雨洪管理多功能景观文化生态系统服务的重要性－满意度研究

IMPORTANCE-SATISFACTION ANALYSIS OF CULTURAL ECOSYSTEM SERVICES OF MULTIFUNCTIONAL LANDSCAPES DESIGNED FOR STORMWATER MANAGEMENT

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摘要

基于可持续理念的雨洪管理多功能景观是城市中重要的生态系统服务供给主体，能为公众提供多种文化服务，兼具环境、美学、教育与经济等多种效益。由于难以进行定量分析，文化生态系统服务的评估研究相对较少，导致业界与公众一直对其重要性认识不足。重要性－满意度分析（Importance-Satisfaction Analysis，简称ISA）以人的主观感知为依据，使抽象的文化生态系统服务功能变得容易理解和评价。本研究以不同类型的雨洪管理景观要素为例，探究了ISA方法在文化生态系统服务评价和景观设计管理决策优化方面的实用性。结果显示：审美欣赏、休闲/生态旅游、场所感是城市雨洪管理景观所提供的最受重视的文化生态系统服务；同时，公众对某些类型的雨洪管理景观提供的文化生态系统服务的满意度与重要性感知之间还存在差距。研究认为，ISA方法可为改善雨洪管理多功能景观的设计与管理决策提供有益的参考。

关键词

重要性－满意度分析；文化生态系统服务；景观设计；多功能景观；水敏性城市设计

ABSTRACT

The multi-functional landscapes for sustainable stormwater management play a significant role in providing various benefits on the environment, aesthetics, education, economy, etc. through the cultural ecosystem services, which have been underestimated by both the professionals and the public, due to the difficulty in their interpretation and quantification. The Importance-Satisfaction Analysis (ISA) makes it easier by evaluating the cultural ecosystem services with human's perception, and was tested with the multi-functional landscapes for stormwater management in this research. The results show that aesthetic value, recreational / eco-tourism, and sense of place are the most valued cultural ecosystem services. Those cultural ecosystem services with a gap between their perceived importance and the public satisfaction with their delivery are also identified. ISA can discover the public's perception and expectation of the stormwater management landscapes, which helps the decision-making about their improvement a lot.

KEY WORDS

Importance-Satisfaction Analysis; Cultural Ecosystem Services; Landscape Architecture; Multifunctional Landscapes; Water Sensitive Urban Design

1 概述

1.1 多功能景观与城市综合水管理

城市森林和公共绿色空间是城市绿色基础设施的重要组成部分，需要对其进行合理规划管理，以发挥最大的公共生态效益[1]。为实现这一目标，城市的管理者和设计者需要对绿色基础设施的生态价值进行科学研究和量化，以求达到“多种公共效益的最优化组合”[1]。生态系统服务（Ecosystem Services，简称ESs）是指“人们从生态系统中获取

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的裨益”，包括供给、支持、调节和文化服务4种类型[2]，其中文化服务包括美学欣赏、精神/宗教价值、知识体系、教育、灵感启迪、社会关系、文化遗产，以及休闲和生态旅游，针对此类服务的研究目前还相对较少[3]。但文化生态系统服务是城市绿色基础设施公共效益的重要组成部分，其价值远不止于提供审美欣赏和娱乐功能[1]。

城市景观具有多种功能，能提供多种生态系统服务，这些服务对于城市综合水管理而言至关重要，如雨水的收集、处理和存储等有利于缓解城市用水供给压力，保障城市水安全。在设计多功能雨洪管理景观时，了解其各项生态服务，特别是文化生态系统服务的价值，有助于更好地权衡不同城市水资源管理方案，并作出正确的设计决策，使城市景观及相关决策能够平衡公共目标与个体利益，调和各方利益矛盾[4]-[7]。此外，对文化生态系统服务价值进行评估可以揭示当地生态系统变化对于人类福祉的影响，从而鼓励更多的可持续生态景观建设投入[6]。例如，南澳大利亚州阿德莱德市的研究表明，以单位效益计算，当地雨洪管理景观的6种文化生态系统服务估值相当于雨水收集系统运营和养护成本的三倍。该结果直观展示了文化生态系统服务的重要性，可以将其作为提高当地水资源管理投资长期回报率的决策依据[8]。只有准确地认识多功能景观的价值，才能在实践中对其进行更好的设计与管理，从而进一步增加其价值、获得更好的投资回报，形成良性循环。这种评估能鼓励城市在综合水资源管理——特别是雨洪管理中更多地采用多功能景观以兼顾经济与生态服务效益。

1.2 多功能景观的生态系统服务

最初，生态系统服务的概念是指人类不需对自然生态系统进行干预或维护，即可从中获得的裨益[9]；后来，人类从人为构建或改造的生

1 Introduction

1.1 Multi-functional Landscapes and Integrated Urban Water Management

Urban forests and green spaces have been recognized by communities as important components of urban green infrastructure, which should be carefully managed to provide ecosystem services as public goods[1]. Designers and managers of urban streetscapes and green spaces need to understand and quantify the value of these services to deliver a “broader portfolio of public goods”[1]. Ecosystem services (ESs) are “the benefits people obtain from ecosystems” and recognized as provisioning, supporting, regulating, and cultural services.[2] Cultural ESs include aesthetic value, spiritual / religious value, knowledge systems, education, inspiration, social relations, cultural heritage, recreation, and eco-tourism, which are less studied, in contrast to other ESs[3]. Nevertheless, cultural ESs are also important benefits of green infrastructure, and their values extend beyond beautification and recreation opportunities[1].

Urban designed landscapes can provide multiple functions and to deliver many ESs, which are important to integrated urban water management. For example, these landscapes can harvest, treat, and store stormwater for other uses, enhancing water security and supplying urban water sources. In designing and establishing multi-functional landscapes for stormwater management, it is important to understand the values of their ESs, especially cultural ESs, to inform decision-making. Well-informed policies can balance societal benefits with individual incentives and reconcile conflicting needs by weighing up different urban water management interests[4]-[7]. In addition, evaluation of ESs can reveal the impacts of local ecosystem change on human well-beings to argue for investment for more sustainable development[6]. For example, in Adelaide, South Australia, a recent research proved that cultural ESs associated with stormwater harvesting were equivalent in value to three times the cost of operating and maintaining the system, as a total estimate of unit benefits of six cultural ESs of stormwater harvesting presented. It demonstrated the importance of the values to optimize long-term water management investment decisions.[8] Conversely, understanding the value of cultural ESs can better inform the design of multi-functional landscapes, thereby enhancing the management of those landscapes and for a greater return on investment. In particular, by creating more multi-functional landscapes, an integrated urban stormwater management can obtain larger economic and ecological benefits.

1.2 Ecosystem Services (ESs) of Multifunctional Landscapes

The concept of ES was originally developed around the

态系统中所获得的裨益也被纳入此范畴之内[4][10]，包括“某些从生态结构和生态过程中间接获得的重要裨益”[9]。城市生态系统被定义为“大部分地表为人工构筑的高密度人居环境，包括城市区域内所有的绿地和水域，例如公园、墓地、庭院和花园、城市公租地、城市林地、湿地、河流、湖泊和池塘”，也包括城市周边受其影响或管理的内陆地区以及其内部的私有园林[11]。一个城市可以被当作一个完整的生态系统，又由于其具有异质性、复杂性和碎片化等特征，也可以被视作由多个生态系统所组成的复合体[11]。珀尔·伯路德与斯温·汉哈默认为，“即便城市的绝大部分区域都由人类构建和管理”，城市生态系统仍然包括7类“具有自然属性的”生态系统：湖泊/海洋、行道树、草坪/公园、城市林地、耕地、湿地和溪流[4]；但他们也承认，严格来说行道树这类小尺度元素应当被看作生态系统的组成部分，而非一个完整的生态系统；对生态系统的分类应更加严谨，并视实际情况而异。

benefits that humans derived from natural ecosystems, which do not require human interventions to establish or maintain[9]. The concept has extended towards the benefits from modified or constructed ecosystems[4][10] where “some significant contribution from ecological structures and / or functions, however, indirectly” occurs[9]. An urban ecosystem is defined as an area of “built infrastructure (that) covers a large proportion of the land surface, or... in which people live at high densities…. They include all ‘green and blue spaces’ within urban areas, including parks, cemeteries, yards and gardens, allotments, forests, wetlands, rivers, lakes and ponds,” as well as the surrounding hinterlands affected or managed by the city and private gardens within it[11]. A city can be considered as a single ecosystem or a composite of multiple ecosystems, given its heterogeneity, complexity, and fragmentation[11]. Per Bolund and Sven Hunhammer distinguished seven urban ecosystems that are considered “natural, even if almost all areas in cities are manipulated and managed by man,” namely lakes / seas, street trees, lawns / parks, urban forests, cultivated land, wetlands, and streams.[4] In doing so, they acknowledged that, strictly speaking,

表1：不同空间尺度下的WSUD景观要素及其在城市雨洪管理活动中的用途[13]–[15]
Table 1: WSUD landscape elements at different scales and their management activities in urban water management[13]–[15]

管理活动 Management activity	WSUD要素的三种尺度 WSUD elements at three scales		
	地块级 Lot	邻里单位级 Neighbourhood	区域级 Region
节约用水 Water conservation	• 雨水收集池 Rainwater tank • 中水回收 Grey water reuse	• 雨水储存池 Stormwater storage/pond • 地下水补给和涵养设施 Aquifer storage and recovery • 下水道管井 Sewer mining • 雨污分离处理系统 Dual reticulation of treated wastewater	• 雨水储存池 Stormwater storage pond • 地下水补给和涵养设施 Aquifer storage and recover • 雨污分离处理系统Dual reticulation of treated wastewater
雨水资源收集 Stormwater capture	• 缓冲带 Buffer strip • 就地雨水滞留池 Onsite retention basin • 绿色屋顶 Green roof	• 缓冲带 Buffer strip • 缓冲洼地 Retarding basin • 池塘 Pond	• 缓冲带 Buffer strip • 缓冲洼地 Retarding basin • 湖泊 Lake
改善水质 Water quality improvement	• 缓冲带 Buffer strip • 就地雨水滞留池 Onsite retention basin • 多孔透水路面 Porous pavement • 砂过滤带 Sand filter • 生物滞留种植池 Bioretention planter • 行道树 Street tree • 雨水花园 Rain garden • 植被缓冲带 Vegetated buffer • 绿色屋顶 Green roof	• 缓冲带 Buffer strip • 街区级下渗洼地 Precinct-wide infiltration basin • 多孔透水路面 Porous pavement • 砂过滤带 Sand filter • 生物滞留洼地 Bioretention swale • 生物滞留盆地 Bioretention basin • 植被种植洼地 Vegetated swale • 城市林地 Urban forest • 人工湿地 Constructed wetland	• 缓冲带 Buffer strip • 滨河缓冲区 Riparian buffer • 自然河道 Natural channel • 城市林地 Urban forest • 人工湿地 Constructed wetland
缓解热岛效应 Heat island effect mitigation	• 雨水花园 Rain garden • 植被缓冲带/植被洼地 Vegetated buffer / swale • 生物滞留种植池 Bioretention planter • 绿色屋顶 Green roof • 垂直绿化 Vegetated facade • 行道树 Street tree • 城市林地 Urban forest	• 生物滞留洼地 Bioretention swale • 生物滞留盆地 Bioretention basin • 植被种植洼地 Vegetated swale • 城市林地 Urban forest • 人工湿地 Constructed wetland	• 滨河缓冲区 Riparian buffer • 城市林地 Urban forest • 人工湿地 Constructed wetland

表2：基于结构与组成部分的WSUD景观要素分类[12]
Table 2: Typologies of WSUD landscape elements categorized by structure and composition[12]

WSUD景观要素 WSUD element	结构与组成部分 Structure and composition						
	建筑结构 Building structure	硬质地面 Hard surface	单一草地型设施 Grassy structure	多植被型设施 Vegetated structure	开敞型水域 Open water area	线性水空间 Linear waterway	湿地 Wetland
雨水收集池 Rainwater tank	√						
缓冲带 Buffer strip			√	√			
雨水滞留盆地 Retention basin			√	√			
雨水储存设施 Stormwater storage					√		√
绿色屋顶 Green roof			√	√			
中水回用（处理池） Greywater reuse (treatment pond)	√						
多孔透水路面 Porous pavement		√					
砂过滤带 Sand filter		√	√	√			
生物滞留池 Bioretention planter			√	√			
行道树 Street tree				√			
洼地 Swale			√	√			
垂直绿化 Vegetated facade				√			
城市林地 Urban forest				√			
自然水道 Natural channel						√	
池塘/湖泊 Pond / lake					√		

“多功能景观”这一概念包含多种与城市水管理相关的景观设计元素。这些元素被称为水敏性城市设计（WSUD）景观要素，涵盖多个空间尺度，小到场地尺度的行道树和雨水花园，大到区域尺度的城市林地和人工湿地（表1），既可以被看作更大范围城市生态系统的组成成分，也可被看作独立的城市生态系统，本研究采用后一种视角。

根据结构与组成部分对WSUD景观要素进行分类，结果如表2[12]。在本研究视角下，单一草地型设施、多植被型设施、开敞型水域、线性水空间和湿地这5类景观要素均属于城市生态系统，其提供的文化

street trees are too small to be an ecosystem but elements of a larger system. They also cautioned that their typology is crude and should be adapted to each case.

Multi-functional landscapes contain various elements designed to function in urban water management. Such water sensitive urban design (WSUD) landscape elements vary in scale from street trees and rain gardens at a lot scale to urban forests and constructed wetlands at a regional scale (Table 1). These elements can be considered as components of a broader urban ecosystem or urban ecosystems themselves. In this paper, we consider them as the latter.

In Table 2, various WSUD landscape elements that might occur in a multi-functional landscape are grouped, based on

生态系统服务将在后文中重点评估与讨论。某些景观要素可以属于多种类别，如缓冲带要素既有单一草地型的，也有多植被型的，这取决于要素形式与组成部分的多样性。该分类不考虑地下水补给和涵养设施、下水道管井、雨污分离处理系统等地表不可见的要素。

WSUD要素所提供的生态系统服务有多种分类方式[2][16]~[19]，本研究采用莫妮卡·埃尔南德斯—莫尔西略等人所提出的分类方式[20]以及千年生态系统评估（MA）提出的框架[2]，前者被认为是目前最全面的生态系统服务分类方式之一，而鲁道夫·德·格鲁特等人利用MA框架重新定义了生态系统服务，并指出了生态系统的生物物理结构或过程与功能在提供服务并产生价值方面的差异：生物物理结构或过程本身可直接提供支持服务，并通过自身的机能运转提供供给、调节和文化服务[18]。然而，城市生态系统所提供的实际服务类型因地点和环境而异[4]，并受当地文化影响，是一种地方产物[21]。此外，MA框架也没有包括修复性文化生态系统服务这一城市绿色空间的重要服务类别[22]。

易受地点与环境影响的特点使城市生态系统服务的评价成为一项相当复杂的工作。文化服务评价的主要依据是人对场所的体验，且涉及价值规范，因此主观性更强[3][8][23]，比起可用生物物理、空间和经济指标进行客观度量的支持、供给和调节服务[24]，更难以量化。于是有学者提出，可以结合地方文化背景，由当地社区的各利益相关方对文化服务价值进行评估[11][25][26]。哈拉德·谢芝等提出将生态系统服务研究和文化景观研究相互联系，尤其是在审美欣赏、文化遗产和场所感方面。[3]以往也有研究采取类似方法，即基于利益相关方对景观的感知对文化生态系统服务进行评估[27]，获取感知的方法包括情境规划、模型构建、结合访谈与谈话资料分析绘制地图[28][29]。评估背景的尺度也十分重要，由于人类在多功能景观中生存并感知生物物理环境和地方文化背景[30]，故景观尺度适用于文化生态系统服务评价。

1.3 重要性—满意度分析

鉴于文化生态系统服务的上述特性，本研究采用重要性—满意度分析法（ISA）对其进行基于感知的评估，以将社会和文化背景、个体态度及信仰、行为习惯与生活方式等因素的影响也考虑在内。[20]该方法

their typologies considering structure and composition[12]. In this research, grassy structures, vegetated structures, open water areas, linear waterways and wetlands are all urban ecosystems providing cultural ESs, which are evaluated and discussed later. Elements with alternative structure and/or composition appear in diverse types, e.g. buffer strips can be grassy or vegetated. WSUD landscape elements not visible in the landscape are excluded, e.g. aquifer storage and recovery, sewer mining, and dual reticulation of treated wastewater.

ESs delivered by WSUD landscape elements can be classified according to several different frameworks[2][16]~[19]. We adopted the recommendation of Mónica Hernández-Morcillo et al.[20], which was argued to provide a most comprehensive overview and categorization of ESs, and the framework proposed by the Millenium Ecosystem Assessment (MA)[2], by which Rudolf de Groot et al. clarified the ESs definition and distinguished biophysical structures or processes from their functions in providing services with an associated value: these biophysical structures or processes directly deliver supporting ecosystem services. Through their functions, they deliver provisioning, regulating, and cultural ESs[18]. However, the actual services delivered by an urban ecosystem are site- and context-specific[4] and culturally grounded. They are the products of place[21]. Absent from this MA framework is the cultural ES of restorativeness, which can be an important service of urban green spaces[22].

This site- and context-specificity contributes to the difficulty in quantifying cultural ESs. Their assessment is subjective, involves normative values, and results from persons' experience of a place.[3][8][23] In contrast, supporting, provisioning, and regulating ESs can be generally quantified with objective biophysical, spatial or economic measures.[24] Although most cultural ESs defy economic valuation, many agree that valuation must be determined by stakeholders of local communities to reflect local cultural context and interests.[11][25][26] Harald Schaich et al. suggested linking ES research to cultural landscape research, especially on landscape aesthetics, cultural heritage, and sense of place.[3] Consistent with this suggestion, previous assessments of cultural ESs relied on stakeholders' landscape perceptions[27], with methods involving scenario planning, modeling, and mapping through interviews, narratives and discourse analysis[28][29]. Scale of context is also important to the valuation process. It matters how people live and experience the biophysical and cultural environments of multi-functional landscapes.[30] Thus, the landscape scale seems appropriate at which to assess cultural ESs.

1.3 Importance-Satisfaction Analysis

Given the above attributes of cultural ESs, this research assesses them with an importance-satisfaction analysis (ISA) based

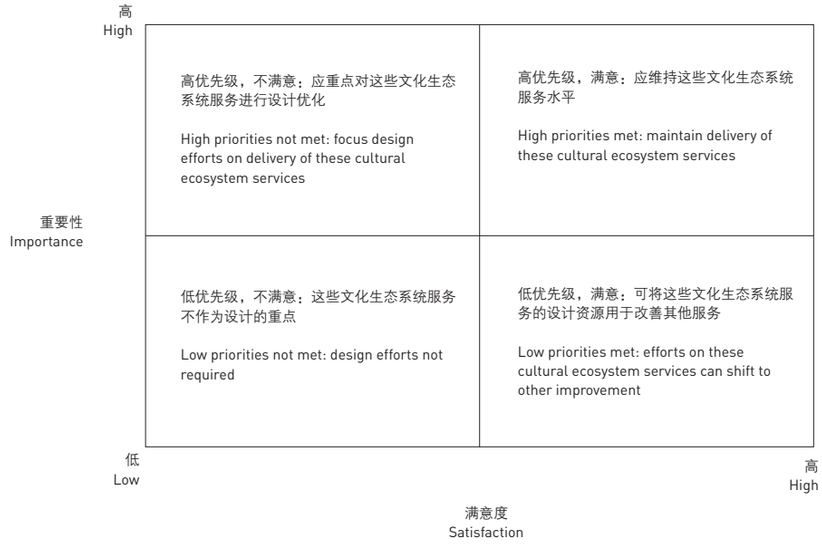
借鉴了一种研究旅游景点体验的重要性—绩效表现分析法[31][32]，主要考察人对某种特定景观属性的重要性的主观感知以及对该属性的体验满意度，并将重要性和满意度之间的差异也作为一项分析指标。将对每种属性的感知重要性和满意度数值绘制成二维坐标系图，并将其划分为4个分区，即得到不同景观属性的管理优先级（图1）。该方法可帮助旅游资源管理者判断资源是否得到最优利用、游客是否获得了最佳体验，亦可被应用于可持续雨洪管理景观的设计、建造和管理，以提供更好的文化生态系统服务。

本研究评估了5种WSUD景观要素的文化生态系统服务。与约翰·M·坎杜鲁等按城市水循环的不同环节来考量文化生态系统服务[8]的方法不同，研究通过直接展示每种景观要素的典型照片来获取受访者对其文化生态系统服务的感知重要性与满意度数据，并分析得到每种文化生态系统服务的价值和管理优先级，从而为类似的多功能景观设计提供指导，在资源有限的情况下，优先改善更符合公众喜好的生态系统服务。将ISA方法与社区调研相结合，还有助于自然资源管理者、水务职能机构及设计师发现他们与公众在文化生态系统服务重要性认知方面的差异。

2 研究方法

2.1 问卷设计

研究通过问卷调查方式获得数据，问卷主要包含三个部分：第一部分介绍了景观所提供的8种文化生态系统服务（表3），以及单一草地型设施、多植被型设施、开敞型水域、线性水空间和湿地5种WSUD景观要素及其各自的雨洪管理功能；第二部分让受访者基于对第一部分基本信息的理解，直接对雨洪管理多功能景观的8种文化生态服务重



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1

on perceptions affected by social and cultural backgrounds, attitudes, beliefs, behaviors, and lifestyles.[20] Adapted from importance-performance analysis used to manage the quality of experience at tourism destinations[31][32], importance-satisfaction analysis assesses the perceived importance of an attribute of a place and the satisfaction extent of the attribute when people are experiencing the place. The results reveal the gap between importance and satisfaction. The values of importance and satisfaction of landscape attributes can be examined by being plotted and distributed into four zones to identify management priorities (Fig. 1). The use of ISA in tourism management is to inform the management agency if it is achieving its desired experiential outcomes while optimally using limited resources. Such information can also help the design, implementation, and management of multi-functional landscapes in sustainable stormwater management for a greater cultural ESs.

In this research, cultural ESs of five types of WSUD landscape elements in multi-functional landscapes in sustainable stormwater management were assessed. We provided representative photographic images of each type in a survey and collected feedback of the perceived importance of, and satisfaction with, their cultural ESs. We did not explicitly consider cultural ESs at different stages in the urban water cycle as what John M. Kandulu et al. did[8]. The data was analyzed to identify the value and management priorities for each cultural ES, which can then guide the design and management of multi-functional landscapes in similar contexts. In this way, limited resources can be best utilized to yield maximum outcomes consistent with community values. Used for community engagement and communication, ISA can also identify those cultural ESs less valued by the community but highly valued by natural resource managers, water authorities, and designers involved in the implementation of WSUD to create effective multi-functional landscapes in stormwater management.

2 Methods

2.1 Survey Design

Data was collected through a survey including mainly three sections: In the first section, eight cultural ESs of landscapes were introduced (Table 3), and the forms and functions for stormwater management of the 5 types of WSUD landscape elements were described. The second section asked respondents to rank the eight cultural ESs of the WSUD landscape elements based on their understanding of the first section. The third section collected the respondents' perception data of the cultural

表3：景观视角下的文化生态系统服务[2]含义
Table 3: Cultural ecosystem services[2] interpreted in relation to landscape

文化生态系统服务 Cultural ecosystem service	景观视角下的含义 Interpretation in relation to landscape
精神/宗教价值 Spiritual / religious value	景观所提供的精神、宗教及与其他庄严活动相关的非物质裨益 Spiritual, religious, and other sacred-related non-material benefits associated with landscapes
审美欣赏 Aesthetic value	通过观赏景观而获得的视觉享受 Visual pleasure and joy
休闲/生态旅游 Recreation / eco-tourism	景观支持休闲活动与/或生态旅游的能力 Landscape capacity to support recreational activities and / or eco-tourism
艺术灵感启发 Inspiration for art	景观激发艺术表达的能力 Landscape capacity to inspire artistic expression
场所感 Sense of place	由景观独特性所唤起的、对某一场所的感情 Resonance aroused by a certain landscape
文化遗产 Cultural heritage	景观所蕴含的文化与历史价值 Cultural and historic values of landscapes
教育/知识 Education / knowledge	景观为人类提供的教育机会与知识，多与多功能景观、可持续雨洪管理、自然景观系统等概念相关 Landscape capacity to provide educational opportunities and to increase knowledge in regard to multifunctional landscapes, stormwater management, natural systems, and so on
社会关系 Social relations	景观支持、促进人们进行社交互动的能力 Landscape capacity to support and foster social interactions

注：
本表将“修复性服务”视作审美欣赏服务的一个方面。
Notes:
Restorativeness is included as an aspect of the aesthetic ecosystem service.

要性进行排序；第三部分为每种WSUD景观要素各列出4张包含相应要素的照片（图2），受访者根据照片，用修正里克特量表评价自己对每种景观要素的各种文化生态系统服务的感知重要性[33]（1～5分依次代表非常不重要、不重要、无所谓、重要、非常重要）和满意度（1～5分依次代表非常不满意、不满意、无所谓、满意、非常满意）程度，即对每种景观要素8种文化生态系统服务的主观感知数据。如果某种景观要素不能提供某种特定的文化生态系统服务，那么受访者可以不评价。问卷有中文和英文两个版本，在正式调查开始前，分别先由10位中国人和10位澳大利亚人进行试填写，研究团队根据反馈意见对问卷中有歧义的表述进行修改，从而确保问卷表达的准确性。

2.2 数据收集

正式版调查问卷于2015年4月至6月底在中国成都和澳大利亚墨尔本进行分发，因为这两个城市都有较成功的绿色基础设施建设项目，

ESs of the 5 types of WSUD landscape elements. For each type, four photos of landscapes with a WSUD landscape element (Fig. 2) were presented to respondents to rate the importance to themselves[33] of the delivery of each cultural ES by that type of landscape element on a modified Likert scale from 1 to 5 (1: not important; 2: slightly important; 3: moderately important; 4: important; 5: very important) and his / her satisfaction with the delivery of each cultural ES (1: very dissatisfied; 2: dissatisfied; 3: neither satisfied nor dissatisfied; 4: satisfied; 5: very satisfied). If a landscape element did not deliver a particular cultural ES, the relevant rating was skipped. The survey was conducted with both Chinese and English questionnaires, which were trailed firstly by ten respondents from China and Australia, respectively. Based on the feedback, the questionnaire was then revised to remove any ambiguities.

2.2 Data Collection

The formal survey was conducted in Chengdu, China, and Melbourne, Australia, from April to late June 2015. Both the cities have successfully implemented green infrastructure, where

图2 © 杨青娟，Meredith Frances Dobbie，张德顺观

市民对WSUD景观要素有基本的了解。受访者均为本地在校大学生，受教育水平相对较高，能较为准确地理解问卷内容。本次研究总共发放362份调查问卷，收回266份，其中235份问卷填写完整，135份来自成都，100份来自墨尔本。

2.3 数据处理

将所有数据输入SPSS 22统计软件（由美国IBM公司开发），先计算出每种WSUD景观要素的8种文化生态系统服务的重要性均值和满意度均值以及二者之间的差值，再将这些文化生态系统服务的重要性、

the citizens would have a better understanding of the WSUD landscape elements. The respondents were university students so that the questionnaire could be understood more properly. 362 questionnaires were distributed and 266 were returned with 235 completed, 135 from Chengdu and 100 from Melbourne.

2.3 Data Processing

Data was processed by SPSS 22 statistical software (IBM, USA). First, mean values of importance and satisfaction (expressed as performance) with each cultural ES for each WSUD landscape element were calculated, as well as the gap between the two. Mean values of aggregated data for each type were also calculated. Secondly, the mean values of each cultural ES for each WSUD landscape element were then plotted onto

满意度得分分别汇总，计算总均值；对于每种WSUD景观要素，分别以重要性均值、满意度均值为纵、横坐标，在同一二维坐标系中绘制出其每种文化生态系统服务所代表的位置，并随之确定服务的管理优先级；最后绘制两张蛛网图，分别比较5种WSUD景观要素各项文化生态系统服务的重要性均值及满意度均值之间的差异。

3 结果与分析

问卷回收率为73.5%。受访者中144位为男性（61.3%），其余91位为女性（38.7%），总共来自28个不同专业。对评价数据的可靠性检验显示Cronbach α值为0.905，数据具有可靠性，表明个体特征的差异对评价结果没有显著影响。

3.1 重要性、满意度均值排序分析

表4展示了感知重要性与满意度的均值及两者的差值。将5种WSUD景观要素汇总，8种文化生态系统服务的重要性均值排序为：审美欣赏＞休闲/生态旅游＞场所感＞教育/知识＞社会关系＞艺术灵感启发＞文化遗产＞精神/宗教价值。问卷第二部分要求受访者根据自己的理解对8种文化生态系统服务直接进行排序的结果为：教育/知识＞休闲/生态旅游＞审美欣赏＞场所感＞社会关系＞文化遗产＞精神/宗教价值＞艺术灵感启发。两个排序结果相似度较高。相比之下，8种文化生态系统服务的满意度均值排序为：场所感＞审美欣赏＞休闲/生态旅游＞社会关系＞艺术灵感启发＞教育/知识＞文化遗产＞精神/宗教价值，与感知重要性排序存在明显差异。5种WSUD景观要素所提供的8种文化生态系统服务的总满意度均值为3.13，低于总感知重要性均值3.52。

3.2 重要性－满意度图示分析

将表中数据绘制成重要性－满意度图示。以重要性和满意度均值对应的直线为基准，图示被划分为4个分区[34]，位于直线下方或左侧的分区分别代表低重要性或低满意度，反之则为高重要性或高满意度。这些图示揭示了5种WSUD景观要素的8种文化生态系统服务获得的感知评价值与管理优先级差异（图3）。如果某种WSUD景观要素的某一文化生态系统服务的感知重要性与满意度均较低，则不必投入过多资源和精力对该类文化服务进行设计或管理。

a two-dimensional coordinate to reveal management priorities. Finally, mean values of importance and satisfaction were plotted as spider charts, respectively, for comparison of each cultural ES across the five WSUD landscape elements.

3 Results and Analyses

The overall response rate is 73.5%. Respondents were in 28 majors, among whom 144 are male (61.3%) and 91 are female (38.7%). Reliability analysis demonstrated the data reliablity with a Cronbach's □ value of 0.905, showing that the variation among these individual attributes has no significant impact on the evaluation results.

3.1 Analyses on Rankings of Mean Values of Importance and Stisfaction

Table 4 demonstrates the mean values of perceived importance and satisfaction, and the gap between them. The results of mean importance of each cultural ES across the five types of WSUD landscape elements are (from the highest to the lowest) aesthetic value > recreation / eco-tourism > sense of place > education / knowledge > social relations > inspiration for art > cultural heritage > spiritual / religious value. This is generally consistent with the results of the eight cultural ESs ranked on the respondents' understanding of WSUD landscape elements, namely education / knowledge > recreation / eco-tourism>aesthetic value > sense of place > social relations > cultural heritage > spiritual / religious value > inspiration for art, from the highest to the lowest. In contrast, the results of mean satisfaction with the delivery of these cultural ESs is sense of place > aesthetic value > recreation / eco-tourism > social relations > inspiration for art > education / knowledge > cultural heritage > spiritual / religious value, from the highest to the lowest, showing a significant gap from that of perceived importance. The total mean satisfaction is 3.13, which is less than mean importance, 3.52.

3.2 Analyses on Importance-Satisfaction Charts

The mean values of importance and satisfaction are plotted into four-quadrant charts. The four quadrants in each chart indicate different priorities.[34] The cultural ES values falling into the lower or left quadrants indicate a lower value of perceived importance or satisfaction. These charts reveal the perception evaluation and management priorities of the cultural ESs for each WSUD landscape element type (Fig. 3). Less attention of design or management could be paid to particular WSUD landscape element if the perceived importance and satisfaction with its delivery are both relatively low.

表4-1：每种WSUD景观要素各种文化生态系统服务的重要性均值（I）
Table 4-1: Mean importance (I) of each cultural ES of each WSUD landscape element type

	精神/宗教价值 Spiritual/religious value	审美欣赏 Aesthetic value	休闲/生态旅游 Recreation/ ecotourism	艺术灵感启发 Inspiration for art	场所感 Sense of place	文化遗产 Cultural heritage	教育/知识 Education/ knowledge	社会关系 Social relations	全部服务类型 All
单一草地型设施 Grassy structure	3.12	3.91	3.87	3.19	3.69	3.34	3.66	3.61	3.55
多植被型设施 Vegetated structure	3.07	3.93	3.64	3.33	3.66	3.24	3.47	3.43	3.47
开敞型水域 Open water area	3.44	4.16	4.21	3.79	3.79	3.54	3.53	3.56	3.75
线性水空间 Linear waterway	2.88	3.80	3.63	3.14	3.47	3.15	3.34	3.24	3.33
湿地 Wetlands	3.12	3.75	3.88	3.39	3.70	3.31	3.63	3.28	3.51
全部要素类型 All types	3.13	3.91	3.85	3.37	3.66	3.32	3.53	3.42	/

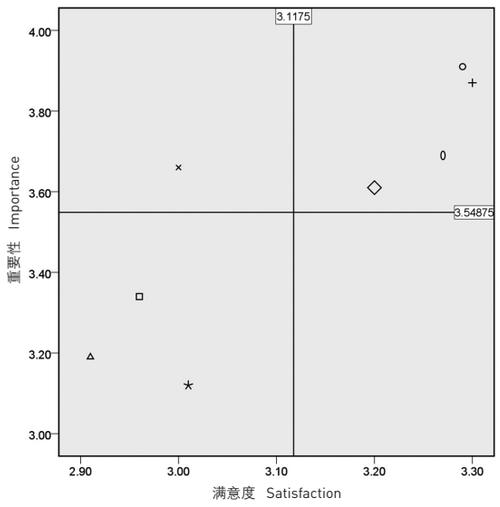
总重要性平均值：:3.52
The aggregated mean value of importance of all cultural ESs of all WSUD element types: 3.52

表4-2：每种WSUD景观要素各种文化生态系统服务的满意度均值（S）
Table 4-2: Mean satisfaction (S) of each cultural ES of each WSUD landscape element type

	精神/宗教价值 Spiritual/religious value	审美欣赏 Aesthetic value	休闲/生态旅游 Recreation/ ecotourism	艺术灵感启发 Inspiration for art	场所感 Sense of place	文化遗产 Cultural heritage	教育/知识 Education/ knowledge	社会关系 Social relations	全部服务类型 All
单一草地型设施 Grassy structure	3.01	3.29	3.30	2.91	3.27	2.96	3.00	3.20	3.12
多植被型设施 Vegetated structure	3.00	3.36	3.21	3.06	3.24	3.00	3.03	3.16	3.13
开敞型水域 Open water area	3.14	3.57	3.55	3.31	3.32	3.04	3.07	3.25	3.28
线性水空间 Linear waterway	2.81	3.80	3.63	3.14	3.47	3.15	3.34	3.24	3.33
湿地 Wetlands	2.98	3.25	3.34	3.04	3.32	3.10	3.12	3.18	3.17
全部要素类型 All types	2.99	3.27	3.26	3.05	3.28	3.01	3.04	3.16	/

总满意度平均值：:3.52
The aggregated mean value of satisfaction of all cultural ESs of all WSUD landscape element types: 3.13

单一草地型设施 Grassy structure

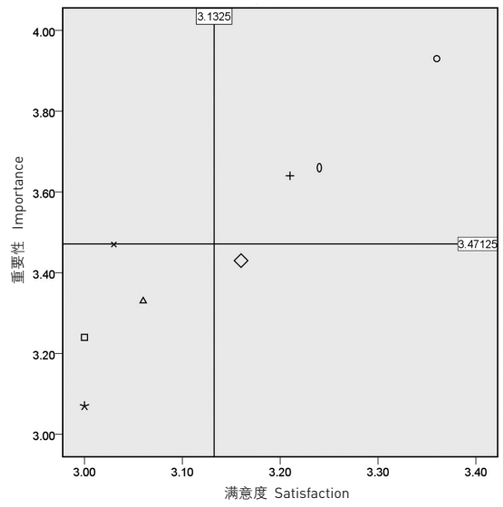


文化生态系统服务名称
Names of cultural ESs

- 审美欣赏 Aesthetic value
- 文化遗产 Cultural heritage
- 教育/知识 Education / knowledge
- 艺术灵感启发 Inspiration for art
- 休闲/生态旅游 Recreation / eco-tourism
- 场所感 Sense of place
- 社会关系 Social relations
- 精神/宗教价值 Spiritual / religious value

3-1

多植被型设施 Vegetated structure



文化生态系统服务名称
Names of cultural ESs

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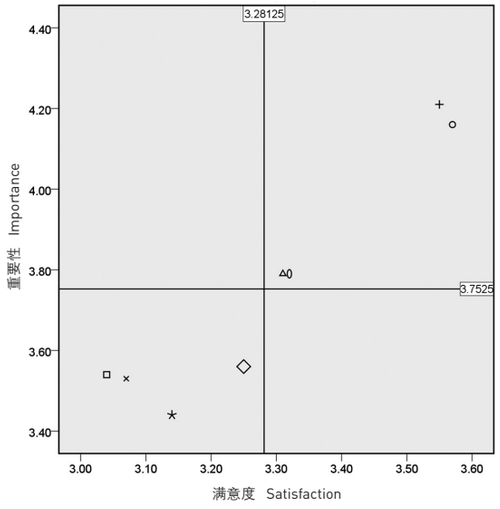
- 休闲/生态旅游 Recreation / eco-tourism
- 场所感 Sense of place
- 社会关系 Social relations
- 精神/宗教价值 Spiritual / religious value

3-2

开敞型水域 Open water area

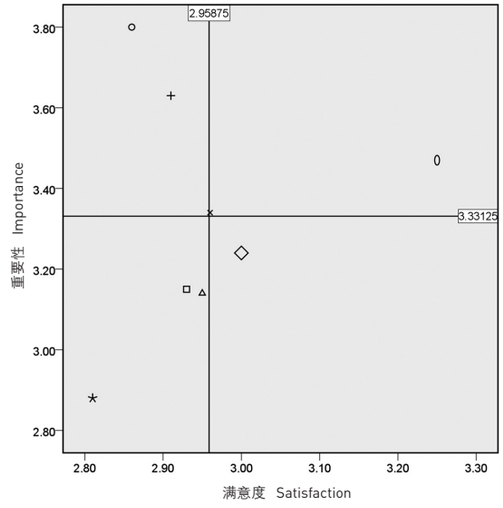


文化生态系统服务名称
Names of cultural ESs

- 审美欣赏 Aesthetic value
- 文化遗产 Cultural heritage
- 教育/知识 Education / knowledge
- 艺术灵感启发 Inspiration for art
- 休闲/生态旅游 Recreation / ecotourism
- 场所感 Sense of place
- 社会关系 Social relations
- 精神/宗教价值 Spiritual / religious value

3-3

线性水空间 Linear waterway

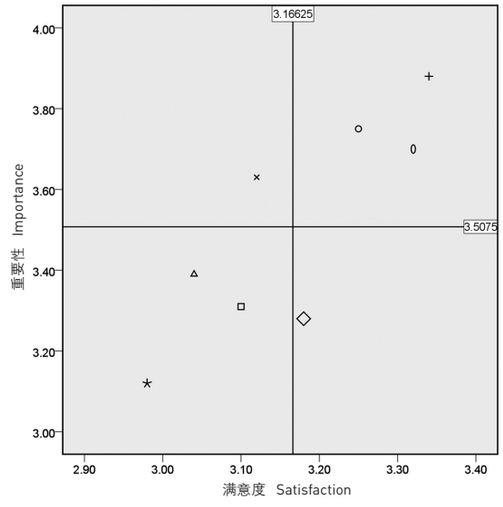


文化生态系统服务名称
Names of cultural ESs

- 审美欣赏 Aesthetic value
- 文化遗产 Cultural heritage
- 教育/知识 Education / knowledge
- 艺术灵感启发 Inspiration for art
- 休闲/生态旅游 Recreation / eco-tourism
- 场所感 Sense of place
- 社会关系 Social relations
- 精神/宗教价值 Spiritual / religious value

3-4

湿地 Wetland



文化生态系统服务名称
Names of cultural ESs

- 审美欣赏 Aesthetic value
- 文化遗产 Cultural heritage
- 教育/知识 Education / knowledge
- 艺术灵感启发 Inspiration for art
- 休闲/生态旅游 Recreation / eco-tourism
- 场所感 Sense of place
- 社会关系 Social relations
- 精神/宗教价值 Spiritual / religious value

3-5

通过进一步分析重要性—满意度图示，可以根据受访者对每种文化生态系统服务重要性与满意度的评价差异，确定更有针对性的雨洪管理景观设计管理策略。位于图示上方两个分区中的文化生态系统服务重要性较高，也具有较高的管理优先级。表5列出了本研究中每种景观要素位于高重要性分区中的文化生态系统服务名称及其各自获得的满意度评价高低。对于多植被型设施与开敞型水域，重要性分值较高的文化生态系统服务也都获得了较高的满意度分值，说明这两类景观要素为公众提供了较为理想的文化生态系统服务；线性水空间的审美欣赏与休闲/生态旅游服务，以及单一草地型设施与湿地的教育/知识服务虽受到公众的重视，但实际服务效果并未令公众满意，需对相关景观元素的设计与管理措施加以改进。

4 讨论

4.1 文化生态系统服务的公众感知用于决策制定

运用ISA方法，景观设计师、规划师，以及土地和水资源管理者可以根据公众对不同WSUD景观要素的各种文化生态系统服务的重要性与满意度排序，结合实际情况，对公众更为重视的WSUD景观要素进行设计和管理决策优化，以更好地提供文化生态系统服务；使用ISA方法亦能进一步探究不同社区和人群对同一景观要素文化生态系统服务的重要性感知与满意度。此外，由于技术认知和审美偏好上的差异，为公众所重视的文化生态系统服务可能与设计师和管理者所重视的十分不同，使用ISA方法有助于在两者间取得平衡。

表5：每种WSUD景观要素在重要性—满意度图表中位于高重要性分区内的文化生态系统服务及其满意度
Table 5: Cultural ESs of each WSUD element type in the two higher importance quardants of the importance-satisfaction plots showing their locations in the two satisfaction quardants

WSUD景观要素 WSUD element	位于高重要性象限内的文化生态系统服务 Cultural ESs in the two higher importance quardants	
	位于低满意度分区 In the lower satisfaction quardants	位于高满意度分区 In the higher satisfaction quardants
单一草地型设施 Grassy structure	教育/知识 Education / knowledge	审美欣赏、休闲/生态旅游、场所感、社会关系 Aesthetic value, recreation / eco-tourism, sense of place, social relations
多植被型设施 Vegetated structure	/	审美欣赏、场所感、休闲/生态旅游 Aesthetic value, sense of place, recreation / eco-tourism
开敞型水域 Open water area	/	审美欣赏、休闲/生态旅游、艺术灵感启发、场所感 Aesthetic value, recreation / eco-tourism, inspiration for art, sense of place
线性水空间 Linear waterway	审美欣赏、休闲/生态旅游 Aesthetic value, recreation / eco-tourism	场所感、教育/知识 Sense of place, education / knowledge
湿地 Wetland	教育/知识 Education / knowledge	审美欣赏、休闲/生态旅游、场所感 Aesthetic value, recreation / eco-tourism, sense of place

The charts further interpret the gaps between importance and satisfaction of each cultural ES, which help inform design and management strategies of multi-functional landscapes to optimize delivery of cultural ESs. The cultural ESs plotted in the upper quadrants are identified with a higher priority for their greater perceived importance. The cultural ESs of each element type in these two quadrants are listed in Table 5 accompanying with their evaluated satisfaction values. For vegetated structures and open water areas, the cultural ESs in the upper importance quadrants all lie in the upper satisfaction quadrant, demonstrating that the public are satisfied with the delivery of these cultural ESs by the two types of WSUD landscape elements. Grassy structures, linear waterways, and wetlands have highly valued cultural ESs yet failing to satisfy the respondents. For linear waterways, delivery of aesthetic value and recreation / eco-tourism is unsatisfactory, as the delivery of education / knowledge for grassy structures and wetlands. Specific improvements of design and management strategies are needed for these WSUD elements to enhance their delivery of cultural ESs.

4 Discussion

4.1 Public Perception of Cultural ESs for Decision-Making

Using ISA for assessing cultural ESs, landscape architects, planners, and land and water managers can readily determine the public's ranking of importance of, and satisfaction with, various cultural ESs for WSUD elements in different contexts. They can then design and manage the desired WSUD landscapes elements to enhance the delivery of cultural ESs. Importance and satisfaction might vary among communities; ISA analysis can also be used to reveal such varieties, as well as the cultural ESs considered important by the community may be neglected by designers or managers due to technical reasons or aesthetic difference. In the future, professionals are asked to close such gaps with more comprehensive considerations.

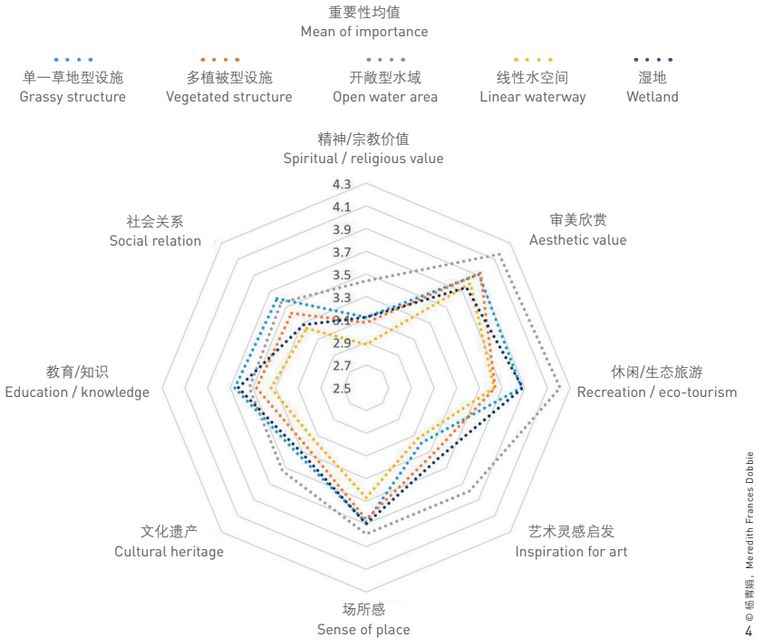
Spider charts are used to visualize the difference in perceived importance (Fig. 4) and satisfaction (Fig. 5) for each cultural ES of each WSUD landscape element type by showing the variety of the value of each cultural ES amongst different element types. As mentioned above, the function of a particular multi-functional landscape and its context together determine the cultural ESs it delivers. Understanding the public's preference on cultural ESs is important to guide decision-making in designing and managing multi-functional landscapes.

在本研究中，根据均值计算结果作出的蛛网图可更直观地展示公众对每种WSUD景观要素各项文化生态系统服务的重要性感知与满意度差异（图4，5）。如上文所述，一处多功能景观所提供生态系统服务的实际效果与其预设功能和所处的背景环境都密切相关；作为背景环境的重要组成部分，当地社区对于不同文化生态系统服务的评价与偏好对多功能景观的设计管理决策具有重要参考意义。

如图4所示，对全部5种WSUD景观要素而言，审美欣赏、休闲/生态旅游、场所感以及教育/知识这4种文化生态系统服务的价值最受公众重视。有学者将人类对自然的认知方式分为6个维度，由主要到次要依次为经验维度、科学认知维度、情感联系维度、个人功利维度、与自然相关维度，以及超自然维度[35]。将图4的排序与该观点相结合，可以推断：因为审美欣赏与休闲活动这两类服务的感知重要性评价最高，且人们也是通过经验性认知活动获得这些服务，因此人们对WSUD景观及其他类型多功能景观的最主要的感知方式就是经验性认知活动。此外，由于公众对不同景观要素的同一种文化生态服务的重要性认知可能存在显著差异，因此，对于不同的文化生态系统服务，可优先选择的景观要素类型也不同。通过将蛛网图的信息与场地位置、功能需求相结合，设计师与管理者能营造出兼具雨洪管理效益与文化服务能力的城市景观。

结合图4和图5，将每种景观要素各项服务的感知重要性与满意度均值分别进行比较，可进一步发现每种景观要素提供文化生态系统服务的实际绩效：例如，单一草地型设施的社会关系服务在感知重要性

As Figure 4 shows, aesthetic value, recreation / eco-tourism, sense of place, and education / knowledge are the four most-valued cultural ESs of all the WSUD landscape elements. Scholars revealed six dimensions of public perception on nature: experience, scientific understanding, emotional connection, utilitarian perspective, connection with nature, and superiority over nature[35], from the most significant to the least significant. The ranking in Figure 4 can be interpreted with these six dimensions. Given the importance of aesthetic and recreation values, this interpretation suggests that the dominant way of perceiving WSUD landscape types, and thus multi-functional landscapes, is experiential. Besides, due to the variety of importance and satisfaction of each cultural ES among WSUD element types, public preference needs to be combined into the design of multi-functional landscape, and should be given to those types with more highly valued cultural ESs. Using the spider charts, designers and managers can choose the type of multi-functional landscape by not only sustainable stormwater management targets but also the importance of each cultural ES, dependent upon location and functional requirements.



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均值排序中位于首位，但其满意度均值仅位于第四位。由于感知重要性也可被看作公众对某项服务的期待程度指标，因此可以推断单一草地型设施当前的社会关系服务水平仍不能达到公众的要求，有必要对其进行针对性的改进。

4.2 不同类型WSUD景观要素的文化生态系统服务差异

WSUD景观要素的面积与尺度也会影响其提供文化生态系统服务的能力及人们的主观感知。例如，根据面积与尺度的不同，单一草地型设施还可细分为缓冲带、滞留盆地、绿色屋顶、砂过滤带、生物滞留种植池和植草洼地等[12]，它们为人们提供了不同的感知情境[36]，与人类形成不同类型的互动，从而使人们产生不同的文化生态系统服务感知。例如，小型种植池只允许人们被动观赏，而大型雨水滞留盆地既可供观赏又可以进入游憩，还能为人们提供自然教育机会及社交空间。对于不同尺度的景观要素评价，ISA方法同样适用。

4.3 ISA方法的实用性

文化生态系统服务因价值不易量化而难以进行评价[3][37]。本研究利用ISA方法将其与特定的景观要素相联系，使文化生态系统服务评估成为可能。研究使用的图片与里克特量表相结合的问卷形式在获得重要性和满意度信息方面易于操作且灵活性较高。这种问卷形式在社会文化认知研究中较为常见，且本研究根据前人“将研讨性方法与问卷相结合，如在问卷中提供额外的辅助性信息，使人们审慎地进行价值评

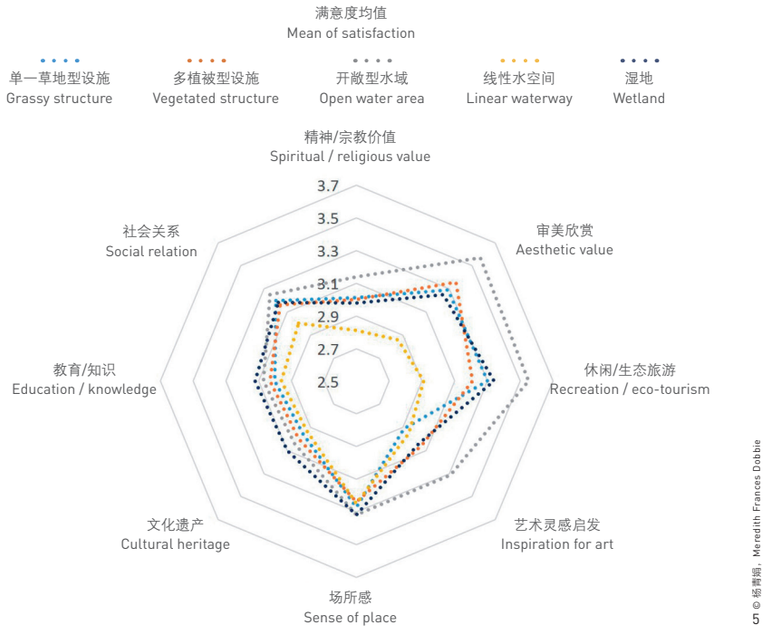

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Figure 5 shows the variation of the mean values of satisfaction with cultural ESs for each WSUD element type. A comparison between Figure 4 and 5 identifies the performance of each cultural ES for each WUSD landscape element. For example, in terms of the service of social relations, grassy structure enjoys the highest perceived importance but with a moderate satisfaction. Because the perceived importance indicates the public's expectation, an improvement in the delivery of the service of social relations of grassy structure in multi-functional landscape design should be considered.

4.2 Differences of Delivery of Cultural ESs among WSUD Landscape Elements

Size and scale of WSUD elements are important determinants in the delivery of cultural ESs of multi-functional landscapes and the public's perception. These can vary within a WSUD landscape type. For example, grassy structures can take forms of a buffer strip, retention basin, green roof, sand filter, bioretention planter or swale[12]. By providing varied situational contexts[36], different human-nature interactions would occur, which are perceived as related cultural ESs. For example, human's interaction with a small grassy planter might be simply visual and for passive recreation, delivering an aesthetic service; in a large retention area, active recreational activities are allowed and people are provided with an opportunity of nature education and spaces for social connections, in addition to aesthetic services. ISA also can be employed to examine the cultural ESs of WSUD landscape elements at multiple scales.

4.3 Practicability of ISA Method

Cultural ESs are intangible and difficult to assess[3][37]. This research proposed an ISA approach relating cultural ESs to a certain landscape type, making an assessment possible. A questionnaire combined with photos and Likert scales proved useful to identify the importance and satisfaction clearly and accurately. As a common method in socio-cultural studies, questionnaire, in this research, is strengthened by “combining deliberative methods... to allow people to deliberate throughout the valuation exercise, for instance by providing them with additional information.”[38] The questionnaire purposefully included an introduction to the concepts of WSUD landscapes elements and cultural ESs, photos of different multifunctional landscape types, and the assessment of perceived importance and satisfaction. This approach can help generate

估”[38]的建议，对问卷做了进一步优化，即引入对WSUD景观要素和文化生态系统服务概念的介绍，并提供不同WSUD景观要素的实景照片以辅助受访者进行重要性和满意度评价，从而获得了更多有利于景观设计和管理决策的有效信息。多功能景观图片的质量对该方法结果的准确性也至关重要，本研究尽可能保证所有景观元素照片都以正常视角呈现，且有足够代表性。

另一方面，该研究方法也存在一定的局限性。首先，基于专业人士视角选择的WSUD景观照片对于某些受访者而言可能难以理解；且某些对WSUD景观概念理解不够准确的受访者可能在评价时加入自己的主观臆测，这对分析结果有一定影响。随着可持续城市水管理的不断推进，公众将会更好地理解WSUD景观，从而克服这一局限。

5 结论

本研究基于旅游设计管理决策优化中的重要性—绩效表现分析（IPA）方法，提出了适用于抽象文化生态系统服务评价的重要性—满意度分析（ISA）方法，使尚不为公众广泛了解的文化生态系统服务变得易于理解，也使其价值评估成为可能；并使用该方法对城市雨洪管理景观的文化生态系统服务提供情况进行了探究，为此类景观的设计和管理决策优化提供了有效的参考信息。研究表明，不同类型的WSUD景观要素提供文化生态系统服务的种类及其水平不尽相同，但总体上，审美欣赏、休闲/生态旅游与场所感这三类服务获得了最高的重要性与满意度评价。研究还识别出了公众抱以较高期望但实际服务水平却不尽如人意的文化生态系统服务，这对于改善设计十分重要。

通过运用ISA方法，多功能景观的设计者与管理者可以为公众提供他们所重视的文化生态系统服务。自然资源与城市水务管理者及其他水敏性城市建设的决策者也可以使用这种方法，对自己与公众之间对某些景观的文化生态系统服务重要性认知差异进行反思，从而调整设计与管理策略，以兼顾景观设计中的专业考量与公众意愿。

有关文化生态系统服务的研究在不断发展，而评价方法的改进是其重要推动力量之一。ISA方法不仅丰富了文化生态系统服务的评估方法体系，也将使雨洪管理多功能景观的设计更加完善，并可同样运用于其他类型景观的文化生态系统服务研究。**LAF**

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more useful information to inform designers' and managers' decision-making process. For this method, the graphical quality of the photos of multi-functional landscapes is very important. We used the most representative pictures of each landscape type with a normal viewpoint.

Nevertheless, there are some methodological limitations to this research: the photos of WSUD landscapes were chosen from the professional perspective and might be difficult for some respondents to understand. So they might fill in the questionnaire partly based on their guess about the WSUD landscape elements, affecting the accuracy of results. In the future, as the concept of sustainable urban water management is increasingly popular across the world, the public may have a better understanding of WSUD, which can help to overcome this limitation.

5 Conclusion

In this research, the ISA method, adapted from the IPA developed for improving tourism design and management, was adopted to assess cultural ESs of multi-functional landscapes for sustainable stormwater management. The method allows otherwise intangible cultural ESs to be understood and evaluated, contributing useful information to decision-makings of design and management. Multi-functional landscapes with different WSUD elements deliver various cultural ESs. However, aesthetic value, recreational / eco-tourism, and sense of place are the most valued services across all WSUD landscape element types, in terms of both importance and satisfaction. ISA also reveals those cultural ESs with a gap between their perceived importance and the public satisfaction on their delivery in the landscape. In such instances, unrealized expectations are usefully revealed.

Thus, by using ISA, designers and managers can ensure that multi-functional landscapes deliver those cultural ESs highly valued by the public. Natural resources managers, water authorities or others involved in the implementation of WSUD can also promote cultural ESs of multi-functional landscapes that they consider important but not yet valued by the public.

The field of cultural ESs research is growing, and assessment methods are an important part to that growth. The ISA method can be used for improving design of multi-functional landscapes for sustainable stormwater management and exploring strategies to improve the delivery of cultural ESs of other landscapes in the future. **LAF**

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