the scientific assessment of the value of ecosystem services and the administrative management of urban ecological functions, and provide decision support for ecologically oriented planning interventions.

2 Particularity of ecosystems in peri-urban areas

2.1 Prominent contradictions between construction and ecological land

Peri-urban area refers to the progressive, fragmented and transitional regional type of rural areas that are gradually transforming into urban areas in the economic, social and spatial attributes out of the urban core built-up area (Webster, 2011). In the process of rapid urbanization, the peri-urban areas are in dynamic spatial reconstruction and social economic transformation. Industrialization and urbanization erode the original ecological landscape, lifestyle and production mode. The coupling of various forces such as the disorderly spread of urban space, the urbanized standardization of landscapes, the deprivation of capital and power through space reconstruction, and the destruction of ecological base by industrialization lead to acute contradiction of land use in peri-urban areas, and the evolution is particularly complicated. It also makes the land in the peri-urban areas completely different from the cities and villages (Cheng *et al.* 2017).

Land use in peri-urban areas is characterized by a mix of industrial, commercial, residential and agricultural uses, of which a large amount of land is still used for agricultural purposes. Industrial land is scattered and spreads rapidly along major traffic routes, intertwined with rural settlements and agricultural land (Tian and Ge, 2011). From the perspective of eco-environmental effects, the expansion of construction land in peri-urban areas has had a strong impact on the land ecosystem, and economic growth is followed by a higher environmental cost.

From this point of view, the peri-urbanization process itself will have a greater impact on the human settlements. The land use in peri-urban areas changes drastically. It is the region where the contradiction between construction land and ecological land is the strongest, which has a great impact on the service of ecosystem. The problems such as human-land conflict, land shortage and environmental pollution are very prominent in the peri-urban areas, which become the focus of land remediation and transformation development. It is necessary to formulate corresponding land use and eco-environment policies for different ecological background characteristics of different regions, optimize land use patterns in peri-urban areas and ease the contradiction between construction land and ecological environment (Pan andTian, 2018).

2.2 Diversified ecosystem services

The ecosystem services in peri-urban areas are highly diversified. In the central area of the city, the ecosystem is relatively simple, mainly as a leisure place for urban residents, so its cultural (tourning) service is the most significant; in rural areas, the ecosystem is also relatively single, mainly responsible for supply, regulation and support services. When it comes to the peri-urban areas, based on the original ecological background, the ecosystem service is more complicated and diversified. It not only undertakes food supply, climate regulation and diversity maintenance, but also maintains certain spiritual culture and entertainment value.

The ecological service of peri-urban areas is closely related to the urbanization process. With the expansion of cities, the ecological land such as farmland and woodland in peri-urban areas will inevitably be transformed into urban construction land, which will be a threaten to the ecosystem and cause a series of social and environmental problems (Simon, 2008; Buxton *et al.* 2006; Liu *et al.* 2003).

Studies have shown that the value of ecosystem supply, regulation, and support services is closely related to the area of ecosystems that provide these services, but rarely have studied the value of ecosystem services from the perspective of “human needs”. In the process of urbanization, due to the expansion of urban built-up areas and reclamation from the sea, the area of cultivated land, offshore waters and tidal flats has been declining, resulting in the reduction and inhibitory effect on the supply, regulation and support services of the ecosystem. Therefore, with the continuous advancement of urbanization, the land use type has been rapidly transformed, and the urban construction land has increased significantly, which has led to a downward trend in ecosystem services on supply, support and regulation. At the same time, the continuously improvement of urban infrastructure and development of tourism and cultural undertakings have promoted the cultural services of urban ecosystem (Huang *et al.* 2012).

3 Methods and Limitations of Traditional Ecosysteml Service Assessment

3.1 Two traditional assessment methods for ecosystem services

The assessment of the value of ecosystem services has long been challenging (Wallace, 2007). There are mainly two types of methods for assessing: one is monetary methods based on cost-benefit analysis, value assessment or payment willingness, and another is based on supply-demand analysis of ecosystem services, carbon sinks, carbon footprints, and ecological integrity.

The first category is a monetary approach based on cost-benefit analysis, value assessment or payment willingness. Innovative approaches to monetary methods such as cost-benefit analysis, value assessment or payment willingness assessment (Costanza *et al. 1*997; Farber *et al.* 2002; Xie *et al.* 2008; Xiao *et al.* 2016), measured the value of ecosystem services quantitatively. The above methods can usually perform spatial simulation and feature calibration, so that ecosystem service assessment can be achieved through map drawing. Existing research is generally based on the estimation of the land classification, and the ecosystem service of the urban area is judged by obtaining a specific economic value. With the advancement of technology, ecosystem evaluation software, such as GIS, InVEST, FUTURES, CA-markov, CLUE-S, SPANs, etc., has been gradually developed, and it is inevitable to modify it into an operational and visual tool for natural resource management (Kienast *et al.* 2009; Burkhard *et al.* 2012; Stürck *et al.* 2014; Wolff *et al.* 2017; Nikodinoska *et al.* 2018; Chen *et al*. 2019; Dang *et al.* 2019). These methods are generally recognized theoretically (Ma, 2005), but due to the complexity and diversity of the ecosystem, the selection of research fields and calibration methods is often "completely integrated", resulting problems in accuracy and consistency (Ludwig, 2000; Spangenberg and Settele, 2010).

The second category is the methods based on ecosystem service supply and demand analysis, carbon footprint, carbon sinks and ecological integrity assessment. Ecosystem service assessment based on ecosystem service supply and demand analysis has several core methods including carbon footprint, carbon sink and ecological integrity assessment (Wackernagel and Rees 1996; Costanza *et al*. 1997; Ma, 2005; Müller, 2005). For example, Paetzold *et al.* (2010) pointed out that the status of ecosystem services is not only affected by itself, but also by human needs and the needs of society. The relationship between supply and demand of social systems and ecosystem services is inseparable. Syrbe and Walz (2012) propose that there is a service connection area between the supply unit and the use unit area of ecosystem services, which is a common space for the supply and use of ecosystem services, where the transmission and conversion of services takes place. Kroll *et al.* (2012) used data on land use, climate, population, energy consumption, etc. to evaluate the supply and demand of ecosystem services in rural-urban areas of Germany, and to analyze the law of spatial change. Burkhard *et al.* (2012) proposed the concept of ecosystem service supply and demand quantification and related spatial visualization, and pointed out that as time and space change, human activity patterns are different, ecosystem service capabilities and land use will also change. Based on the application practice of land use management, Chen (2019) identified the thresholds of land use ratios required for different services in the ecosystem services to fill the deficit and balance supply and demand.

3.2 Limitations of existing ecosystem service assessment methods

A large number of ecosystem services researches aim to the well-being of human beings. Deriving the extent of human well-being only from the ecosystem server cannot fully consider the real ecological needs of people. . Few studies focus on the value of ecological services from the perspective of human needs systematically.

The value of ecosystem services is usually measured by monetary value, carbon sinks, land changes, etc. (As seen in Figure 1). For example: (1) GDP accounting, usually select one element as the benchmark and the rest are derived through simple calculation. It is widely used in explaining the relevant large-scale ecological service mainly in agriculture and forestry. However, there are obvious scale differences in space and time of the ecosystem service in the city, which leads to the planning management department not being able to obtain the judgment information accurately; (2) the GEP accounting, usually calculates the ecological service of the factor as carbon and judges it through carbon storage. In current urban development, people's needs are developing rapidly and the carbon is rapidly consumed, which contradict with the nature of carbon sequestration, so it is difficult to advance decision-making. (3) LUCC land change accounting, usually plots the changes of various factors over the years and reflects the future development trend of the city by superimposing the change of land use. Based on the level of social and economic development, people are more sensitive to changes in the process of urban development, amplifying their own needs and neglecting the needs of others, just like the choice of neighboring facilities. Thus, it is also difficult to put forward decision-making.

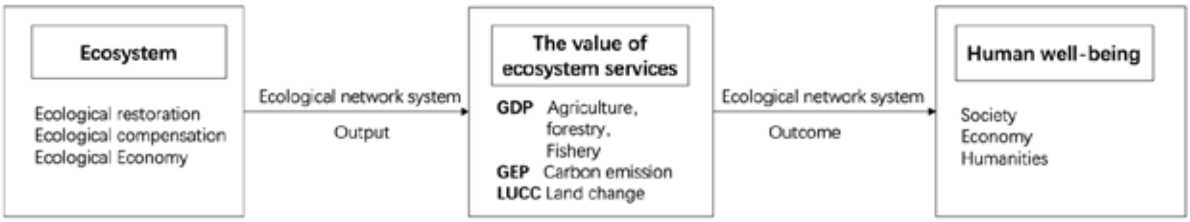

Figure 1 Schematic diagram of the research process of ecosystem service value

Source: Author self-painting

These assessments have certain limitations in supporting urban ecological planning at the application level. Urban ecosystem services are considered as an important basis for decision-making support for decision makers (Bai, 2018), and the integration of demand-side into ecosystem services assessments, ecological processes that focus on time and space are also generally considered to be very important. . However, as the spatial characteristics of ecosystem services change by time and usage, the research on ecosystem services is relatively lagging, which makes the correction methods for obtaining human well-being relatively simple, thus affecting the judgment of decision makers. With the aim of ecosystem protection, combined with the land use scenario dynamic-city (LUSD-city) model, looking for key ecosystem service areas and conducting graded protection, the natural resources can be effectively planned, developed and used, which also provide important decision-making basis for urban decision makers. (Knight *et al*. 2008, Lv *et al*. 2013, Lv *et al*. 2017, Orsi and Geneletti, 2010). Rapid and efficient clustering, integration of complex information such as time changes, spatial characteristics and distribution patterns of ecosystem services, and the formation of visual display tools will enable decision makers (such as land managers) to conduct sustainability assessments effectively (Swetnam *et al*. 2010).

4 Construction of ecosystem service assessment method for diversified human needs

4.1 Overall framework

At present, traditional ecological service assessments usually target abstract human well-being, but there are few ways to deal with the relationship between local needs and ecosystem services provided elsewhere (Seppelt *et al.* 2011). The author believes that the value of urban ecosystem services should be measured from the single natural resource supply to the diversified human demand. Relevant scholars believe that in the process of rapid urban development, we should still follow the guidelines of equality and guide the overall balanced development of cities through the changes in the supply and demand relationships of urban land-use unit ecosystem services. Finding acceptable and equitable levels of ecosystem services and properly balancing the supply and demand for local ecosystem services is an important step towards sustainability (Burkhard, 2012). Therefore, we need to follow the overall framework of ecosystem services assessment. According to the study of Costanza (1997), MA (2005), Müller (2007), Burkhard et al. (2009, 2012), Groot *et al.* (2010), based on the actual conditions in China, an overall assessment framework for cultural, supporting, regulating and provisioning services of the ecosystem is obtained, meeting the existing data conditions. (As seen in Table 1)

Further, certain human needs may generate a large number of negative ecological effects and should be included in the overall accounting. In the process of urbanization, the ecosystem aims to improve service functions, but the goal of this improvement is not always consistent with the needs of urban development. The diverse needs of human production and life often affect the ecological space directly and destroy the logic of ecological service value optimization, leading to the assessment of ecosystem service far from diversified human needs, which affects the judgment of decision makers.

Based on the content conversion of ecosystem service assessment, this paper considers that the function of ecosystem service in the evaluation unit is a comprehensive process, that is, supporting, provisioning, regulating and cultural services. Although some scholars have proved that the dominant order of human needs is regulation, provision, support and culture, the author believes that rather than the ecosystem of the unit be analyzed separately, it should be considered as a whole. One of the important consideration is that if it cannot be closely related to the needs of urban development, then the research on the value of ecological services can optimize the ecological environment, but it is difficult to meet the diversified

Table 1 Indicators of ecosystem service value assessment revised by author

classification	Ecosystem services	Function of ecosystem services
supporting services	Biodiversity	Whether there is a selected species, (functional) population, habitat composition or species composition
	Abiotic heterogeneity	Providing suitable habitats for different species, species functional groups and processes is critical to the functioning of ecosystems.
	Biological water flow	Balance of the operation of the inter-aquatic water system
	Metabolic efficiency	Refers to the energy required to maintain a specific biomass and is also used as a pressure indicator for the system
	Nutritional loss	Irreversible loss of elements in the ecosystem
	Storage	Store the system's nutrients, energy and water, etc. and release them when needed
regulating services	Climate monitoring	Land cover changes will locally affect temperature, wind, radiation and precipitation
	Global climate regulation	Ecosystems play an important role in the climate by isolating or emitting greenhouse gases
	Flood control	Suppress flooding
	Groundwater supply	Surface runoff, changes in system water storage potential, such as wetland conversion or replacement of forests. Farmland or farmland in urban areas
	Air quality regulation	The ability of ecosystems to remove harmful substances and other elements from the atmosphere
	Erosion regulation	Soil conservation, prevention and control of wind and sand, mountain protection
	Nutritional regulation	The ability of the ecosystem to perform (re)cycles, such as N, P or others.
	Clean water	Ability to purify water
	Pollination	Pollination distribution, abundance and effectiveness
provisioning services	Crop	Grain production
	Livestock	Feeding animal
	Vegetables	Amount of edible vegetables
	Fishery	Capture commercially interesting fish that fishermen can enter.
	Aquaculture	Animals are raised in terrestrial or marine aquaculture.
	Wood	A tree or plant used in wood.
	Wild food	Wild animals, plants
	Combustion consumption	Area used for combustion consumption
	Energy (biomass)	fossil fuel
	Biochemistry and medicine	Production of biochemicals, pharmaceuticals.
	freshwater	Fresh water volume
cultural services	Entertainment and aesthetic value	Landscape and visual quality. Capacity and number of arrivals
	Intrinsic value of biodiversity	Native species, endangered species

Source: According to the study of Costanza (1997); MA (2005).; Müller (2007); Burkhard et al. (2009, 2012); Groot et al. (2010), conforming to Chinese Computable Logic and meeting existing data conditions.

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4.2 Indicator selection

This study quantifies the service value of ecosystems from the perspective of people's needs, explores the spatial mismatch between land use and the supply and demand of ecological service related to urbanization, and feeds them back to land management and urban development decisions. Therefore, we selects assessment indicators as criteria that are quantifiable, can be quickly mapped and fed back into land management, and can be directly related to human needs. In this way, carbon storage consumption, food production, PM2.5, and entertainment are four important indicators for urban areas, mainly because most urban areas face local pollution (such as polluted air), natural resource waste (such as carbon emissions exceeding the standard), mismatch between supply and demand of living conditions (such as food shortage) and the need for leisure space.

Specifically, 1) Supply: Select the grain crop yield as the core indicator and compare it with the per capita consumption. Food supply capacity can benefit urban residents; 2) Support: Select carbon storage capacity as the core indicator to compare adult per capita use with demand, which helps to improve residents' understanding of global carbon emissions and atmosphere changes; 3) Regulation: Selecting the PM2.5 concentration of climate monitoring as the core indicator, which is helpful to improve residents' awareness and maintain a clean and safe living environment by comparing with the damage of urban population; 4) Culture: Select entertainment as the core indicator to compare the real-time population activity with the land capacity. Cultural and recreational services can help residents maintain a good mental state and enjoy a high quality of life (Bai *et al.* 2018; Chen *et al.* 2019).

4.3 Clustering of ecological service value

This study believes that the township and streets can be used as a unit to cluster and analyze the four types of ecological service values: provision, regulation, support and culture. The functions of ecosystem service of peri-urban areas are classified according to the leading functions of each analysis unit ecosystem. The resulting ecosystem classification may be, but is not limited to, the results shown in the table below（As seen in Table 2）: