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# Restoration design for Three Gorges Reservoir shorelands, combining Chinese traditional agro-ecological knowledge with landscape ecological analysis

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ABSTRACT

One of the greatest challenges associated with the Three Gorges Dam and Reservoir is the massive extent of the drawdown zone, causing soil erosion, loss of habitats, and landscape aesthetic degradation. Through two rounds of field and interview surveys, we have re-engaged with traditional agro-ecological knowledge as a source of solutions to these challenges. A modified pond-land terrace (MPLT) land/water use system is proposed to maximise shoreland conservation and associated ecosystem services based on local practices of paddy terrace and dike-fish pond farming. The MPLT system has a functional structure comprising water retention ponds at the top, vegetation fields in the middle, and the reservoir lake at the bottom. The design of the system is described in detail in this article by reference to the Wuyang Bay in an urban wetland park. Face-to-face questionnaire survey revealed that the community holds a positive willingness to participate in the MPLT project. Given significant environmental uncertainties in this region, post-construction monitoring is recommended for an extended period in order to determine how its benefits meet the predictions and further inform adaptive management and refinement of the system. The results illustrate the value of combining modern ecological design with traditional land-based knowledge and community engagement when seeking innovative, site-specific, and multifunctional landscape solutions to changing environments.



## 1. Introduction

Water levels of the Three Gorges Reservoir (TGR) are operated between 145 m during summer and 175 m above sea level during winter. This is opposite to natural river flooding rhythms in China. It has created a complex and completely new ecosystem – drawdown zone – surrounding the TGR, with a total area of 348.9 $km^2$. The long, erratic water impoundments have brought environmental and social challenges to local people, such as soil erosion, bio-diversity reduction, bio-invasion, loss of capacity for filtration of non-point source pollution from the uplands (Huang, 2001; New and Xie, 2008; Yuan et al., 2013), as well as loss of cultural heritage and riverscape aesthetics significant for the tourist industry.

Great opportunities exist to improve drawdown zone ecosystem performance by application of ecological design and management (Mitsch et al., 2008; Yuan et al., 2013). Ecological approaches embrace the notion of mediating human destructive impacts on the environment through working with natural processes (Van der Ryn and Cowan, 2007). They incorporate wider consideration of physiography, climate, vegetation, wildlife, and thereby encourage the development of multifunctional landscapes that deliver ecosystem services and poverty alleviation (McHarg, 1969; McNeely and Scherr, 2003; Nassauer and Opdam, 2008).

Human interactions with nature are often neglected in ecological engineering. However, improved human-ecological design models have been developed to recognise human-nature dependency and "cultural cohesiveness" (Forman, 1995). The ways of integrating cultural considerations are diverse and many projects are conducted largely on a case by case basis (Moshia et al., 2008; Yahner et al., 1995). The overall principle is that design needs to be culturally sensitive: respect local values and knowledge through

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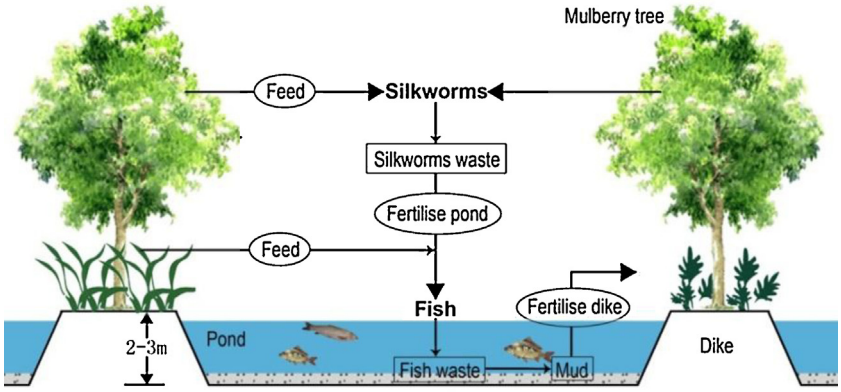


**Fig. 1.** Concept diagram of traditional dike-fish pond model from southeast China.

integrating bio-physical and socio-cultural inventory of the local environmental history and historical landscape use (Ndubisi, 2002; Steinitz, 1990).

Traditional agro-ecological knowledge is a pivotal source of inspiration for more sustainable solutions to today's environmental problems (Martin et al., 2010). Incorporating such knowledge into eco-friendly land management has recently been practised in the TGR region (Willison et al., 2012; Yuan et al., 2013). For example, dike-pond engineering based on traditional mulberry dike-fish pond, was experimented within Laotudi Bay, Pengxi River, Kaixian (Li et al., 2011). Traditionally, the mulberry trees feed silkworms for sericulture, and waste from the silkworms and poultry provides extra food for the fish, while the accumulated fish waste at the bottom of the pond is dredged and used as fertiliser for the mulberry trees along the dikes (Fig. 1). This integrated system maximises the use of land and water resources, recycles nutrients and captures energy within an overall balanced ecosystem (Ruddle and Zhong, 1988; Zhong, 1982). A recent variant is employed in coastal lowlands to overcome seasonal inundation and salinisation. There the dikes are usually cultivated in a rice-sugar cane rotation with interpolated vegetables (Ruddle and Zhong, 1988). This brings economic benefits to local people in otherwise unproductive coastal land.

Our proposal for rehabilitating the drawdown zone is a modified pond-land terrace (MPLT) system based on hybridising long-established farming practices from southern China and modern ecological restoration design analysis. It was applied to Hanfeng Lake, which became the second largest urban lake in China as a result of TGR formation within Kaixian. With its unique landscape and rich rural culture, it has been designated a national urban wetland park. One of the goals of the park is to use the drawdown land wisely and combine environmental protection and landscape aesthetics to create a multifunctional land use exemplar for other similar locations (Chongqing University, 2010).

Some sections of the drawdown zone around the Hanfeng Lake are already hardened with concrete to protect the shoreline from erosion[1]. Compared with such conventional riverscape practices in China, our design is intended to demonstrate an optimised, ecologically sound shoreland management that is visually and culturally desirable. From 2011 our interdisciplinary team began a comprehensive investigation of local land management practices and environmental variables such as topography, soil types and hydrological conditions. It is anticipated that it will be a valuable reference for comparable areas which have the intention of promoting local culture, ecological integrity and landscape aesthetics against the background of rapid urbanisation and increasingly complex, dynamic environments.

## 2. Methodology

### 2.1. Site description

Kaixian of Chongqing Municipality is a new town relocated to higher ground to make way for the TGR. Pengxi River, one of the most important primary tributaries and recharge sources of the Yangtze River, meanders through Kaixian urban areas (Fig. 2). To minimise the adverse effects of dramatic seasonal flooding on the city, a dam has been constructed on the Pengxi River and forms Hanfeng Lake. When the dam is in use, the Hanfeng Lake is operated above a minimum of 170.28 m during summer, by contrast the TGR falls to 145 m. During winter, both TGR and Hanfeng Lake are held at 175 m. Nevertheless, Kaixian has a drawdown zone of 58 $km^2$, the largest of any town/county within the TGR catchment. The affected land is generally 220–800 m wide on each side (Zhang and Zhu, 2005), of which 72% was previously used for agriculture.

Hanfeng Lake Urban Wetland Park was established with a total area of 13.03 $km^2$ and drawdown zone area of 3.74 $km^2$, mainly surrounded by urban and suburban land. The demonstration project (31°10′55″N, 108°27′45″E) is being carried out between the 170.28 m to 179 m elevations on Wuyang Bay of Hanfeng Lake. The total project area is 1.6 ha. Previous land uses were paddy farming, cropping on the flats, and scattered forest which still remains on steep slopes (Fig. 2).

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 (below 173 m) and purple soil. Subtropical broad-leaved evergreen forest is the regional climax vegetation.

### 2.2. Methods

#### 2.2.1. Data

This study used 2002 SPOT imagery (10 m resolution) and 2012 high resolution (0.5 m) satellite aerial photography to produce

[1] From Kaixian 2012 satellite aerial photography, we calculated that currently for some urban sections of Hanfeng Lake, manicured shoreline greening (trees and flower beds) accounts for 30% of the shoreline plaza.