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Incorporating local ecological knowledge into urban riparian restoration in a mountainous region of Southwest China

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ABSTRACT

Modern cities use straightened and concrete watercourses with simple greening for riparian zones, which has been criticised for insensitivity to natural system integrity and cultural identity. This increases the challenge to urban ecologists, landscape designers and managers to conceive innovative and effective design solutions that do not jeopardise hydraulic efficiency yet are culturally acceptable to local communities. This paper introduces the field of local ecological knowledge (LEK) as rich sources of inspiration and design solutions to meet this challenge. LEK refers to knowledge and practices of various local cultures about the relationship of living beings (including humans) with their environments. Wepropose a pragmatic framework that integrates LEK with modern landscape design. It includes steps: (1) investigate existing practices, skills andmeasures relating to LEK; (2) explore how and whereLEKcan inspire or integrate withdesign. Here we propose three aspects for integration in accordance with the nature of landscaping process: overall structure, component and maintenance.(3)evaluate and test the integration in terms of its acceptability by local communities. Taking the riparian revegetation project of Hanfeng Lake Urban Wetland Park (Chongqing Municipality) as an example, we illustrate the utility of this framework. 11 local common practices relating to LEK were identified. According to thethree aspects for integration, alternative design solutions were offered. The survey showed that LEK based designwas more highly valued than other conventional ways in terms of useracceptance. We conclude that LEK provides actionable ecologically sound and culturally desirablesolutions for urbanlandscape. We also recognise that LEK evolveswith changing environments and new harmonious and dynamic human-nature relationships arecontinually re-forming. The process of acquisition and application of LEK could encourage multidisciplinary and synthetic approaches to urban ecosystems. Such adaptability and interdisciplinary engagementare crucial totoday'schanging and complexurban environments.

1. Introduction

Modern cities use straightened and concrete watercourses with biologically simple, low statured greening to speed the egress of stormwater and protect banks from erosion. Such practices have been criticised for biodiversity depletion, surface water degradation, urban flooding, and landscape disconnect (Kenwick et al., 2009; Theriot et al., 2013), as well as loss of cultural heritage and aesthetic quality (Cole, 2012; Junker and Buchecker, 2008). Research and practice to date suggests adopting ecological approaches as a form of therapy for nursing more naturalistic ecosystems and the services they provide back to health (Forman, 1995; Mitsch and Jørgensen, 2003; Van der Ryn and Cowan, 2007). However, simply focusing on ecological function fails to satisfy the cultural and spiritual dimension of ecosystem services (MEA, 2005). This dimension is especially critical for urban settings since cities are by definition socio-ecological systems. There is increasing acceptance that mature urban design and management should not only be ecologically sustainable, but capture the history, identity and spirit of the place to achieve landscape legibility (Lynch, 1960; Nassauer, 1997; Turner, 2005). The anticipated benefits include winning individual and community support for greening

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and conservation oriented projects over the long term (Aswani and Hamilton, 2004; Bohensky et al., 2013; Johannes, 2002; Uren et al., 2015).

Local people who have been on the land for generations possess a wealth of practical knowledge, skills and techniques about the relationship between living things (including humans) and their environments in terms of flora and fauna, water resources, habitat suitability, changing environmental conditions, and natural disaster reduction. This cumulative understanding forms so-called "indigenous", "traditional" or "local" ecological knowledge (Bohensky et al., 2013; Davis and Wagner, 2003; Martin et al., 2010; Syafwina, 2014; Thornton and Scheer, 2012). Local or traditional ecological knowledge (LEK hereafter) is site specific and based on adaptive learning, handed down through generations by cultural transmission (Aswani and Hamilton, 2004; Berkes et al., 2000; Bohensky et al., 2013; Martin et al., 2010). The resulting interaction between nature and culture has reshaped our physical environment to form landscapes that reflect our history, sociocultural identity and norms. For example, rice terraces in hilly areas (e.g. Hanni Terrace, China, UNESCO World Heritage) is such an iconic living landscape with a distinctive aesthetic and immediately identifiable as rural heritage found in many countries. Often embodied in these altered landscapes lies a well spring of inspiration and problem solving potential relevant to urban landscaping and greening.

A growing number of studies have come to realise the ecological values and rationales behind LEK and indicate they are complementary to modern science (Liedloff et al., 2013; Syafwina, 2014). For example, traditional management of rice terraces are shown to provide energy-effective and efficient tillage in hilly areas, since series of flat surfaces both conserve soil and retain nutrient-rich rainwater runoff and silt from the uplands (Gliessman, 1990; Shen et al., 2010; Wei et al., 2016). Such practices have significantly informed landscaping of mountainous cities and regions. Among southeastern China's rural communities, the dike-fish pond farming system is a typical application of LEK (Ruddle and Zhong, 1988; Weng, 2007). It is composed of dikes on which multi-layered crops/vegetables/fruits are grown, and ponds in which a variety of fish are raised. The ratio of bank to water area has through time been optimised at a minimum of 2:3 in order that there is adequate land for plants to sustainably drive the rest of the system. Such LEK is tangible and grounded, directly relating to land and natural resource management.

The incorporation of LEK into modern natural resource management is increasing worldwide and involves many types of ecosystems (Bohensky and Maru, 2011; Johannes, 1989). One of earlier examples dating back to the 1970s is associated with afforestation techniques in difficult terrain of Hungary (Telfer and Schemnitz, 1974). More recent examples include coastal habitat conservation (Drew, 2005), endangered species protection (Tang and Gavin, 2010), wildfire suppression (Diaz et al., 2016; Ray et al., 2012), community-based biodiversity conservation (Ruiz-Mallen and Corbera, 2013), reservoir conservation (Yuan et al., 2013), and forest management (Falkowski et al., 2016). However, there has been a reluctance to apply it in urban or peri-urban environments since "urban" has been conventionally depicted as a separate domain from the natural and rural worlds where nature and culture intermesh.

Here we propose that LEK can inspire or be incorporated into planning, design and management of urban green space since it provides tangible ecological and cultural values. We presented a LEK based design framework and demonstrated how it can be used in the real-world by taking an urban riparian landscaping project as an example. The purpose of this paper is not to present a full procedure of the project, but rather to illustrate how communities might organise and manage land, water, plants and other natural resources in an orderly frame and therefore buy-in to ecologically important landscaping and greening. We hope this study will offer insights into ways of incorporating LEK in contemporary design, use and maintenance of urban nature against the background of rapid urbanisation and homogenisation of urban landscape. In a wider sense, we support greater acceptance in the scientific world of the roles, potential, and imperatives of actively engaging local communities and their practice-based knowledge towards sustainable cities and land use.

2. Materials and methods

2.1. Study area

Hanfeng Lake, a section of Pengxi River, became the second largest urban lake in China as a result of the Three Gorges Reservoir (TGR) formation within Kaixian, which is a new town of Chongqing Municipality partly relocated to higher ground to make way for the TGR. With its special landscape, it has been designated a national urban wetland park with a total area of 13.03 km^2. Controlled by both the Three Gorges and Hanfeng dams, the Hanfeng Lake water levels alternate between 170.28 m in summer to 175 m above sea level in winter, creating a 3.74 km^2 water-fluctuation-zone (WFZ). The long period of water impoundment has brought environmental and aesthetic challenges to the new town. One of the goals of the park is to revegetate WFZ wisely and create a multifunctional land use exemplar that mitigates environmental and social impacts for other similar locations (Chongqing University, 2010).

The riparian demonstration project (31°10′55″N, 108°27′45″E) is being carried out between the 170.28 m to 179 m elevation on Wuyang Bay of Hanfeng Lake, including the WFZ plus 4 m elevation (175 m–179 m) to accommodate important adjacent riparian functions. The total project area is 1.6 ha. Previous land uses were paddy fields, dry cropland, and sparse forests which still remain on steep slopes and side gullies (Fig. 1). The region has a northern subtropical humid monsoonal climate with an average annual precipitation of 1200 mm, 60–80% concentrated between April and September. The mean air temperature is 18.2 °C, and there are less than 20 frost days per year. The main soil types at the project site are paddy soil and purple soil that supports subtropical broad-leaved evergreen forests as the regional climax vegetation.

2.2. A design framework incorporating LEK

Fig. 2 presents a framework incorporating LEK. Applying this framework requires a multidisciplinary team of ecologists, designers, landscape architects, as well as community residents. The research methods are detailed in the following sections.

First, existing practices, skills and measures relating to LEK should be thoroughly investigated. Second, the team must explore in which aspects this knowledge can inspire or integrate with urban landscaping and greening. It is a key step in the whole procedure, and also a challenge since design seems not to follow a fixed sequence of steps as science research. In order to make integration easily and effectively, we broadly classify and propose three aspects for integration in accordance with the nature of landscape design process (Booth, 1990; Simonds and Starke, 2006): structure, components and maintenance. Structure refers to the overall pattern, arrangement and order of all the components included in a design. Components are the plants, water, stones, pavements, roads and other material details, like colour and texture. Although maintenance may not be a focus in the design stage, it is a pivotal item for building sustainable projects. And LEK is essentially related to natural resources management. Therefore we consider the maintenance issue in the design process. Third, the team must evaluate