

*Sustainable Study on Rural River Landscape Based on the Eco-Priority Principle:
A Case Study of Landscape Design for the River Yaxi*

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Abstract

Accompanying the increasingly conspicuous homogeneity in urban and rural development in the process of China's contemporary urban development, the rural river landscape is largely copying the landscape construction techniques available to urban rivers, causing several inappropriateness. This paper argues that rural river landscape design has two core demands. First, to achieve sustainable development of rivers via regeneration of natural landscape based on the Eco-Priority Principle. Second, to arouse viewers' emotional return to the river landscape by following the design principle of localness. Taking the River Yaxi of Yaxi Town, Gaochun District, Nanjing City as a case study, this paper presents the application process of rural river landscape in its township planning and design, and summarizes its sustainable regeneration methods under the eco-priority principle as follows. Firstly, make interpretation for natural ecological conditions of rivers based on present situation survey, apply centralized and detailed analysis on such basic elements as height of normal water level, water quality and surrounding situation of the site in recent ten years, and understand the historical memory of local residents for River Yaxi through questionnaire survey. Secondly, address the flood discharge specific to the existing rivers under the eco-priority principle, realize landscape regeneration by treating river revetments and arranging pumps, etc., and based on the confirmed node type of landscape design as per space atmosphere and historical imprint, adopt three design strategies of retention, extraction and derivation. Finally, while fully considering the ecological sustainability and emotional return of river landscape, satisfy the modern lifestyle needs.

Keywords: Rural rivers, Landscape design, Eco-regeneration, Loss of local characters, Gaochun, China

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1 Background

1.1 Present Situations

China is now becoming a highly urbanized country with the urbanization rate over 50%. People pay more attentions to the residential environment, and the problems that have been challenging urban waterfront spaces are being solved gradually. Along with the advancement of China's new countryside construction, built-up environment of the rural areas, instead of urban areas in the past, is becoming a concern of the public. Rural river landscapes surrounding urban areas also come to be valued. Rural rivers are quite different from urban ones in their spatial, ecological and functional properties, making the research on rural rivers an urgent issue.

1.2 Difference between urban and rural rivers

Location. Most rivers in cities are closely connected with surrounding public spaces, construction structures and roadways. For this reason, they are renovated, often cemented (by pavement), to match the urban spaces. While in rural areas, most rivers remain their natural forms except that some are rebuilt to ditches for irrigation or other agricultural purposes.

Function. There are two obvious differences. Firstly, in cities rivers collect water not only by confluence on the earth surface. Rain water is separated from sewage and then drained through pipe network into rivers. Sewage is purified to the state or local standard and then also drained into rivers. In rural areas water are collected into rivers mainly through confluence on the earth surface. Therefore most rivers are low-lying linear spaces that facilitate natural confluence of surface water. Secondly, cities have more flood prevention requirements, and therefore embankments become higher and higher, and other facilities such as wave walls are set in key areas. Those soaring structures separate the river from the city spaces. In the contrast, embankments and other structures in the countryside, though also are necessary, are lower and smaller because of less flood prevention requirements. The surrounding spaces are less affected and keep close with the rivers.

Transportation. Rivers inside urban areas are often a significant part of the city's waterlogging prevention and flood draining system. They seldom play the function of shipping or irrigation. Rivers in the countryside, however, are important not only for drainage, but also for water supply and even shipping.

Ecology. In cities rivers are over-intervened by human being. Besides embankments **and other** structures, revetments are always hardened, destroying the bog plant systems near the waterfront line. While in the countryside, such bog plant systems are well reserved. There are waterfront vegetations like reeds and giant reeds, and other signs of life resting along the revetment, such as shrimps, loaches, etc. In one word, biosystems in the rural water environment are more complete than those in urban areas.

Landscape. Banks of urban rivers are mostly used for human activities, and thus are artificially designed to satisfy the demands and tastes of human being. For rural rivers, bank spaces are in their primitive conditions, with the natural forms and complete ecological plant systems (underwater plants, bog plants and terrestrial plants) better preserved.

To summarize, rural river systems largely differ from urban ones in many ways. Regulation methods for the latter are not suitable for the former, and will cause a lot of problems if applied irrespective of these differences. We need to find the way for regulating rivers in the rural areas of China.

2 Challenges for rural rivers and design principles

Simply building some parks cannot promote social development. The overall construction of landscape in a country is the key. Switzerland is an example, whose rural river system pattern was changed as the mode of agriculture varied. Once a lot of terraced fields had been constructed in Switzerland to meet the needs of production. Later however, those water systems were restored to a more ecological and naturalized pattern. This is also the trend for rural river construction in China. At present we have two major problems in rural river development, namely ecological pollution is increasing and river characteristics are lost day by day.

2.1 Increasing ecological pollution

Situations: most rural rivers in China are now facing eutrophication of different degrees. Signs of life are becoming less and less, and the water environment of rural rivers is trapped in vicious circle (*1).



Figure 1: Increasing pollution of rural rivers (Internet image)

Reason: in traditional agricultural societies, the traditional farming practices largely relied on the water source. Drainage of domestic sewage is the major pollution source of rural rivers. However, at that time this caused just a little negative effects because the rural population is small. Nowadays as the rural areas are developed, industry and excessive agricultural farming result in non-point source pollution. This becomes the root of rural water environment deterioration, and brings much more negative effects than domestic sewage. ¹

Principles of design: we need to find scientific methods to cope with the pollution of rural rivers, which becomes increasingly intensified during the urbanization process. Firstly, river eutrophication shall be solved through both waste water purification and scientific fertilization and irrigation. Thus the source of pollution can be controlled from both rural industry and agriculture. Secondly, function of rivers shall be improved. The function of any independent water system is minimal comparing with

¹Non-point source pollution: in agricultural production, large amounts of fertilizers are used and could not be totally absorbed by the crops. Most fertilizer residues penetrate into underground water and then are segregated into river water systems, causing non-point source pollution.

the network of rivers. We shall connect the existing river systems into a network, avoiding fragmentation of single water system or stagnant water. In addition, we shall increase the mobility of water systems by utilizing the natural height differences in landforms, so as to rely less on irrigation and drainage, and keep the water flowing. Finally, aquatic plants shall be grown along the riverbanks to further relieve pollution. Common aquatic plants like calamus, canna and iris can remove nitrogen and phosphorus in river water with slight eutrophication. Flush-irrigation and flushing shall be used as supplement to improve the self-purification of riverways.

2.2 Loss of local characteristics

Situations: rivers in urban and rural areas of China nowadays tend to become identical. River landscape in the countryside lost their individual characteristics, becoming similar to the river landscape in cities.



Figure 2: River landscape in different cities (Nanjing, Jiangsu VS Hanzhong, Shaanxi) are becoming alike (Internet image)

Reason: Water environment in rural areas tightly connects with local features. As a result, river landscape often becomes the carrier of local culture and nostalgia culture. The unique features of a local environment not only give special characteristics to its inhabitants, but also "nurture" the diversified ecological structure of a specific region, and thus creating varied modes of production and styles of life. For example, the river network of Xiazhu Lake region in Zhejiang is quite different from that of Lixiahe region in north Jiangsu, which is only 300km away. Those differences involving agricultural operation patterns, spatial forms, etc. Totally distinct regional characteristics are caused by differed physical forms, production modes and life styles even across such a short distance. Nowadays river construction in rural areas is often copied from urban areas, erasing the original characteristics of the rural rivers.

Principles of design: local characteristics of rural areas involve the ecological environment, life style and mode of production. Rural river landscape shall be constructed to match the three. The construction shall include growing region-specific plants, collecting regional elements and so on. Moreover, traditional life style and production mode shall be revitalized. For example, evident symbols of agricultural production like watermills can be used in river building. In this way the original landscape features may be all restored (*2).

3 Rural river space building strategies

Currently most rivers of China are facing the major problems of intensified ecological pollution and loss of rural characteristics, but the actual situations may differ because of varied river locations, natural conditions, degree of pollution, etc. Therefore, we shall seek for different strategies suitable for those specific situations. In general two strategies can be considered, ecology-first and function-first.

3.1 Ecology-first strategy

This is a principle of application considering ecology elements in all subjects. In the construction of rural rivers, it mainly refers to planning and building rivers by first considering protection and restoration, so as to protect regional ecological environment against impacts or even damage from the construction. This is often suitable for rural areas with developed river network, which have higher ecological adaptability because of widely-covering water network and favorable natural resources. During rural river space construction, ecological adaptability and biological diversity of the rivers and surrounding regions shall be preserved. Significant natural landscape resources shall also be protected and optimized, such as primitive/historic cultural heritages, natural reserves and ecological-sensitive natural patches, etc.

The ecology-first strategy can be widely applied in the rural districts in the south to Huaihe River and some north areas with dense river network and not restricted by river functions, such as Mudu (in Jiangsu) and Langchuan (in Zhejiang) villages.

3.2 Function-first strategy

This principle is mainly applicable to rural rivers used for shipping or production functions. These rivers, for better functioning, were often cut off to become as straight as possible. In a short period their expected functions are not possible to change. In construction of such rivers, we shall comprehensively consider what future impacts will these functions have on the rivers. The current environment status shall be sorted out and assessed in details, so that we can decide which lands are suitable for the construction. The development shall mainly include ecological planting and revetment restoration. In addition, ecological optimization measures shall be taken along the whole riverway, such as aeration basin, ecological floating bed or other artificial technologies. This can restore the riverway ecological environment in a short period, but does not address the cause of ecological problems of rural rivers as what the ecological-first strategy does.

The function-first strategy is suitable for most rural rivers used for shipping, production, etc. in China, such as surrounding villages along the lower-and-middle section of Yangtze River.

The ecology-first strategy is more practical than function-first for landscape construction of most rural rivers in China, and therefore shall become our focus. Proper landscape design could rebuild the traditional rural river spaces, restore their original ecological patterns, renovate rural characteristics and appearance, revive productivity as well as provide new style of recreation in the rural regions. It is an effective way for revitalizing our rural rivers.

4 Case study of Yaxi, Gaochun

The Yaxi river in Yaxi town, Gaochun has favorable ecological conditions, and rather complete local characteristics available for collection and restoration. Landscape design in an ecological-first way is possible here. In the overall planning of the town,

the Yaxi river is the focus of development in recent years, and the target is to recover its original natural landscape features. It will be a practical example for exploring the sustainable development of rural rivers.

4.1 Overview of Yaxi town, Gaochun

Yaxi town is a new small town located in the west of Gaochun District of Nanjing City, Jiangsu Province. It borders Liyang City in the west, 8km away from Dingbu village in Langxi county in Anhui Province, and is adjacent to the Lishui District. The town covers 115km² in total with a population of 50,000, enjoying convenient land and water transportation. Yaxi river flows through the town. It is a branch of Xu river, the earliest artificial canal in ancient times. It is a "golden channel" connecting to the Taihu water system, and forms a river network together with surrounding water bodies in Suzhou, Wuxi, Changzhou and Shanghai. Yaxi river is 31km long, with the average width from 10m to 160m. Rice and tea grow in abundance on its both banks. Our study, accompanied with field practices, mainly researches a 1.5km section (town area section) of the river, which nears the main town area of Yaxi.

4.2 Current situations of Yaxi river

We have interpreted the natural ecological conditions of the river through field investigation. First the hydrological conditions of the river including precipitation, flow capacity, flow rate and peak flow, are sorted out, and those useful for the research object (the town area section) are picked over. The straight-line length of town area section is 1500m. On its south side there are residential houses, and its north side nears the new agricultural trade market of the town and some plant areas. The main statistics of Yaxi river in the last decade measured by the water authorities are as follows: the highest water level in flood season is 7.62m, the normal water level 3.4m, the average riverway width 7-10m, the average height between water surface and embankment 2.4m, degree of slope at north bank (steeper) 1:4.5, and that at south bank (gentler) 1:1.5. (*3)

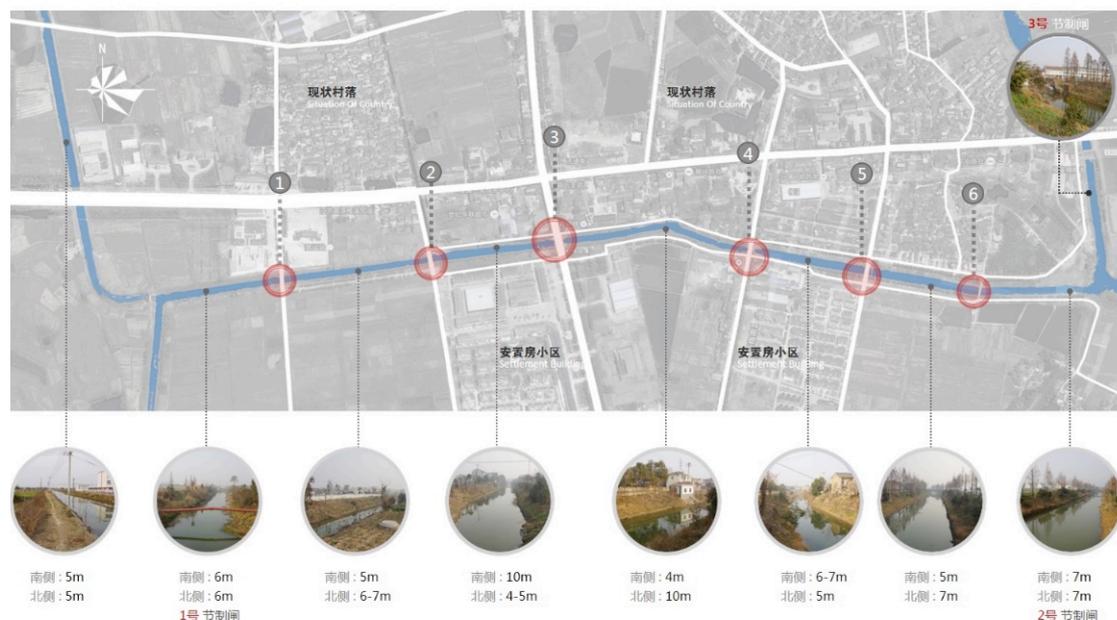


Figure 3: Current status of Yaxi river system (drawn by the author)

Along the Yaxi river there are altogether 9 pump stations for flood storage, two of which within the town area section. The river enjoys relatively favorable natural conditions and is equipped with complete flood prevention facilities. However, currently there are two major problems. Firstly, the riverway lacks vitality and connection with the surrounding environment. The existing green land is not reasonably developed, and nodes are not sufficient. Secondly, there are seldom human activities on the riverbank due to spatial restrictions. For example, the riverway is narrow, water level is low, revetment is also narrow with steep slope (often between 45% and 60%), and plantation is too simple.

4.3 The ecology-first strategy for rural river landscape design

For a long time we rely too much on the human intervention to the nature during the development of agricultural culture. For convenient and efficient agricultural production, we excavated numerous water systems on the basis of even water resource distribution. These water bodies were mostly cut off to a straight-line form. Besides that, riverbed tops were modified artificially to satisfy human irrigation needs. The change of revetment forms and riverbed height indirectly affects the natural distribution of water systems, and thus reducing the self-cleaning abilities of riverways. Not to mention the irreversible damage of natural river ecological systems by discharged domestic and industrial sewage. As times progresses, economy develops and new industries emerge, rural rivers shall have more functions than meeting agricultural production requirements. People pay more and more attention to their emotional needs. They hope that Yaxi river could recall things of the past, offering them a sense of belonging and resonance. For these reasons, the ecological-first strategy is ideal for revitalizing the landscape of Yaxi river. To be specific, the construction shall take the regeneration and sustainability of natural river characteristics as the first consideration, and try to arouse people's sense of nostalgia. On this basis, we shall reduce human disturbance to the river to the least. To summarize, the strategy is to, through smaller economic investment and less human interference, restore the original river characteristics and satisfy the emotional demands and modern life style of people.

(1) Regeneration of natural characteristics

Yaxi river faces the common problems of any other rural river in China nowadays, i.e. damage to natural ecology. The main pollutant of Yaxi river is discharged domestic sewage; so regulation is not difficult. Based on the current situations of the river and the requirement that design shall facilitate sustainable development, the regulation work will be divided into three stages, namely the near term, the middle term and long term. The former two will be the focus of our current work.



Figure 4: Rain water and sewage separation establishment in rural areas

In the near term, clear away silt and dredge waterways

In this stage, clear away matters that block the water flow, such as silt, sandstone and garbage, to dredge the riverway, recover and improve its flood passage and waterlogging drainage capabilities, increase water movement and improve the water quality. Waste water discharge shall be controlled from the sources. The water quality of Yaxi river is level 3 according to the current waste water control standards in China. Rain water and sewage separation facilities shall be equipped at residences and factories along both riverbanks, protecting the riverway against pollution by the large amount of waste water. The waste water is discharged by the separation facilities through sewage pipes to the sewage treatment plant or sewage pump stations, purified by the activated sludge process, and then discharged into the riverway (*4). Rain water and surface water is collected by rain water pipes and directly drained into the riverway. This could effectively control the pollution of Yaxi river.

In the midterm, build embankments and revetments

This involves waterfront sort-out, waterfront repair, adding plantation revetment, etc. The form of embankment and revetment shall be selected to suit the actual conditions. In the sections where the riverway is greatly affected by water flow scouring, use rigid embankments; while in other sections, adopt ecological embankment as much as possible to reserve the original ecological features. For regions where people may gather, allow the intimacy between the embankment and persons. Maintain the natural forms of the river and revetments and avoid cut-off. Diversity of the river and aquatic lives in it shall be also protected.

By sorting out revetments of the Yaxi river and based on the current situations, three methods were put forward to renovate the revetments. 1. Make the slope of revetments gentler. As restricted by the riverbank width (7m) and slope rate (1:4.5), this shall be realized by a vertical change along the banks. 2. Parts of revetments can be curved to reduce the flow rate and thus protect the revetment against damage by

the water level in flood seasons. 3. According to surrounding waterfront conditions, add river islets in central sections of the riverway, which can be built with the small amount of earthwork generated by waterfront adjustment(*5) .

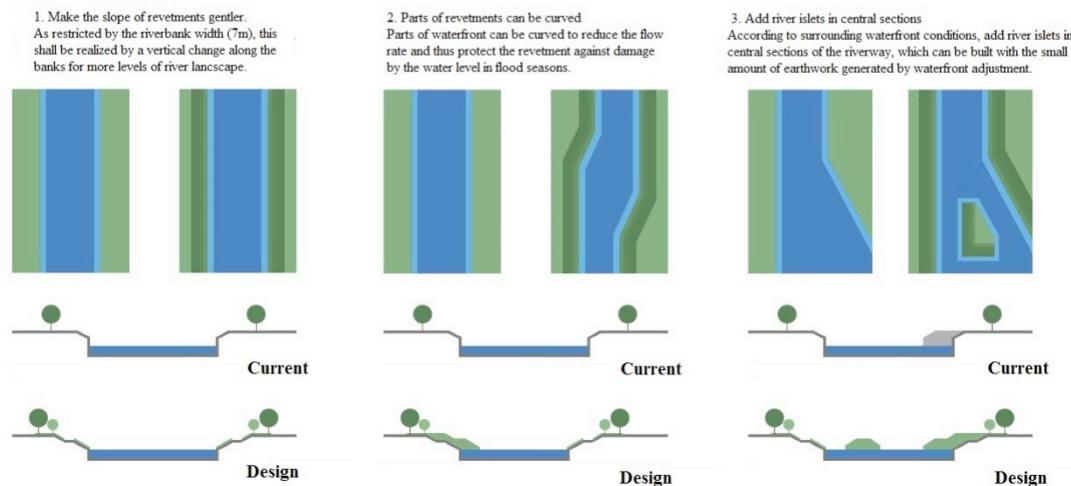


Figure 5: Revetment renovation method
(drawn by the author)

In the long term, initiate water system connection work

The object of our research is a water system in a plain region, where water flows at a low rate and the directions are variable. In addition, water levels at different stations such a region are tightly connected; their water level differences can be used to define the hydrological connectivity. That is, the connectivity between two neighboring stations on a riverway is reflected on the water level difference. We can collect the average water level data of a certain time period. Small water level difference between two neighboring stations shows smooth connectivity (water levels are synchronized) and large difference shows poor connectivity. Therefore, we shall utilize the existing water conservancy facilities of Yaxi river and build new water gates, stations and channels, so that the river connect with proper surrounding water systems. In this way its water mobility can be increased, water quality improved, flood prevention and waterlogging drainage capabilities strengthened, guaranteeing the persistent development of the area.

(2) Recall of nostalgia emotions

Along with the development of Yaxi town, the Yaxi river, once a significant water system for the life of local residents, has gradually become no more than a "ditch". The memories it had been carrying are getting lost. The traditional ecological environment, production mode and life style are dying out. As stated above, such loss of local characteristics is common in rural rivers during the development process of "China's new countryside". To carry on the local cultures in river landscape design for rural areas, the nodes shall be selected according to the features of space and traces of the history. Design can be realized through reservation, extraction and continuation.



Figure 6: Rendering of rural river landscape renovation (drawn by the author)

1. Reservation

Taking respect to and protection of local cultures and spatial features as the first principle, investigate the spaces surrounding the river, and organize the data. Classify the spatial nodes which are rather completely maintained and which greatly embodies local cultures, and work out measures for reservation as well as schemes for successive development. Repair or update those nodes according to the classification, so as to make them suitable for the existing spaces and reserve people's memories about these spaces.

2. Extraction

Through field investigation and interactive interviews, find out and maintain the historic atmosphere and local features. Firstly, extract and utilize local culture symbols. As the form to represent and pass local cultures, these symbols played a key role in the inheritance and development of historic cultures. They can evoke people's emotion and memory about local cultures. Secondly, use local materials in the landscape, because these materials, as unique production of the local geographical environment and climate conditions, are a significant means to express the emotions about local cultures. Traditional landscape materials such as regional plantation, woods, stones, soil and bricks reflect the change of nature and mark the development of human being. Application of such materials in the landscape will further improve the local flavors of the site.

3. Continuance

Original textures and dimensions of the riverway is an external expression of the town's internal mechanism and order. They shall be continued as a response to the original mechanism and order. Thus the landscape is filled with the vitality of rural life. The continuance is also realized by connecting river landscape with surrounding spaces such as courtyards, streets and lanes. It extends the local style of life, creating unique experience of the rural river(*6).

5 Conclusion

Based on theoretical and practical researches, we conclude that,

1. Two major problems have emerged to rural rivers in China during the urbanization process, namely the increasingly intensified ecological pollution and the loss of rural characteristics along the river banks. Generally speaking, development of most rural rivers is a lagging-behind issue, and the renewal of rural river spaces are being widely focused. To build rural rivers, we shall, taking into first consideration the natural pattern, textures and modern life style, optimize the landscape pattern and ecological environment in our country.
2. Taking Yaxi in Gaochun as an example, we worked on the specific ecological-first design strategy for a rural river. It mainly involves regeneration of natural characteristics of the river and recall of local emotions. The regeneration work is divided into the three stages of the near term (silt clear-away and waterway dredging), midterm (embankment and revetment protection) and long-term (water system connection). The restoration of local landscape features are supposed to be realized through reservation, extraction and continuance.

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