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Bridging the gap between policy logic and stakeholder perceptions: a dual assessment of ecosystem services in Chengdu's peri-urban agricultural areas

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Peri-urban landscape planners are increasingly aware of the value of ecosystem services in improving the quality of life of urban residents and strengthening the protection of peri-urban agriculture. However, the ecosystem service framework in China has not yet been systematically integrated into agricultural spatial planning. Therefore, this study aims to assess the ecosystem services in peri-urban agricultural areas and the specific objectives are (1) to assess the way the ecosystem services framework is implemented in the current agricultural land use planning in Chengdu city and (2) to assess the importance of the current peri-urban agroecosystem services with case study in Chengdu Eco-Zone. This study conducted a case study of Chengdu Eco-Zone in China combined document analysis and interview method. Firstly, 8 strategic documents related to land planning in Chengdu were selected for analysis, secondly, 36 planners and practitioners were interviewed. Analyses of agriculture-related planning documents revealed that the term 'ecosystem services' is not explicitly mentioned in formal planning documents at present. Still, the content of the most recent strategic documents reflects the relevance of the ecosystem services framework. In assessing agro-spatial ecosystem services, as represented by the Chengdu Eco-Zone, the cultural services provided by the respondents have the highest value (100%), followed by supporting services (94.44%) and regulating services (94.44%), while the value of provisioning services is slightly lower (62.04%). Our findings suggest that incorporating the concept of ecosystem services and using a people-centred valuation approach in planning urban and peri-urban agricultural land can promote the conservation of existing agricultural land and communicate the benefits that peri-urban agricultural areas provide citizens at all levels of agricultural spatial governance.

KEYWORDS

agricultural areas, agroecosystem services, Chengdu eco-zone, ecosystem service, peri-urban

1 Introduction

Peri-urban agricultural areas, situated at the dynamic interface between urban and rural systems, are globally recognized as multifunctional landscapes (Zasada, 2011). These areas provide a suite of essential ecosystem services (ES), including provisioning services (agroforestry products), regulating services (climate regulation, carbon sequestration), and cultural services (landscape aesthetics) (Castro et al., 2018; Chakravarty et al., 2019; Mattsson et al., 2015; Bargali and Bargali, 2020). However, the rapid expansion of urban footprints has led to intense competition for land, rendering peri-urban ecosystems highly vulnerable to fragmentation and degradation. While the Millennium Ecosystem Assessment (MEA) and frameworks like InVEST have standardized ES evaluation (Hails and Ormerod, 2013), existing methodologies often struggle to capture the nuances of small-scale, mixed-environment landscapes where human-natural interactions are most intense (Wood et al., 2022; Toledo-Gallegos et al., 2022).

The Chengdu Plain, China, historically celebrated as the “Tianfu Granary,” exemplifies this global challenge. Despite its fertile land and unique “farmland-wetland” mosaic, the region has faced a significant decline in arable land—decreasing by 40% between the second and third national land surveys (Ministry of Natural Resources, 2021). This loss is driven not only by physical urban expansion but also by the “non-grain” conversion of farmland into high-value nursery plantations and floral landscapes. In response, the Chengdu government has launched ambitious initiatives, such as the “Ring of Ecological Parks” and the “Tianfu Granary Construction” project, to safeguard food security and ecological integrity (Jia et al., 2021).

However, a critical gap exists between high-level policy implementation and scientific ecological management. While current government actions (e.g., the vacation of 4,733 ha of fruit trees for grain) demonstrate a strong political commitment to land restoration, these interventions are primarily driven by sociological and food security imperatives—defined here as the urgent social need to meet land-use quotas and grain production targets—rather than a comprehensive understanding of the underlying ecosystem service trade-offs (Xie et al., 2021). For instance, converting “flower fields” back to “rice paddies” may satisfy grain quotas from perspective of sociological value, but could inadvertently alter other regulating or cultural services. Without a systematic assessment of how ES frameworks are integrated into these plans, and the evaluation of the resulting ES importance, there is a risk that restoration efforts may be ecologically suboptimal or unsustainable in the long term (Chan et al., 2012).

In the existing field of ecosystem services (ES) research, scholars have utilized various models such as InVEST, ARIES, and SolVES (Hails and Ormerod, 2013; Wood et al., 2022; Toledo-Gallegos et al., 2022; Luo et al., 2022; Jeyavanan et al., 2017) to conduct extensive mapping and value assessments of ecosystem services across different scales (Costanza et al., 2017; de Groot et al., 2010) and monetization methods based on economic value (Costanza et al., 2017; Hails and Ormerod, 2013). These methods have played a crucial role in revealing ES supply potential and spatial patterns at large scales. However, while research targeting purely urban or agricultural areas has reached a level of maturity, studies within peri-urban areas—characterized as highly dynamic and complex social-ecological systems—remain relatively sparse. A significant limitation in current academia is that

most studies tend to focus on static assessments or the spatio-temporal evolution of ES supply, while neglecting the intrinsic link between policy governance frameworks and actual ecological performance (Geneletti, 2016). Especially within small-scale mixed landscapes, existing theoretical frameworks struggle to explain how local land-use planning (such as Chengdu’s arable land protection policies) procedurally incorporates ES concepts, and whether these policy interventions accurately respond to the actual importance of ecosystem services. This disconnect between “policy logic” and “ecological evidence” constitutes a critical theoretical gap in current research. Furthermore, traditional quantitative research often emphasizes “outputs” over “processes.” When dealing with complex subjective factors such as policy logic, governance frameworks, and social perceptions, it often struggles to explain how ES are integrated into actual planning decisions (Geneletti, 2016).

Meanwhile, conducting an in-depth exploration of ecosystem services in peri-urban agricultural areas holds significant theoretical and practical value. From an ecological perspective, these areas serve as “green buffer zones” for urban expansion, playing an irreplaceable role in mitigating urban heat island effects, regulating runoff, and maintaining regional biodiversity (Zasada, 2011). From a socio-economic perspective, peri-urban agriculture is not only a core base for ensuring urban food sovereignty but also a vital carrier for maintaining landscape diversity and preserving regional cultural services (Andersson et al., 2014). Investigating the importance of these services facilitates the scientific identification of “trade-offs” and “synergies” between ecosystem services, thereby providing a scientific basis for the decision-making processes involved in implementing the United Nations Sustainable Development Goals, particularly SDG 11: Sustainable Cities and Communities. Through the case study of the Chengdu Eco-Zone, we can not only redefine the perception of peri-urban agriculture from “urban reserve land” to a “regional sustainable asset” but also provide a Chinese model that can serve as a reference for land-use optimization in other rapidly urbanizing regions globally.

Within the context of Chengdu’s “Tianfu Granary Construction” project, the government’s protection of arable land is not merely an ecological action but an administrative decision driven by sociological values. Qualitative analysis allows for a deep dive into the governance intentions behind policy texts, revealing the procedural internalization of the ES framework—a feat that purely physical indicator calculations cannot achieve (Van Eck et al., 2025). While quantitative methods excel at answering “how much,” qualitative methods are better suited to answering “how it is implemented” and “why it matters,” which is better in this study (Creswell and Poth, 2018; Krippendorff, 2018). This method effectively bridges the gap between “scientific evidence” and “policy execution.” It assesses not only the objective existence of ES values but also the application potential of the ES framework in peri-urban protection by analyzing stakeholder logic, providing direct evidence for policy optimization, rather than merely simulated values.

Therefore, this study aims to assess the ecosystem services in peri-urban agricultural areas. To achieve this aim, the research objectives of this study were proposed: (1) To assess the implementation of the ES framework in current agricultural land-use planning: This objective evaluates the procedural aspect—understanding to what extent existing policies already internalize ecological values versus purely administrative targets. (2) To assess the importance of current peri-urban agroecosystem services in the Chengdu Eco-Zone: This objective provides the empirical evidence base on the actual supply

and demand of ES. The logical connection between these two objectives lies in the feedback loop between planning and performance: only by understanding how policies are currently framed and what the actual ecological status is can we optimize management strategies to maximize the ecosystem service value of peri-urban landscapes.

2 Literature review

2.1 Benefits of peri-urban agriculture (PUA)

Due to the multiple benefits of urban agriculture (UA) and peri-urban agriculture (PUA) to cities, they are in line with the goals of the United Nations' 2030 Sustainable Development Agenda (SDGs): poverty eradication; zero hunger; sustainable cities, and neighborhoods and life on the land, especially urban sustainability (Grădinaru et al., 2018). UA emerges when agricultural land is fragmented and surrounded by urban areas during urban expansion. Urban agriculture (UA) has evolved into many forms, including urban agritourism gardens, allotment gardens, controlled environment agriculture gardens, community gardens, home gardens, etc. (Artmann and Sartison, 2018). A typical type of UA is the peri-urban agro-park. Peri-urban agro parks are a mixture of multiple UA elements, such as circular agro-parks, allotment gardens, gleaning gardens, and landscape parks. The function of UA has evolved from simple food production to encompass multiple functions (Artmann and Sartison, 2018). Rapid urbanisation threatens urban and peri-urban agricultural areas, with some cities neglecting them or converting them into real estate (Ayambire et al., 2019). Building edible cities and promoting participation in nature-based solutions (NBS) can raise awareness of UA. In the edible city framework, urban and peri-urban agriculture contributes to food security, poverty alleviation, and other social challenges (Khumalo and Sibanda, 2019; Barthel and Isendahl, 2013). In addition, Wilhelm and Smith (2018) recognise PUA's land-saving potential, which can represent a mechanism to conserve and protect sensitive natural and peri-urban ecosystems. Therefore, integrating peri-urban agriculture (UA) into urban ecosystems is crucial for sustainability, especially in food systems. Some researchers have developed assessment frameworks for urban agriculture (Artmann and Sartison, 2018); however, further assessments of different types of UA or PUA are needed to provide evidence for practice.

2.2 Peri-urban ecosystem services

As urban densities increase, in response to climate change and the provision of adequate social infrastructure and a high-quality urban environment, urban planning attempts to address these challenges by developing planning strategies and policy guidelines. The natural and social sciences have developed frameworks to help identify the value of the natural environment to urban populations and to make specific planning recommendations. In particular, researchers developed the ecosystem services framework (Millennium Ecosystem Assessment, 2005; TEEB, 2011) to highlight the benefits of ecosystems to human societies. Later, the Millennium Ecosystem Assessment (2005) categorized ecosystem services into four groups: provisioning,

regulating, supporting, and cultural services. Peri-urban ecosystems have a significant impact on human well-being through the provision of a wide range of services, including disaster risk management such as flood protection, attenuation of the urban heat island effect, food security, air and water purification (Dolley et al., 2020; Kuusaana and Eledi, 2015; Wangai et al., 2019).

Since the beginning of the 21st-century, the Chinese Government has introduced a series of policies on constructing beautiful villages, rural land consolidation and agricultural supply-side reform, and has planned a road map for rural revitalisation. As a result of these efforts, significant results have been achieved in developing rural economies, the optimisation of rural infrastructure and the harmonious development of urban and rural areas. However, these activities may irreversibly alter the natural environment, leading to soil degradation, loss of biodiversity, and decline of various services (Sylla et al., 2020). Previous research on the environmental quality of China's countryside has shown significant 'landscape pollution', i.e., repetitive landscapes without distinctive features, in rural or peri-urban areas of China. In addition, more than 60 per cent of villages have "fair" or "poor" rural landscape quality, and more than three-quarters of villages have insufficient ecological facilities and residential green spaces along field roads. From an ecological point of view, rural and peri-urban areas play an essential role in maintaining basic ecosystem functions. Spatial planning documents often consider them as hotspots for urban and regional ecological integrity. Intensive and productive agricultural land traditionally supports specific habitats with high species diversity and provides critical landscape services (Guerra and Pinto-Correia, 2016). To maintain this multifunctionality, adaptive intervention strategies are essential to maintain the balance between different components of social-ecological systems (Bretagnolle et al., 2018; Kanter et al., 2018). Ecosystem services assessment effectively facilitates environmental decision-making processes (Nowak and Grunewald, 2018).

2.3 Ecosystem services in peri-urban agricultural areas

Peri-urban ecosystems, particularly peri-urban agriculture, are essential in rural and urban sustainability and resilience. For example, expanding urban and peri-urban agriculture can expand the ecosystem services available in the built environment while reducing pressure to convert sensitive non-urban, non-agricultural ecosystems to agriculture (Wilhelm and Smith, 2018). As a result, the benefits of peri-urban ecosystems are increasingly recognised. However, there is little data to support these hypotheses, information on how these benefits is perceived and valued by urban residents is unavailable primarily to policymakers, and the ecosystems on which this diverse range of services depend have not received the commensurate attention that has been accorded to the urban subject (Chen et al., 2023). In recent years, while the growth of research on PUA suggests a growing recognition of the potential role played by PUA systems in global food production, few studies have placed peri-urban agriculture in the context of ecosystem services, and there is an even more significant lack of empirical research in the Chinese context. The ecosystem services framework has been recognised as valuable for understanding the synergies and trade-offs arising from land use change and addressing the challenges associated with urbanisation

and climate change. However, it has yet to be directly integrated into spatial planning due to a lack of understanding by planners and practitioners of the ecosystem services that peri-urban agricultural areas can provide (Spagnoli and Mundula, 2021), limiting effective ecological policy-making and urban and rural planning.

Expanding the scope of future research on peri-urban agriculture, including quantifying ecosystem services and functions, will help elucidate the ecological trade-offs associated with agricultural production in the built environment. As demand for food increases and urban populations continue to grow, it is critical to understand better the role that urban environments play in global agricultural production and ecosystem conservation. In addition, the assessment of ecosystem services in peri-urban agricultural areas is intended to provide planners and practitioners with a better understanding of the benefits provided by agricultural spaces and to serve as a positive argument for green infrastructure development so that city builders are better able to develop/value peri-urban agriculture and enhance agricultural sustainability.

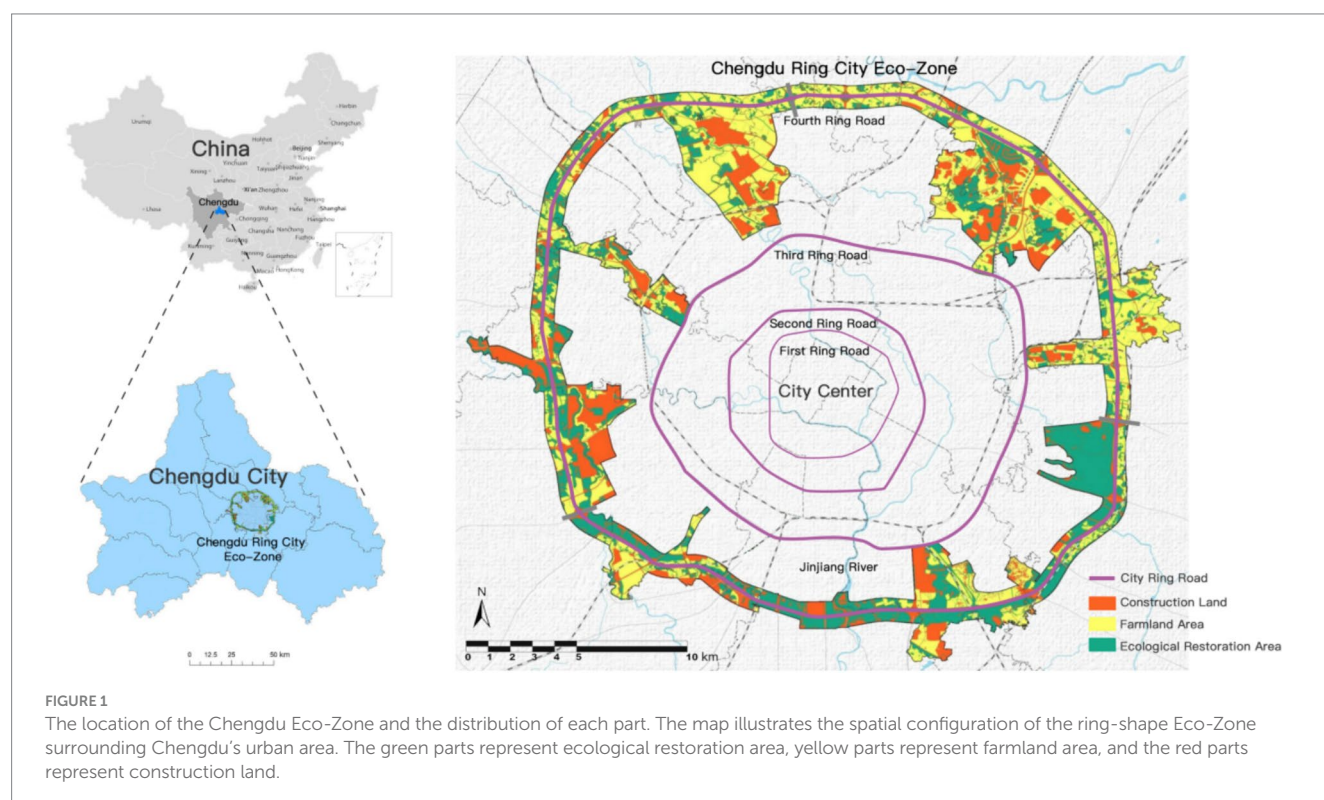
3 Research methodology

3.1 Study case

Chengdu is located between 102°54′–104°53′E longitude and 30°05′–31°26′ N latitude, in the hinterland of the Chengdu Plain (Figure 1). Chengdu is one of the most important cities in Chinese history. It is the capital city of Sichuan Province, a provincial political, industrial and cultural centre, and a major economic centre in Southwest China (Qin, 2015). During the past 20 years, Chengdu, like other rapidly developing big cities, has seen a large amount of

land leased out for factories, warehouses, and markets, and waste materials and construction waste piled up everywhere, leading to a continuous loss of agricultural functions, a continuous degradation of ecological functions, a gradual shrinkage of irrigation water systems, land abandonment, and a decline in the quality of arable land. At that time, the planning of cities was almost always confined to urban areas and did not cover rural areas. As a typical urban–rural integration area at that time, the Eco-Zone created many problems in continuous urban expansion. Therefore, to prevent urban expansion and disorderly development, the Chengdu Municipal Government formally proposed planning the Chengdu Eco-Zone in 2013. From the beginning of the planning of the Eco-region, it has been the most critical task of all levels of government to make the city's sustainable development and ecological protection go hand in hand to satisfy the people's aspirations for a better life.

The Chengdu Eco-Zone (Figure 1), now under construction, is a control zone consisting of 500 m on each side of the city ring motorway along the central city, as well as ecological land and construction land in seven wedge-shaped plots around it, with a total area of 187.15 km², of which the ecological land consists of agricultural land and landscaped greenspace, with a total size of 133.11 km². Permanent bare farmland will be strictly protected within the ecological zone, and the restoration of arable land will be promoted in conjunction with the clean-up of unauthorized building works and the vacating of low-end functions. At the same time, the eco-zone is based on agriculture and landscape integration, constructing a creative and diversified urban agricultural landscape, planning three zones and nine sections of standard agricultural zones, constructing a new farmland form through large-scale cultivation of farmland, and enhancing the economic value and landscape value of farmland. Therefore, this case



represents the current situation of Chengdu's agricultural land use planning and the development level of peri-urban agriculture.

3.2 Document content analysis

This study employs documents content analysis to conduct a systematic review of land-use planning and relevant policy documents in Chengdu city. There are two steps for the document content analysis: document collection and content analysis.

(1) Document collection

The planning documents related to peri-urban agricultural areas were selected in this study. The selection process was based on the following criterion: the documents should represent strategies that address the development and conservation of agricultural land at the regional, urban or specific green space level in this area. The specific green space level documents includes planning documents directly addressing specific agricultural spaces (e.g., Chengdu Eco-Zone). The final list of planning documents is shown in Table 1. They belong to the category of strategic plans as they provide a long-term vision, objectives and measures for the further development of the planning area.

(2) Content analysis

To ensure scientific rigor, the content analysis of planning documents using the ecosystem services framework (Sukhdev et al., 2014) aimed to identify explicit or implicit references to the concept of ecosystem services. Explicit means that the document refers to the term “ecosystem services”, while implicit means that it refers to the benefits humans derive from nature or specific ecosystems rather than specific services. As the specific academic term “Ecosystem Services” does not explicitly appear in some policy documents, this study utilized latent content analysis to determine relevance by identifying “functional equivalents” (Neuendorf, 2017). For instance, while documents might use terms such as “water conservation,” “biodiversity maintenance,” or “landscape beautification,” these are essentially policy-oriented expressions of regulating and cultural services according to internationally recognized standards like CICES (Haines-Young and Potschin-Young, 2018). This approach allows for a more authentic capture of policy-makers' actual focus on ES values, rather than being restricted by specific terminology.

To ensure the accuracy of the result, the analysis strictly followed the systematic coding procedures common in qualitative research (Krippendorff, 2018). The coding procedure includes three distinct stages: open coding stage, axial coding stage and selective coding stage.

Open coding stage: The research team conducted a line-by-line reading of eight selected strategic documents (e.g., *The Ten Measures for Farmland Protection in Chengdu*), extracting initial terms related to land functions, ecological protection, and agricultural production.

Axial coding stage: The initial terms were categorized based on their internal relationships. Drawing on *Millennium Ecosystem Assessment* (2005) framework, relevant expressions were classified into four main axes: provisioning, regulating, supporting, and cultural services.

TABLE 1 Planning documents related to Chengdu Eco-Zone agricultural land and ecosystem services.

Scale	Planning	Chinese original title	Type
Chengdu-Chongqing region	Territorial Spatial Planning for the Chengdu-Chongqing Twin-city Economic Circle (2021–2035)	成渝地区双城经济圈国土空间规划 (2021—2035年)	Strategy
	Chengdu Plain Economic Zone Territorial Spatial Planning (2021–2035)	成都平原经济区国土空间规划 (2021—2035年)	Strategic Plan
City	Chengdu City Master Plan (2016–2030)	成都市城市总体规划 (2016–2030年)	Strategic Plan
	Chengdu Land Use Master Plan (2006–2020)	成都市土地利用总体规划 (2006–2020年)	Strategic Plan
	Chengdu Territorial Spatial Master Plan (2020–2035)	成都市国土空间总体规划 (2020—2035年)	Strategic Plan
City and district specific	Chengdu High-standard Farmland Construction Plan (2021–2030)	成都市高标准农田建设规划 (2021–2030年)	Strategic Plan
	Optimisation and Enhancement of the Master Plan of Chengdu Eco- Zone (2020)	成都市环城生态区总体规划优化提升 (2020)	Strategic Plan
	Regulations on the Protection of Chengdu Eco-Zone (2013)	成都市环城生态区保护条例	Strategy

Selective coding stage: The final stage involved distilling the implementation logic and priority distribution of the Ecosystem Services (ES) framework within the policies. The entire process was managed using NVivo software to enhance transparency and traceability (Neuendorf, 2017).

3.3 In-depth interview

To obtain primary evidence regarding the planning implementation process, semi-structured interviews were conducted with 36 relevant stakeholders.

This study employed purposive sampling to select key informants with profound insights into and decision-making influence over peri-urban agricultural planning in Chengdu (Creswell and Poth, 2018). The focus was on experts who understand spatial planning for agriculture and are familiar with planning for the Chengdu Eco-Zone

including five engineers, five university faculty members, six experts from agricultural research institutes, three landscape students, six staff members from the Land Planning Bureau, six landscape designers, and five experts from the agricultural industry (Table 2).

To ensure the representativeness of the interviewee and reliability of the in-depth interview, the sample of interviewee is structured as follows:

Policy Makers ($n = 12$): Representatives from government departments such as Natural Resources and Agriculture and Rural Affairs, responsible for drafting and supervising macro-policies.

Professional Planners ($n = 14$): Experts from planning and design institutes responsible for spatial layout and the technical translation of the ES framework.

Local Practitioners ($n = 10$): Including community managers and heads of agricultural enterprises responsible for the localized execution of policies.

The proportional design of the sample distribution aimed to balance three dimensions: “top-level design,” “technical support,” and “grassroots implementation.” By covering different functional departments and multi-level respondents, the study ensured a diverse and comprehensive perspective. The final sample size was determined based on the principle of data saturation, meaning sampling was concluded when subsequent interviews yielded no new themes or insights (Saunders et al., 2018). This multi-dimensional sampling strategy significantly enhances the representativeness and scientific value of the findings within the specific context of Chengdu’s ecological zones.

The interviews were conducted from March 2024 to May 2024 and lasted 30–60 min. The interview questions consisted of three parts: the interviewees’ roles and functions in urban agricultural land use planning; an assessment of the importance of each specific agroecosystem service and an explanation; and finally, the interviewees’ perception of the ecosystem service concept and their assessment of its application. The detailed information of interview questions is pre-set, but it will be expanded based on the different answers of each interview.

The interview guide was based on open-ended and closed-ended questions, including questions that revealed preferences for ranking ecosystem services in the selected agricultural landscapes. Based on our literature review, we formulated the research questions. A selection of core questions from the interviews is presented in the Annex. All interviews were conducted in person by the same

researcher. Relevant experts who were contacted received invitations to the interviews, explaining in detail the study’s objectives and the critical interrelationships between agriculture and ecosystem services. Interviews began with a short description of the objectives and context of the study. Interviews were transcribed and then manually transcribed verbatim. Qualitative content analysis was also used to analyze the anonymised transcript in accord with the coding procedure includes open coding stage, axial coding stage and selective coding stage.

4 Results

4.1 Representations of ecosystem services in agricultural spatial planning

At the regional level, the “Territorial Spatial Planning of Chengdu Plain Economic Zone (2021–2035)” examines the role of peri-urban agriculture as an ecological barrier from a regional strategic perspective. Its explicit recognition of ES focuses primarily on regulating and supporting services, explicitly proposing the construction of regional ecological corridors to achieve soil and water conservation as well as biodiversity maintenance. Its implicit recognition of ES is manifested through the institutional guarantee of provisioning services; although the term “ES” is not directly employed, the objectives of “modern agricultural development” and “water resource security” implicitly embed food supply and water conservation functions into the regional security pattern. This reflects a strategic transition by planners to treat peri-urban agriculture as a regional ecological shield rather than a mere production space, emphasizing ecological stability at a cross-regional scale. Furthermore, the positioning of the Ring Ecological Zone (CEZ) in the “Master Territorial Spatial Planning of Chengdu Plain Economic Zone (2021–2035)” demonstrates a high degree of systematicity. Its explicit ES directly point to provisioning and regulating services, particularly by juxtaposing “premium grain and oil cultivation” with “urban wind corridors,” which highlights the dual functionality of peri-urban agriculture in material output and the mitigation of the urban heat island effect. Its implicit ES internalize the mechanisms of high-quality output assurance and urban resilience enhancement through the development of “modern agricultural demonstration zones” and the flood attenuation capacity of wetland systems. The analysis indicates that the plan attempts to reconstruct a

TABLE 2 List of respondents.

Category	Representatives	Num.	Interests in agriculture and ecosystem services
Policy maker	Officials in the land planning Bureau	6	- Involvement in agricultural space planning and citywide discussions - Involvement in the development of recent three major agricultural strategies
	Experts from agricultural research institutes	6	- Involvement in agricultural space planning and citywide discussions - Involvement in the development of recent three major agricultural strategies
Professional planner	Lecturers at Agricultural University	5	Involvement in agricultural space planning and citywide discussions
	Landscape designers	6	- Involvement in implementation of agricultural strategies on district level - Involvement in local agriculture and ecosystem services initiatives and planning projects
	Students of landscape design	3	Involvement in local agriculture and ecosystem services initiatives and planning projects
Local practitioner	Engineers	5	Involvement in the construction of agricultural space projects
	Agricultural industry experts	5	Involvement in implementation of agricultural strategies on district level

“production-city-ecology” dynamic balance in highly urbanized fringe areas through the synergistic layout of climate regulation and urban agriculture, embodying the coupled management logic of social-ecological systems.

At the city level, the “Chengdu Urban Master Plan (2016–2030),” serving as an integration and “spongification” expression of all-domain ecological elements, is grounded in the all-domain ecological security pattern. Its explicit ES recognition aligns closely with the concepts of “Sponge City” and the “mountain-water-field-forest” community, explicitly emphasizing water resource utilization, flood prevention, and climate regulation services. Its implicit ES are mapped onto the “five-level greening system” and the construction of Chengdu as a “World Cultural City,” implicitly transforming the landscape value of peri-urban agriculture into public education, aesthetics, and social well-being. This mode of expression indicates that early comprehensive planning had already begun to shift from traditional engineering governance toward the integrated synthesis of ecosystem services, aiming to realize the dual growth of urban climate adaptability and cultural soft power through the protection of ecological elements. The “Chengdu Land Use Master Plan (2006–2020),” as a resource-constrained policy, centers its explicit ES on the “bottom-line” protection of provisioning and regulating services, with a significant emphasis on cultivated land red lines, water resource security, and soil erosion control. Its implicit ES indirectly achieved habitat support and rural aesthetic values through comprehensive land consolidation and forest maintenance. Although this stage lacked a clear ES terminology system, its protection of land productivity and ecological stability formed the physical foundation for peri-urban agricultural ES output, reflecting a “passive” maintenance path of ecosystem services driven by resource management.

The “Chengdu Master Territorial Spatial Planning (2021–2035)” reflects multi-dimensional values under the ecological security pattern and characterizes the comprehensive features of territorial spatial governance in the new era. Its explicit ES focus on regulating and supporting services, directly safeguarding biodiversity and carbon sequestration capacity by delineating ecological protection red lines and establishing a system of natural protected areas. Its implicit ES deeply map the synergy between enhanced food production capacity and modern urban recreational functions through the optimization of agricultural layouts and the construction of a park system. This expression signifies that Chengdu has established a complex ES network centred on “carbon sequestration-habitat-restoration,” aiming to facilitate the transition of peri-urban agriculture from a singular space to a carrier of multi-functional ecological values through spatial regulation. The “Chengdu High-Standard Farmland Construction Plan (2021–2030)” represents the synergistic gain of production functions and ecological resilience. Focusing on the micro-governance of agricultural landscapes, its explicit ES recognition is precisely positioned within provisioning services (grain capacity) and supporting services (soil fertility). Its implicit ES are embedded within the construction of ecological ditches and the application of green agricultural technologies, implicitly achieving hydrological regulation, non-point source pollution control, and the mitigation of habitat fragmentation. The analysis suggests that high-standard farmland construction is no longer merely an engineering task but an ecological engineering tool that, by enhancing the intrinsic quality of farmland ecosystems, indirectly strengthens the robustness of peri-urban areas as the city’s “life-support system.”

The “Optimization and Upgrading of the Master Plan for Chengdu’s Ring Ecological Zone (2020),” a document addressing welfare enhancement and urban resilience through landscape narratives, transforms the peri-urban agricultural landscape into a core urban competitiveness. Its explicit ES are highly focused on cultural services (perceptible parks, greenway experiences) and regulating services (blue–green interwoven networks). Its implicit ES internalize high-level service functions such as regional carbon neutrality and public health promotion (e.g., healing landscape values) through the large-scale restoration of wetland and forest systems. This reflects that, under the influence of landscape urbanism, planners have implicitly activated the multiple spillover effects of peri-urban agriculture in terms of social equity and climate regulation by explicitly improving spatial accessibility and perception. As a legally binding framework, the “Regulations on the Protection of Chengdu’s Ring Ecological Zone (2013)” focus explicit ES on the legalization of regulating and supporting services, strictly defining the boundaries for prohibiting topographical destruction and water pollution. Its implicit ES implicitly safeguard the region’s food security bottom line and the regulatory potential of natural resources through rigid clauses prohibiting changes in the use of agricultural land. Through institutionalized intervention, this regulation provides the most robust rule-based foundation for ES output in the Ring Ecological Zone, reflecting Chengdu’s determination to achieve “stock protection” and “functional non-degradation” of ecosystem services through administrative and legislative means.

This series of planning documents collectively outlines the logical chain of evolution for Chengdu’s peri-urban agricultural areas, transitioning from “single production spaces” to “multi-functional ecosystem service complexes.” From the early bottom line of resource protection to the mid-term integration of elements, and finally to the current stage of deep value coupling, the recognition of ES has shifted from singular, materialized provisioning services to complex, systematic mappings of regulation and cultural well-being (see Table 3).

4.2 Importance of peri-urban agroecosystem services

Over the past 5 years, the planning and construction of the Chengdu Eco-Zone have progressed positively. New developments also include the creation of 30 speciality gardens, which, in conjunction with the construction of the Jincheng Greenway, will create a diverse range of experience gardens according to the principle of “one garden, one speciality.” Some realised developments have paid particular attention to the area’s ecological potential. For example, the Qinglong Lake Wetland Park in the eco-zone is the largest lake in the Chengdu metropolitan area. It has also become a paradise for wild waterfowl, native flora and fauna, seasonal migratory birds, and a wide variety of organisms that form a complete ecosystem.

In addition to the agricultural land space that has been built and is under construction, the governance process of the Chengdu Eco-Zone has included developing the two strategic planning documents mentioned above: the Optimisation and Enhancement of the Master Plan of the Chengdu Eco-Zone (2020) and the Regulations on the Protection of the Chengdu Eco-Zone. Over the last few years, they have been developed with different social actors (planners,

TABLE 3 The extent to which the ecosystem services framework is integrated into the planning system.

Document	Service category	Explicit services	Implicit services
Territorial Spatial Planning of Chengdu Plain Economic Zone (2021–2035)	Provisioning Services	/	Water supply: Ensuring water security; Food production: Promoting modern agricultural development.
	Regulating Services	Constructing ecological corridors to enhance soil and water conservation; strengthening collaborative river basin governance to improve flood control capacity.	Climate regulation: Promoting joint prevention and control of air pollution; optimizing energy structure to reduce emissions.
	Supporting Services	Protecting biodiversity and maintaining ecological balance.	Soil formation: Restoring and enhancing regional soil and water conservation functions; Habitat support: Strengthening forest land protection and enhancing carbon sequestration capacity.
	Cultural Services	/	Leisure and recreation: Creating cultural tourism routes; Aesthetic value: Promoting rural revitalization and shaping urban–rural forms.
Master Territorial Spatial Planning of Chengdu Plain Economic Zone (2021–2035)	Provisioning Services	Premium grain/oil and urban agriculture supply: Implementing high-quality grain and oil cultivation in the Minjiang-Tuojiang Irrigation Area within the Ring Ecological Zone; constructing modern urban agriculture demonstration zones.	Modern agricultural output assurance: Ensuring stable supply of high-quality agricultural products (vegetables, flowers, etc.) through the construction of demonstration zones.
	Regulating Services	Climate and ventilation regulation: Functioning as “urban wind corridors” to mitigate the urban heat island effect and enhance air circulation.	Atmospheric purification: Improving urban air quality through green belt vegetation and assisting in the treatment of ozone and particulate matter pollution; Stormwater reduction and detention: Utilizing water networks and wetlands within the Ring Green Belt for flood attenuation during rainy seasons to enhance urban resilience; Carbon sequestration: Acting as the “green lungs” of the city to sequester carbon through vegetation growth, supporting carbon peak goals.
	Supporting Services	Habitat provision and biodiversity maintenance: Providing habitats and ecological corridors for migratory birds and local species as a critical urban ecological space.	Soil fertility protection: Maintaining soil productivity by strictly protecting the agricultural space of the Dujiangyan Plain Irrigation Area; Nutrient cycling: Maintaining basic material and energy cycles relying on wetland and farmland systems within the green belt.
	Cultural Services	Leisure tourism and greenway experiences: Establishing an attractive space display system based on the Ring Green Belt, providing fitness, leisure, and ecological sightseeing spaces.	Park City value demonstration: Serving as a core carrier for the “Park City” concept and exemplifying a livable lifestyle; Aesthetic and landscape value: Enhancing urban brand image and resident well-being by constructing “Ba-Shu charm” urban landscapes; Science education: Providing ecological civilization publicity and environmental education as a venue where nature meets the city.
Chengdu Urban Master Plan (2016–2030)	Provisioning Services	Ensuring the sustainable utilization of water resources.	Food and raw material supply: Constructing a modern industrial system; developing urban agriculture to enhance agricultural product supply.
	Regulating Services	Constructing a “Sponge City” to improve flood and waterlogging prevention; optimizing ventilation corridors to improve urban climate.	Climate regulation: Promoting green and low-carbon development to reduce pollution; Hydrological regulation: Strengthening water system governance and maintaining aquatic ecology.
	Supporting Services	Protecting “mountain-water-field-forest” ecosystems and maintaining biodiversity; constructing an ecological security pattern.	Soil formation: Promoting comprehensive land consolidation to enhance soil fertility; Habitat support: Strengthening the management of nature reserves.
	Cultural Services	Developing Tianfu culture and enhancing cultural soft power; building a world-renowned cultural city and protecting historical heritage.	Leisure services: Constructing a five-level greening system for public experience; Educational value: Promoting Park City construction and providing recreational space.

(Continued)

TABLE 3 (Continued)

Document	Service category	Explicit services	Implicit services
Chengdu Land Use Master Plan (2006–2020)	Provisioning Services	Rationally developing and utilizing water resources to ensure agricultural water use.	Food supply: Protecting cultivated land to ensure food security; developing specialized agriculture to increase output.
	Regulating Services	Maintaining water resource security and preventing water pollution; strengthening soil erosion control to enhance water retention capacity.	Hydrological regulation: Promoting water-saving irrigation to improve water use efficiency; Climate regulation: Optimizing land use structure to reduce ecological pressure.
	Supporting Services	Protecting ecological land and maintaining biodiversity; conducting comprehensive land consolidation to improve soil quality.	Habitat support: Strengthening forest maintenance to promote ecological recovery; promoting ecological restoration to enhance ecosystem stability.
	Cultural Services	/	Aesthetic value: Promoting rural revitalization and shaping beautiful countryside; Tourism services: Developing leisure industries combined with agricultural and forestry resources.
Chengdu Master Territorial Spatial Planning (2021–2035)	Provisioning Services	/	Food supply: Strictly observing the red line for cultivated land protection to enhance grain capacity; optimizing agricultural layout to ensure supply; developing modern agriculture to strengthen the food production base.
	Regulating Services	Delimiting ecological protection red lines and strengthening ecological regulation; constructing ecological patterns to enhance soil and water conservation; protecting water systems and wetlands to maintain hydrological balance.	Promoting flood control and climate adaptation; strengthening pollution control to improve environmental quality.
	Supporting Services	Constructing a natural protected area system and protecting biodiversity; strengthening habitat restoration to maintain ecological stability; protecting forest resources to enhance carbon sequestration.	Habitat support: Carrying out ecological restoration to support habitat networks; promoting soil improvement to facilitate ecological processes.
	Cultural Services	Protecting historical culture and building a cultural city; developing Tianfu culture to enhance leisure value.	Constructing a park system to provide recreational space; creating tourism routes to enhance aesthetic experiences; promoting rural revitalization to inherit local culture.
Chengdu High-Standard Farmland Construction Plan (2021–2030)	Provisioning Services	Constructing high-standard farmland to enhance grain capacity; ensuring agricultural supply and stabilizing agricultural production.	Developing efficient agriculture to increase food output; optimizing planting structures to improve resource efficiency.
	Regulating Services	Constructing ecological ditches to improve farmland hydrology; preventing soil erosion to enhance farmland disaster resistance.	Hydrological regulation: Improving irrigation and drainage systems to regulate the water cycle; Pollution regulation: Promoting green technologies to reduce non-point source pollution.
	Supporting Services	Maintaining farmland ecosystems and protecting cultivated land quality; promoting soil improvement to enhance soil fertility.	Soil formation: Protecting the plow layer and promoting soil health; Habitat support: Strengthening biological protection to enhance ecological resilience.
	Cultural Services	/	Tourism services: Developing leisure agriculture in conjunction with rural revitalization; Educational services: Creating pastoral complexes to provide cultural experiences.

(Continued)

TABLE 3 (Continued)

Document	Service category	Explicit services	Implicit services
Optimization and Upgrading of the Master Plan for Chengdu's Ring Ecological Zone (2020)	Provisioning Services	Ensuring water resources and supporting urban agricultural development.	Food supply: Developing urban agriculture to provide fresh produce; optimizing agricultural structures to enhance supply resilience.
	Regulating Services	Constructing a "blue-green" interwoven ecological network to improve climate; strengthening water body protection to enhance hydrological regulation.	Climate regulation: Optimizing ventilation corridors to promote air circulation; Hydrological regulation: Promoting stormwater management to reduce inland flooding risks.
	Supporting Services	Protecting biodiversity and constructing habitat systems; restoring ecosystems to enhance stability.	Carbon sequestration: Conducting ecological restoration to enhance soil carbon sequestration; Habitat support: Maintaining natural vegetation to support species reproduction.
	Cultural Services	Creating accessible and perceptible parks to provide leisure services; integrating cultural elements to enhance landscape value.	Recreational services: Promoting the integration of culture and tourism to enhance experiences; Health value: Constructing green spaces to promote public health.
Regulations on the Protection of Chengdu's Ring Ecological Zone (2013)	Provisioning Services	/	Food supply assurance: Prohibiting changes in the use of agricultural land; regulating agricultural activities to ensure resource sustainability.
	Regulating Services	Protecting water bodies, preventing pollution, and maintaining water quality safety; strengthening ecological balance management to prevent environmental degradation.	Climate regulation: Maintaining ecological balance and reducing human interference; Hydrological regulation: Controlling development activities to protect natural resources.
	Supporting Services	Protecting ecological land and maintaining biodiversity; prohibiting the destruction of topography and geomorphology to ensure ecological integrity.	Habitat support: Strengthening vegetation protection to support ecological processes.
	Cultural Services	Protecting cultural heritage and inheriting historical context; providing public leisure spaces to promote social well-being.	Educational services: Regulating tourism activities to ensure the protection of cultural resources; Leisure services: Optimizing landscape design to enhance aesthetic value.

university representatives, citizens). These positive developments in recent years - new agricultural land development, green planning strategies, and collaboration through university networks - show that Chengdu's policy and planning institutions have built up some expertise over the years in the benefits of peri-urban agricultural space. However, these positive developments do not mean that the whole process of agricultural land governance (including the application and assessment of ecosystem services) is free of problems. The authors identified the importance of ecosystem services by analysing interviews with experts. These assessments of importance reflect the main objectives of the current planning and governance of the Chengdu Eco-zone and future directions. The four dimensions of ecosystem services—provisioning services, regulating services, habitat or support services, and cultural services—were used to explain the specific services provided by peri-urban agriculture. The next section directly references the reasons for the choices mentioned by the experts in the interviews. Table 4 summarises the services identified and their importance.

Quantitative statistical analysis was conducted on semi-structured in-depth interview data from 36 relevant stakeholders. The results reveal that respondents exhibited distinctly different evaluative tendencies toward the four categories of ES provided by the Chengdu

Ecological Zone (Table 4). Regarding provisioning services, the evaluation results exhibited a significant low-value distribution. Data indicate that over 75% of respondents rated the importance of “food supply,” “raw material supply,” and “medicinal resources” as “Not Important” or “General.” Qualitative interview transcripts show that respondents commonly identified the potential risk of soil pollution from urban expansion and the high costs associated with fragmented cultivation as the primary drivers of the low scores for provisioning services. In contrast, regulating services and cultural services received consistently high ratings. Within regulating services, “local climate regulation” and “air quality regulation” were designated as “Very Important” by 88.9% of respondents. In the cultural services dimension, all 36 respondents identified “leisure and tourism” and “aesthetic and inspiration” as core functions, with mean scores approaching the maximum value of the Likert 5-point scale. Respondents explicitly noted that the area's attribute as an “urban green lung” and an inelastic demand for recreation has transcended its traditional agricultural production function. For supporting services (e.g., species habitat and genetic diversity maintenance), the evaluation results remained robust, with approximately 80% of respondents classifying them as “Important” or “Very Important.” The data distribution demonstrates that expert cohorts generally recognize

TABLE 4 Ecosystem services and their importance (source: 36 respondents' interviews).

Type	Subtype	Very important	Important	Overall importance percentage	Unimportant	Unimportant percentage
Provisioning service	Food supply	9	15	62.04%	12	37.96%
	Raw material supply	8	16		12	
	Medicinal resources	3	16		17	
Regulating service	Climate regulation	23	11	94.44%	2	5.56%
	Air quality regulation	25	11		0	
	Run-off mitigation	17	18		1	
	Nutrient release	20	16		0	
	Waste-water treatment	11	21		4	
	Erosion control	15	16		5	
Habitat or supporting service	Habitats for species	24	12	94.44%	0	5.56%
	Genetic diversity	19	13		4	
Cultural service	recreation and tourism	27	9	100%	0	0%
	Aesthetic and inspiration	24	12		0	
	Spiritual experience	22	14		0	
	Education and learning	24	12		0	

the foundational supporting role of peri-urban agricultural spaces in maintaining regional biodiversity and ecosystem stability. Further analysis follows:

4.2.1 Provisioning service

Compared to the other three services, respondents did not identify the provisioning service as the most important ecosystem service in the Eco-Zone, with an overall importance percentage of only 62.04%, even though the zone has large areas of arable land and permanent basic agricultural land. Among the specific items of provisioning services listed, 9 respondents (25.0%) believed that “food supply” is essential. In addition, due to the ornamental value and high economic added value of medicinal resources, the item “medicinal resources” was considered necessary by 16 respondents (44.4%), a landscape designer interviewed explained, “The Eco-Zone is an important urban ecological barrier in Chengdu, and the arable area is also very vast, which can form a completely natural ecosystem near the city and can provide a variety of food and raw materials for the ecosystem, as well as part of the medicinal resources, such as oilseed rape, wheat, maitake, honeysuckle, etc., which have both edible value and medicinal value.” Clearly, as part of the city’s already scarce agricultural land, the Eco-Zone is a pathway to sustainable development by providing food, raw materials, and medicinal resources that are closely linked to human social activities. This not only enhances the land’s functionality and value but also improves the relationship between humans and nature. However, 12 respondents (33.3%) believed that “food supply” was unimportant, while 17 respondents (47.2%) believed that “medical resources” was unimportant. In this case, a researcher from the Academy of Agricultural Sciences mentioned that although the Chengdu Eco-Zone has a relatively complete farmland production model and meets the needs of the primary industry, it is not a central agricultural production area in Chengdu, and its main task is not to supply grain and oil. Therefore, the quality of its essential provisioning service is difficult to control, and it has yet to be known how much it contributes to the urban food system. Another expert also pointed out that Chengdu Eco-Zone, with its dispersed and irregular layout, did not have a large-scale effect on the provisioning services of food, raw materials and medicinal resources and could only serve as a complementary improvement of the urban provisioning service.

4.2.2 Regulating service

Regulating Services show a high degree of quantitative importance, with an overall importance percentage of 94.44%. As a mega-city centre in the west, the regulating ecosystem service provided by the Eco-Zone was generally regarded by the interviewees as very important, and of extraordinary significance to the sustainable development of the city and the life and health of the people. Twenty-five respondents (69.4%) considered “air quality regulation” to be very important, followed closely by “climate regulation” (23, 63.8%) and “buffering and regulating nutrients” (20, 55.6%); one of the architects interviewed explained: “Due to the various topographical features of the Eco-region, the large number of ditches, wetlands and lakes, the rainwater collected during daily rains will be purified through the infiltration of wetlands and then fed to the green belts, which together with the large forested areas regulate the air quality in the peri-urban areas. In addition, the rotation of crops keeps the soil fertile, and artificial intervention prevents the entry of harmful organisms.”

Another teacher interviewed also agreed, “The main urban area is densely populated, the current situation of ecological environment development is more serious, the ecological zone ecosystem as an important ecological belt around the main urban area of Chengdu, which provides Regulating services for the main urban area of the ecological and climatic regulation, has an undeniable and irreplaceable role.” Moreover, an engineer added: “Through the relevant GIS analysis, this area connects the city and the suburbs and has a good potential to promote the protective survival of the ecological plate and the construction of the ecological pattern of diversity, so this service is important.” Therefore, the above interviews show that the experts attach great importance to the regulating ecosystem service in the Eco-Zone, especially when considering the basis for crop cultivation and growth, and recognise the importance of “climate regulation” in the region. Although 11 respondents (30.6%) were aware of the importance of “wastewater treatment,” 4 (11.1%) did not consider this service important. This is probably because wastewater should be integrated directly into the sewerage network for cities, and the provision of “wastewater treatment” in the region would be of little use to cities.

4.2.3 Habitat or supporting service

The quantitative evaluation of Habitat or Supporting Services aligns closely with Regulating Services, also maintaining an overall importance percentage of 94.44%. Regarding habitat or support services, all 36 respondents agreed that the Eco-Zone provides suitable “species habitat” and that good habitat in the area is essential for habitat protection and restoration. The “habitats for species” subtype is particularly prominent, with 24 respondents labeling it “very important” and zero respondents labeling it “unimportant.” An interviewed engineer gave an example, “Qinglong Lake Wetland Park, located in the Eco-Zone, is not only the largest lake in Chengdu urban area, but also a paradise for wild waterfowl, with local plants and animals, as well as seasonal migratory birds inhabiting the area, and a wide variety of organisms comprising a complete ecosystem.” It can be seen that the Eco-Zone, as the central ecological transition zone and buffer zone of the main urban area, provides an ideal place for species to inhabit. A researcher from a scientific institute also added: “Humans are just a part of nature and not an invader. Habitat development should be done with the original species conservation in mind.” This emphasises the respondents’ attitude towards biodiversity conservation. Human beings are inseparable from nature, and biodiversity is intrinsic to sustainable urban development. Therefore, “genetic diversity” is widely supported by 32 respondents (19 very important, 13 important). However, 4 interviewees disagreed, explaining that “biodiversity conservation is often influenced by size, geography, and the migratory needs of organisms, and the limited resources and site size of the Eco-Zone contribute to its less importance for species conservation.”

4.2.4 Cultural service

As the center of the development of a modern urban landscape, the Eco-Zone has attached great importance to people’s need for the cultural service since the early stages of planning. Among the four categories of ecosystem services, Cultural Services demonstrate the highest level of cognitive consistency among respondents, achieving an overall importance, indicating that all interviewees considered the cultural ecosystem service provided by the zone is important. “The

explosive growth of the urban population brought about by urbanisation has led to an increasingly critical situation for the city's ecological environment and the need for people to expand outwards to seek a more ecological and natural leisure experience. The Eco-Zone perfectly combines its original ecological and human resources to meet people's physical and spiritual needs." An respondent in the agricultural sector explained. Within this category, "recreation and tourism" received the highest "very important" rating, with 27 respondents (75% of the total sample) identifying it as a critical service. When referring to "leisure and tourism" as a specific cultural service, interviewees repeatedly cited the example of the "Tianfu Greenway" in Eco-Zone. "Tianfu Greenway is China's longest urban independent leisure greenway. It is more than 100 km long, spans 12 administrative districts, and connects 121 ecological parks in a circular shape. You can enjoy flowers and grass while riding on the greenway. You can also visit the Cute Pet Paradise and have a rich farming experience. At the same time, it is also an education base and a wedding base. It has been a good place for citizens to travel on weekends for many years." The Tianfu Greenway has become a new business card for Chengdu's residents, and cultural tourism meets the immediate needs of urban residents in the Greater Chengdu Metropolitan Area for a livable life. Respondents also cited "Education and Learning" and "Aesthetics and Inspiration" as the second most important cultural services. In recent years, the Chengdu Municipal Education Bureau, relying on the Tianfu Greenway, has launched various series of citizens' study routes covering civic literacy, education on city conditions, environmental protection and science popularisation, sports and health, artistic cultivation and red culture. A professor from a scientific research institute, for example, "We through the most advanced holographic projection, naked eye 3D, luminous materials, gravity sensing and other experience system technology, so that the public feel the charm of the low-carbon city; Guixi will be the organic combination of the park form and the urban space, for the public learning activities to create a party of green space, interpreting the city's livability of the beautiful original intention." The project builds a green learning classroom for the public, promotes a low-carbon and healthy lifestyle, transforms the city's ecological value into educational value, and is a powerful initiative to build a learning society in which "everyone learns, learns all the time, and learns everywhere." At the same time, the project involves interactive experience art, earth landscape art, and science and culture art, all of which reflect the Eco-Zone's planners' consideration of "aesthetic and inspirational" services.

Twenty-two interviewees also believe that "spiritual experience" is significant. A staff member of the Planning Bureau explains: "Every year, we will organize greenway life festivals with different themes. Through the integration of culture, business, tourism and sports, the greenway is no longer just a way to walk, but a convergence of many possibilities, which will lead to a new lifestyle in the city and then enhance the quality of life of the whole city." The greenway is also a boon for urban runners. Many people living in cities are in a state of sub-health, and the greenway is essential for soothing a range of urban ailments. In the decades a landscape professor interviewed has lived in Chengdu, she has witnessed the historical changes in the Eco-Zone. Nowadays, the Eco-Zone is not only a place for her to exercise but also her spiritual reserve. "I go around the nearby greenway every morning and evening. It has a wide view and good air." The professor told researchers that the greenway fills a void in her old age, "There are so

many people exercising on the greenway, and life is lively, so it's not so lonely living in the city." These evidences indicate that the cultural value of the ecosystem is its most undisputed function, with every participant acknowledging its significance.

The results show that the experts need to fully recognise the importance of essential services, which leads to differences in their considerations when making management decisions. On the other hand, their responses proved that they are deeply aware of agricultural space's contribution to humanity and their responsibility to take care of it.

5 Discussion

5.1 Recognition of the concept of ecosystem services in agricultural spatial planning

Although many ecosystem services, such as provisioning or cultural services, were mentioned in Chengdu's geospatial planning documents, the term ecosystem services and the framework were rarely explicitly considered. Furthermore, 28 interviewees had heard of the term before, but they needed to link agricultural space to ecosystem services when preparing their planning documents.

So far, there is no official strategic document in Chengdu that explicitly mentions the concept of "ecosystem services," but many documents address the spatial sustainability of agriculture and the benefits of ecosystems, e.g., the Chengdu-Chongqing Twin Cities Economic Circle Land Spatial Plan (2021–2035), the Chengdu Land Use Master Plan (2006–2020), the Chengdu Territorial Spatial Master Plan (2020–2035), the Chengdu High-standard Farmland Construction Plan (2021–2030), and the Chengdu Eco-Zone Master Plan (2020). The Chengdu Land Use Master Plan (2006–2020), a programme document for implementing the land management system in Chengdu and coordinating land use in the city, introduces the term "landscape function". This term reinforces the ecological landscape function of the land and demonstrates a similar understanding of ecosystem benefits, even though landscape function is a less anthropocentric concept (Albert et al., 2014a). The value of agro-ecosystem services is also highlighted by the reference to "food supply" as a service type in all planning documents. In addition, the cultural services provided by urban agricultural landscapes are explicitly considered in the three most recent planning documents, namely the Chengdu Territorial Spatial Master Plan (2020–2035), the High-standard Farmland Construction Plan (2021–2030), and the Master Plan for the Eco-Zone (2020), reflecting the focus on the planning of contemporary urban agricultural landscapes, even though some of the current research in China has not paid much attention to the value of cultural services provided by the agricultural space (Li et al., 2018).

While biodiversity has emerged as a global policy consensus, this study reveals that the integration of "Habitat/Supporting Services" within Chengdu's current agricultural spatial planning remains entrenched in macro-narratives, lacking precision in spatial implementation. Textual analysis of eight core planning documents indicates that, with the exception of the Territorial Spatial Planning for the Chengdu-Chongqing Economic Circle (2021–2035)—which explicitly links planning objectives to species habitats—the majority

of agricultural spatial planning documents, such as the Chengdu General Land Use Plan and the High-Standard Farmland Construction Plan, prioritize provisioning services (food security) and landscape cultural services. References to habitat supporting functions remain largely “indirect and implicit,” characterized by a lack of specific spatial control indicators (Zhong et al., 2024). This lag in policy execution stands in stark contrast to the high degree of consensus among respondents. Interview data shows that 94.44% of experts consider supporting services vital for the Ring Ecological Zone, underscoring the irreplaceable role of agricultural spaces in providing habitats for migratory birds and functioning as ecological corridors. This is in accord with the findings of Kabisch (2015) and Albert et al. (2014b), who found that ‘habitat for species’ was one of the most frequently mentioned ecosystem services after a content analysis of urban green space planning documents in Germany. Compared to practices in developed nations like Germany, where “species habitat” is a core element of urban green space planning, Chengdu’s current model resembles a “policy promotion” rather than a binding spatial constraint. Given the proven scientific value of peri-urban farmland ecosystems in maintaining biodiversity and ecological stability, future agricultural spatial planning must undergo a paradigm shift from “elemental protection” to “functional integration.” It is recommended that future planning revisions explicitly recognize the spatial value of habitat supporting services (Piwowarczyk et al., 2013). By implementing spatial strategies—such as the creation of ecological ditches and the protection of traditional vegetation communities—habitat restoration should be deeply integrated with high-standard farmland construction, thereby transforming agricultural spaces from singular production sites into multi-functional biodiversity hubs (Tang and Huang, 2021; Baul et al., 2021; Lemonsu et al., 2012).

5.2 Importance of peri-urban ecosystem services

Agroecosystems in peri-urban areas have important ecosystem service values. In the case of the Eco-Zone, for example, the spatial characteristics of agriculture in the region are different from those in other parts of the world, leading to different ecosystem service values, which explains the differences in the supply of and demand for, agroecosystem services in different regions (Liu et al., 2023). Chengdu is undergoing a period of rapid urbanisation, and the increasing demand for cultural services has led to changes in the size, shape and biodiversity of different types of urban green spaces (Das and Das, 2015). For example, planners’ plant selection in some urban agricultural landscapes will add more ornamental plants to the cash crops planted to satisfy people’s spiritual and cultural pursuits, but the core plant species may remain unchanged and representative of the local flora (Albuquerque et al., 2005; Zhuang et al., 2022). Agricultural landscapes are, therefore, vulnerable to human activities. This was also verified through interviews with 36 experts, who tended to place a very high value on the cultural ecosystem services of the Eco-Zone (100%), depending on the functions of recreation and tourism provided by the area; Secondly, regulating ecosystem services and supporting ecosystem services were also considered important by the experts (both are 94.44%), probably because their existing knowledge would have allowed them to recognise functions that could be inferred

from the environmental and agricultural characteristics of the Eco-Zone. This result supports the study of Marino et al. (2022), in which experts also gave high ratings to the regulating and supporting services provided by agroecosystems.

Through the comparison between interview consensus and policy articulation, demonstrating the conceptual gap that poses significant challenges for the implementation of future agricultural policies (Fu et al., 2024). Interview findings reveal that although 94.44% of respondents highly acknowledge the value of regulating and supporting services in agricultural spaces, the absence of an explicit Ecosystem Services framework at the policy level makes it difficult for planners to translate intricate ecological logic into operational spatial control measures (Liu et al., 2023). This conceptual deficit directly results in the passivity of ecological functions within peri-urban agricultural zones: governance often prioritizes the preservation of natural forests while neglecting the proactive role of agricultural landscapes in climate mitigation and biodiversity maintenance. Consequently, future policy agendas must transcend simplistic qualitative descriptions of “multifunctionality” and establish decision-making mechanisms grounded in explicit ES assessments (Li et al., 2024). By converting regulating and supporting services into legally binding spatial constraints or criteria for ecological compensation, a paradigm shift can be achieved—moving from narrow cropland protection toward resilient urban–rural landscape governance (Marino et al., 2022; Fanfani et al., 2024; Wittmer and Gundimeda, 2012).

5.3 Suggestions for the sustainable protection of peri-urban agriculture areas

Currently, urban governments are more committed to natural forests and urban landscape conservation while neglecting the ecological functions and ecosystem services of peri-urban agricultural areas (Chen et al., 2023). In fact, peri-urban agricultural areas can mitigate and adapt to climate change, maintain biodiversity, and increase ecological stability (Marino et al., 2022), which is closely related to human health and well-being. The government should give full play to the cultural service value of peri-urban agroecosystems and promote the synergistic enhancement of the value of material product supply, Regulating services and cultural services. This requires that the protection and use of peri-urban agricultural areas should follow the goal of sustainable development (Spagnoli and Mundula, 2021), combine the resource endowment of peri-urban agriculture in different regions with socio-economic development, maintain the characteristic landscapes, develop the peri-urban agricultural resources by local conditions, improve the value of the ecosystem services, and realise the multi-functional benefits of peri-urban agriculture. The protection of peri-urban agricultural areas should be organically integrated with the construction of towns and cities, new rural communities and agricultural industries. It is recommended that the government formulate village collective action plans, including organic agriculture, rural tourism, lodging medical care, and ecological compensation, to increase residents’ economic income and promote village collective conservation. In addition, peri-urban agricultural areas need to maintain traditional characteristics, focus on plant diversity conservation, and promote

synergistic improvement of ecosystem services (Chen et al., 2023; Zhuang et al., 2022).

In addition, peri-urban agricultural zones are located at the junction of urban and suburban areas, with better infrastructure, and are easily disturbed by human activities (Liu et al., 2023). The advantage of peri-urban agricultural zones, represented by the Chengdu Eco-Zone, lies in the richness of agricultural landscape resources, with rice, fruits, flowers, Chinese herbs and other agroforestry products. Therefore, it is suggested that the government should take ecological protection and construction as the core to improve the efficiency of agricultural land use; meanwhile, tourism enterprises need to maintain the traditional style, create a unique industrial model for leisure tourism and agro-tourism, accelerate the integration of agriculture and tourism, and form a diversified modern urban agricultural landscape.

6 Conclusion

By synthesizing qualitative insights from planning document content analysis and in-depth interviews, this research systematically assesses the integration of ecosystem services within peri-urban agricultural planning and their perceived importance in the Chengdu Eco-Zone. The findings reveal that while the formal academic terminology of “ecosystem services” remains largely latent in current statutory planning documents, its functional core—comprising soil and water conservation, climate regulation, and landscape aesthetics—has been deeply, implicitly, embedded across spatial planning tiers, from regional strategic frameworks to micro-level governance. This underscores a significant paradigm shift in Chengdu’s planning logic: a transition from traditional production-oriented spaces toward multifunctional socio-ecological complexes.

The empirical evidence highlights critical gaps between institutional decision-making logic and social perceptions: (1) Heterogeneity in Value Recognition: There is a robust consensus among experts and practitioners regarding the supremacy of cultural and regulating services. Peri-urban agriculture is increasingly prioritized as a vital “urban lung” and a sanctuary for spiritual restoration, functions that are now perceived to transcend its traditional role in agricultural commodity production. (2) Cognitive Deviation in Provisioning Services: Despite the rigorous top-down implementation of the “Tianfu Granary” initiative and cropland reclamation policies, participants expressed skepticism regarding the relative importance of provisioning services. This perceived lower value is driven by concerns over land fragmentation and potential urban pollution risks, creating a tension between national food security mandates and localized ecological realities.

Based on these insights, this study offers the following recommendations for land-use policy in rapidly urbanizing regions: (1) Integrating Explicit ES Evaluation Frameworks: Future territorial spatial planning should transition from “implicit consideration” to “explicit accountability” by establishing quantitative ES accounting mechanisms. Such frameworks are essential for the scientific monitoring and evidence-based management of peri-urban agricultural landscapes. (2) Navigating Functional Trade-offs: In implementing large-scale cropland

restoration (e.g., “returning forest to farmland”), policymakers must exercise caution to avoid unintended degradation of cultural and regulating services. A holistic “socio-ecological systems” perspective is required to ensure that the pursuit of singular production targets does not undermine the inherent multifunctionality and biodiversity value of the peri-urban fringe. (3) Establishing Human-Centred Incentive Mechanisms: Given the high social valuation of cultural services, landscape urbanism strategies should be leveraged to enhance the accessibility and legibility of agricultural spaces. Integrating agricultural heritage preservation with resident well-being will facilitate the transformation of peri-urban agriculture into a high-value regional sustainable ES provider.

This study bridges the gap between policy discourse and ecological perception through qualitative inquiry, yet several limitations persist. First, the data primarily reflect the perspectives of experts and practitioners; future research should adopt a more inclusive multi-stakeholder lens by incorporating the voices of local residents and landowners. Second, while this study focuses on subjective cognitive assessments which lacks the precision of quantitative biophysical mapping, and the focus on the Chengdu Eco-Zone (187.15 km²) limits the direct applicability of the findings to other regions with different landscape configurations spatially, subsequent research could couple with quantitative mapping tools—such as the InVEST or SolVES models—to analyze the spatiotemporal coupling of ES supply and demand in more regions. Ultimately, the Chengdu case provides a compelling “China Model” for high-density urbanized regions globally. Its experience in balancing the area of cropland with rising ecological welfare demands offers a valuable point of departure for comparative studies across diverse metropolitan clusters in the developing countries.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Academic Committee, School of Fine Arts and Design, College of Chinese & ASEAN Arts, Chengdu University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

RL: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. MH: Writing – review & editing. SS: Writing – review & editing. QZ: Writing – review & editing. HY: Writing – review & editing, Conceptualization.

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