

ECOSYSTEM RESTORATION OF A LAKESIDE WETLAND AT ERHAI

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ABSTRACT

The wetlands along any lakeside are the “crossover” between the water and land ecosystems associated with the lake. They form an important part of any lake ecosystem and provide a function for the general environment and ecosystems as well as performing water volume adjustment and storage. They also provide a protection barrier for any lake.

The major problems of the wetland along the lakeside of Erhai are: (1) The wetland along the lakeside is bordered by man-made architectural structures. (2) Non-point sources of pollution are prominent (3) The structure of the wetland ecosystem has broken down and the ecosystem environment is deteriorating and (4) the natural view of the wetland is seriously compromised. In recent years the citizens of Dali have recognized the seriousness of the problem. They have begun to eliminate the human interference, lowered the pollution loads entering the lake and implemented environment protection as well as carrying out dredging and ecosystem restoration of the wetland along the lakeside.

While introducing methods of ecosystem restoration, its technologies and the effects on the wetland along the lakeside, this paper also discusses issues such as (1) How to have reasonable orientation and be able to restore the natural ecosystem of the wetland (2) How to combine the local social economy and tourism spots (3) Achieving a reasonable handling of the relationship between the utilization and protection with the consideration for farmer's benefits and (4) Fulfilling the organic unification of wetland maintenance with economic development.

Key words: Erhai Lake, Lakeside Wetland, Ecosystem Restoration

INTRODUCTION

Lakeside Wetland & Its Function

A lakeside wetland is an important ecological “crossover” between the water and land ecosystems of the lake. It forms an important part of any lake ecosystem. It is the necessary organic part of a perfect lake ecosystem. The mineral matter and nutrient substance as well as organic matter and toxic substance can flow into the lake water body from the watershed through lakeside wetlands after various physical and chemical as well as biological processes. Therefore, to a certain extent, the lakeside wetland is a protection barrier for the lake. As there is interaction among the different ecosystems, the lakeside wetland is comprised of especially rich flora and fauna. The function mainly expresses as energy flow and substance flow adjustment in the “crossover” and variation or stability in the landscape and nutrition flow through the lakeside wetland as well as energy flow expressed in carbon organic substances. As well as having an effect on the adjacent ecosystems the functions of lakeside wetlands are mainly expressed as: environmental function, ecologic function and both economic and aesthetic value.

The environmental function of the lakeside wetland includes the interception and filtration of contaminants and nutrient conversion as well as toxic substance removal, water quality improvement and settling and abrasion control functions.

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The ecologic function includes the provision of high biological diversity in the lake wetland and is the location where fish reproduction occurs and bird habitat exists. The lake wetland can also supplement underground water systems, adjust the runoff, control flooding and stabilize adjacent ecosystems.

The economic and aesthetic values of the lake wetland provide renewable resources associated with production and environment improvements for human beings. The lake wetland can also bring human beings unique entertainment and aesthetic experiences as well as educational and scientific research values.

Erhai Watershed Issues and the Main Problems of the Lake Wetland

Geographic Position

Erhai Lake (Figure 1) is located in the Dali Bai Nationality Autonomous Prefecture in the west of Yunnan Province. The area of the lake is about 250km².

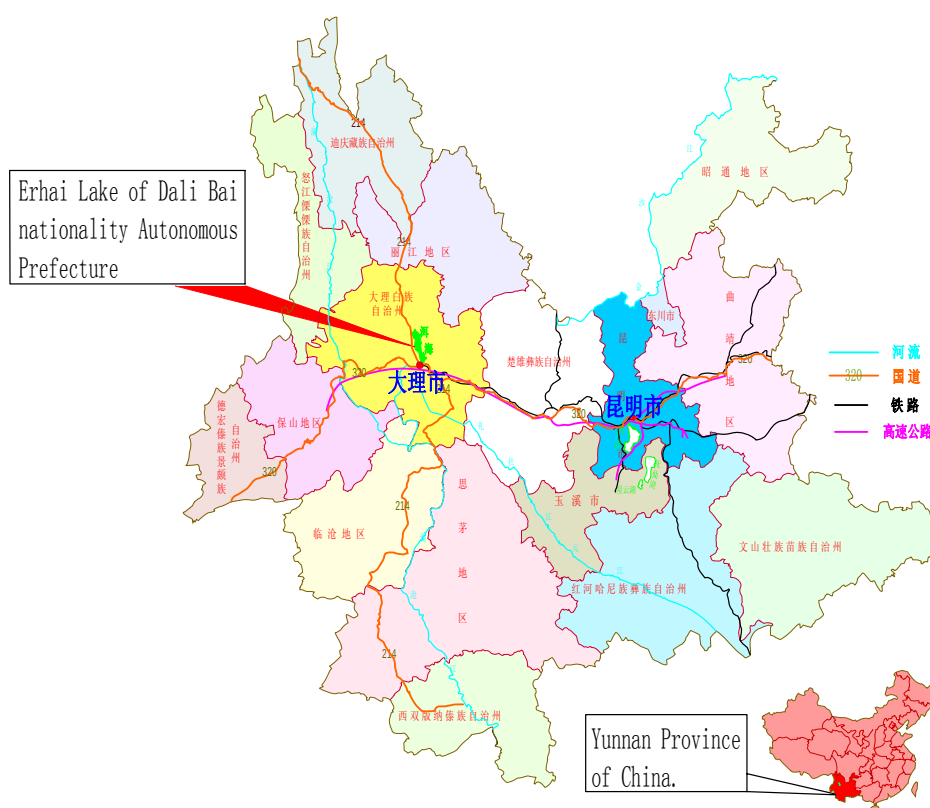


Figure 1. Location of Erhai Lake.

Natural Environment Summary

The south-north length of Erhai Lake is 42.5km and the average width is 6.3km. The average water depth is 11.8m.

The Erhai Lake is at an altitude of about 2000m and belongs to the North-Asia tropical plateau monsoon climate with obvious dry and humid seasons. The dominant prevailing wind direction in the lake zone is southwesterly throughout the whole year.

The Erhai watershed belongs to the Lancang River drainage system. The Miju, Yongan, and Luoshi Rivers together with 18 Rivulets from Cangsang Mountain are part of this drainage system. The water-level control of Erhai lake is kept at 1971.0m to 1974.2m annually (elevation system: coastal defense elevation, same as below).

The soil texture of Erhai lake wetland is typically classed as gritty. The blanket soil at the elevation of about 1974m is typically paddy soil with corresponding soil fertility.

The poplar and osier are the dominant terrestrial plants in the Erhai Lake wetland. There are also a few spruce, eucalyptus and alpine banyans. The aquatic vegetation in Erhai includes emerging plants, floating leaf and submerged plants. In total there are 61 kinds of aquatic vegetation in 44 families and 26 species.

Social & Economic Summary

The Erhai watershed includes Dali City and Eryuan County with 18 villages and towns. The total population in this watershed is 737 000 persons.

The main industry of the Erhai watershed is Tourism.

Dali is one of the first batch of national-level historical and cultural city and scenic areas defined and published by the Chinese government. The specific historic culture and natural landscape, the national regime and fables from the Cangshan Mountain and Erhai as well as the Bai nationality have become an inseparable part of Dali.

Main Issues Relating to Lakeside Wetland

The serious “nibbling away” of the foreshore by building on the lake wetland

The foreshore is an important part of Erhai lake wetland and it plays an important role in the protection of the lake ecosystem. The physical basis on which the natural lake wetland relies is destroyed when many parts of the foreshore are occupied.

Serious non-point source pollution

Runoff from the farmlands and sewage from the villages as well as piscine (fish pond) activities around the lake are the main sources of non-point source pollution.

Serious destruction of the ecological structure and deterioration in the lake wetland

The ecological structure of the natural community in the Erhai lake wetland has been seriously destroyed. The loss of the complete and continuous ecological succession from aquatic vegetation to terrestrial plant vegetation has occurred. The biological diversity is reduced and the function of the lake wetland as a storage basin for nutrients and a buffering belt for substance and energy flow is also weakened. This further aggravates the deterioration of water quality and causes lake eutrophication.

Effects on tourism

There is still a lot of tourism based on the regional scenery but the natural landscape of lake wetland. The Dali region has unique tourism relating to the natural and human related scenery resources. Because of insufficient recognition of the need for the protection and management of the lake wetland, the natural scenery has been destroyed and the aesthetic and ornamental values also reduced.

Right now, Dali has recognized the severity of above issues and started to execute ecosystem restoration for the lake wetland areas.

Ecosystem Restoration Targets and Functions Focusing of the Lake Wetland

Ecosystem Restoration Target for the Lake Wetland

The ecosystem restoration of the lake wetland actually coordinates the need for a relationship between human beings and nature is to value both human society and the natural environment. The ecosystem restoration of the lake

wetland is designed to eliminate human interference and reduce the load of contaminants flowing into the lake. As well, it is designed to re-establish and complete the structure of the ecosystems of the transition zone and maintain the ecological environment of the lake wetland including the association of plants and animals residing in the lake wetland. Also required is the need to keep the functional diversity of the lake wetland as high as possible.

The targets are listed below:

(1) Eliminate human interference and various types of unreasonable occupation of the lake wetland and to recover the physical basis for the Erhai Lake.

(2) Establish the healthy ecologic structure of the lake wetland and to recover the ecosystem to its normal benign circulation status from the out-of-step bad conditions so that the ecosystems can regain their regular functions.

(3) Restore the interception and filtration as well as contaminant purification functions of the lake wetland. Reduce the containment load from surface sources and the amount of contaminant flowing into the lake thereby improving the water quality of Erhai Lake

(4) Restore the beauty of the lake wetland.

Function Focusing for the Lake Wetland

Firstly, restore the ecological function of the lake wetland area. Under this premise, take into account increasing tourism and viewing of the lake scenery so as to properly develop the economic benefits of the lake wetland area. As well, compensate for any loss during the period when the farmland and fish stocks are affected before they are returned back after wetland maintenance and ecosystem restoration. The long-term operating expense of the engineering can be independent from this process as far as possible. The main function therefore focuses on the following:

- The natural structures under certain nutrition levels which have existed in recent history are used as the template for restoration. The biological structure and the associated species with high economic values and special usage have strong adaptability and good ecological benefits. They must form the natural structure which not only makes it easy for restoration but matches natural succession trends.
- Improve the inshore water quality of the lake
- Increase the ecological diversity and harmony of the area
- Provide a location for fish breeding areas and bird habitat. Improve the passage of substance flows between aquatic and terrestrial ecosystems and the passage of water utilized by human beings to enable the system to meet ecological requirements:
- Plan the lake wetland scenery in with the background of Cangshan Mountain and Erhai to tightly combine the ecosystem restoration with scenery restoration and sufficiently develop the aesthetic value of the lake wetland. Also to assist Dali to continuously develop as an ecologically based tourism city.

Construction Project Plan

Humans take some time to recognize the nature and the importance of any ecosystem. Therefore, the ecosystem restoration of the lake wetland in Erhai must proceed in an orderly way, step by step:

The total length of the lake wetland shoreline around Erhai Lake is 128km. The west bank length is 48km and east bank length is 80km. During the ecosystem restoration, a 2km length to test engineering methods will be firstly started on the west bank. A 10km ecosystem restoration project in the phase-I engineering at west bank will then be executed on the basis of the experience and results gained from this test section of engineering after it has been analyzed. After the phase-I engineering is successful, the remaining 36km ecosystem restoration in the phase-II engineering project along the west bank of lake will be carried out. Finally, the 80 km ecosystem restoration along east bank is to be carried out. At the same time, the restored lake at west bank is to be maintained and controlled in order to develop, on a small scale, the effect on the total 128km of wetland.

Ideas and Principles of Lake Wetland Structure & Restoration

Ideas for Lake Wetland Structure & Restoration

The thinking behind the lake wetland structure and restoration in Erhai Lake is shown in the Figure 2.

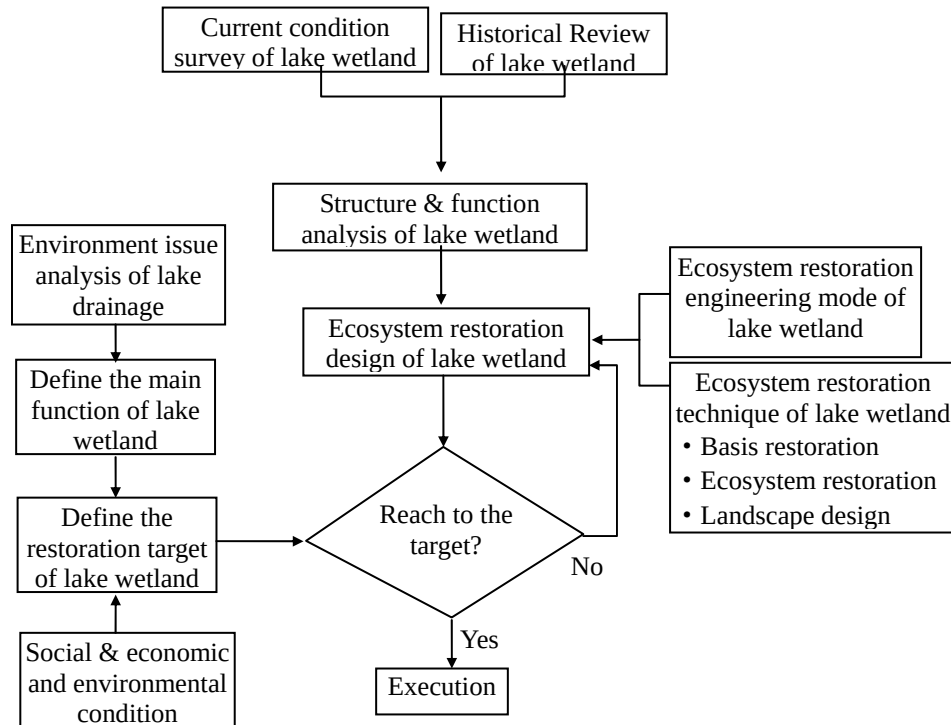


Figure 2. Thoughts on the lake wetland structure & restoration at Erhai.

Structure of Lakeside Wetland

The complete sere structure of the lake wetland within the water level amplitude strip of Erhai mainly includes from the land to water areas the arbor protection, shrub hygrophYTE, emergent vegetation, floating leaf, and submerged plant zones (Figure 3). After investigation it was found that the wetlands with above complete structures are now distributed only on the wide lake foreland where there has been little human interference throughout its history. The complete lake wetland structure cannot be restored along some bank sections due to restrictions from the terrain, substrate or hydrological conditions. Normally, it is the emergent vegetation zone that has been lost, hence forming an incomplete sere.

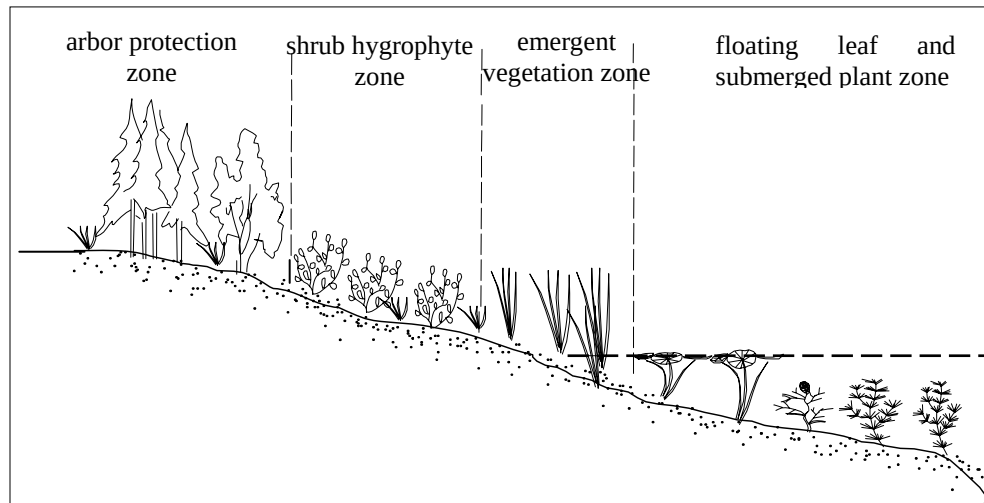


Figure 3. Schematic structure diagram of the lake wetland for the complete sere of Erhai Lake.

Restoration Principle

The basic principles of lake wetland ecosystem restoration

(1) Plant restoration

The restoration of stable and healthy plant communities is the basis for the balance in the lake ecosystem restoration. Therefore, plants are the first things to be re-introduced in the lake wetland ecosystem restoration program.

(2) Adaptation to local conditions

Any plant community restoration system must be suitable for the regional conditions. It should be noted that human demands must also be considered.

(3) Natural restoration is dominant with human measures being secondary

Too much human interference was the main reason why the original lake wetland was destroyed. Therefore, any human interference should be eliminated and the contaminants flowing into the lake reduced. Conditions for natural restoration of the lake wetland should also be created. The human restoration measures are only the auxiliary means of achieving the restoration.

Staging, Zoning Plans and Execution

Ecosystem Staging for the Restoration of Lake Wetland

Stage 1, Core zone

This is the zone located along the water's edge. It has high sensitivity ecologically and it is easily interfered with by humans. Being the core zone of the lake wetland interference needs to be eliminated in order to restore the natural features.

Stage 2, Protection zone

The lake wetland is the last protective barrier to any healthy lake ecosystem. For various pollutants entering into the lake it is the last measure of protection. Therefore, it is necessary to take protective measures for both the land and water areas either side of the core zone. For example, the inshore land area can be used as the protection zone for the lake wetland. However, limited development and utilization based on the protection of the lake wetland is better.

The local community impacts and pollution into the lake should be limited.

Stage 3, Development zone

The offshore zone can be used as the development zone of the lake wetland. Development and utilization can happen on the condition that the self sustaining ecosystem is maintained so as to prevent the production of pollution that is likely to drain from the protection and core zones of the lake wetland.

Subdivision of the Lake Wetland Ecosystem Restoration

Before ecosystem restoration, there are a great variety of activities in the lake zone background to be considered such as adjacent villages, piscina (fish farms), farmland, etc. It is necessary therefore, to comprehensively analyze the issues relating to factors such as terrain, utilization of the area, pollution and the condition of the vegetation in different sections of the lake zones. For each of the subdivisions different restoration plans and technologies need to be taken. For example, the wide farmland and foreland will be restored as a complete sere or ecological succession of the lake wetland. The adjacent villages restrict some of the development. They will need to be gradually moved and their domestic sewage treated. The different vegetation types are arranged in the piscina combining with the scenery and economic requirements.

Physical Basis of Renovation

The physical base is the carrier for any ecosystem development and existence. The basis for renovation mainly proceeds according to the requirements of the ecosystem restoration. It includes the terrain and geomorphologic restoration and renovation as well as the maintenance of basic stability in the systems. At the same time, the toxic and harmful pollution substances need to be reduced and a suitable or stable growth environment will then be created. For lake wetlands, the environment-protection dredging and basic protection are the main basis of renovation measures.

Environment-protection Dredging

Any wastewater running into the lake and sand brought in from runoff as well as other contaminants, dead organisms, and suspended substances in the lake combine to form polluted sludge. The nutrients in the bottom sludge will be slowly released and can cause eutrophication in the lake. Therefore, it is necessary to deal with the contaminants by removing the seriously polluted bottom sludge. Environment-protection dredging is one of most direct and quickest means of removing the polluted bottom sludge. However, simply dredging the lake will not completely solve the environment issues for the water body. Generally, the purpose of environmental protection dredging is to remove the contaminants in the lake. It mainly uses methods for taking out the polluted bottom sludge from the lake and moving it to the designated safety zone. Special attention needs to be paid to dredging accuracy, any diffusion of material during the dredging process, leakage during the transportation process and secondary pollution at the storage location.

Environment-protection dredging needs to be combined with the requirements of the ecosystem restoration. Not only do we need to look at the characteristics of the environmental protection dredging that involves removal of contaminants in the lake but also, at the same time, the creation of the conditions for ecosystem restoration. Improvement to the regional water environment can be realized through a tight combination of these. Therefore, the dredging should proceed in association with any ecosystem restoration plan.

Firstly a survey on the ecology and environment should be carried out. This should be done according to the conditions of the river and lake in order to get knowledge of the historic ecological and environmental situation of the Erhai. Also information is required on the succession of the vegetation including what species were advantageous at different historic stages and why a succession of advantageous species happened. Secondly, an analysis of the current ecology and environment of Erhai and what ecosystems and vegetation communities can be restored for the creation of long lasting stable ecosystems needs to be done. Thirdly, a proper ecological restoration plan should be made, including:

- Which aquatic vegetation, such as floating vegetation, emerging vegetation and hygrophytes should be restored;
- Which zones should have the different plants assigned to them;
- At what scale should the various plants be restored;
- How various vegetation communities should be arranged and matched.

It is known that suitable conditions are needed for the growth of plants and that different plants need different living conditions. The major environmental factors that control the growth of aquatic vegetation includes: water temperature, illumination, pH levels, content of nutrition salts in the water, bed conditions etc.

The conditions to be created necessary for restoring aquatic vegetation include:

- Control of blue algae;
- Control of wind and waves;
- Creation of shoal environments along banks;
- Removal of polluted bed sediments;
- Adjustment and control of water depth;
- Update of water quality.

Finally, based on the determined ecological restoration plan, we need to know which conditions will be or can be provided through dredging, and which shall be achieved through other measures that also need to be analyzed. In general, dredging can assist in creating the following conditions:

Proper water depth

A healthy and stable ecosystem is composed of various life-forms. Different aquatic plants need different water depths. On the one hand, specific vegetation has specific water conditions in order to survive. Water too deep or too shallow may affect normal and healthy growth. On the other hand increasing water depth affects illumination at the bottom. Weak or strong illumination may not be appropriate for the vegetation in question.

Dredging can be selectively arranged. If a shallower water depth is necessary, the polluted sediment layer may not be removed completely. However areas can be back filled to obtain suitable water depth for vegetation growth and in some cases a thin layer of the nutrient rich “polluted” material may provide some nutrition to the plants, at least in their initial growing stages. If deeper water depths are necessary, more excavation can be appropriately done provided that the soil below is suitable for vegetation growth.

Proper soil condition

The polluted bed sediment layer normally has a high water content and is mostly made up of fine grained material. It is usually extremely soft and has high levels of nitrogen, phosphorous, and organic substances. Such soil has some shortcomings such as:

which is not suitable for vegetation growth. The reason for turbid conditions is the presence of floccules and suspended substances in the water. Much of this is kept suspended in water separated from polluted bed sediments by waves and currents. They seldom settle down to the bottom due mainly to continuous wave and current action. The main sources of polluted floccules in Erhai need be cut off through the removal of them close to the river or lake bed in association with the polluted bed sediments. This should improve water quality and illumination in the water and create conditions for the growth of submerged plants. However, regular environmental dredging mainly focuses on removing polluted bed sediments and generally does not adopt special measures for removing floccules together with any other suspended substances. Special dredging techniques are necessary for this.

Finally, after completing the above analysis, fundamental environmental dredging can be implemented and the restoration of the local ecology can be carried out.

Basic Protection Measures for Shorelines

Without any protection the stability of the banks will generally be lost under strong wind, wave and water flow action. The stability of the ecosystems will be affected as well. For the protection of waterside foreshores the community generally prefers the use of stone walls or reinforced concrete. These materials cannot normally be used in the surrounding environment as they may cause break up and damage to the natural ecosystems and to the scenery in the area.

There is a need for the foreshore to be suitable for a continuous sere in order for the lake wetland ecosystems to be restored and created. There is a need for smooth gradation of the shoreline along with “natural picturesque disorder”. It is an advantage for restoration to be undertaken using ecosystems with high diversity. Therefore, the uniformity cannot be pursued as a basis for protection. The adaptation of local conditions and locally-produced raw materials should be used. When the ecosystem of the lake wetland in Erhai is restored there are two main protection measures to be taken for basis protection.

The wetland vegetation will be reaped and trimmed periodically after growth has been allowed for a certain period. The reaped vegetation, such as reeds and wicker, is a protection material taken from nature and can be formed manually into brush mattresses. This process is not harmful to the ecological environment. The brush mattress can cover the foreshore to a suitable height so that protection can be effectively realized.

Fish returning after the lake maintenance will need a lot of stone and earth habitat. All of this will occur outside and within the roots of the vegetation and help to reduce the wave and water flow action. Some level of protection can be reached using simple earthwork protection structures in a scattered arrangement. These will collapse gradually due to long-term water flow action and waves so that they will eventually come to be in harmony with the surrounding lake beaches.

Additionally, some wave-proof vegetation should be consciously arranged when undertaking the above two measures so that mutual protection between vegetation and banks can be achieved.

Engineering Measure Relating to the General Effect of Wetland Ecosystem Restoration

The final purpose of lake wetland ecosystem restoration is to improve the water quality and ecological environment of Erhai. Therefore, the ecosystem restoration must be used comprehensively together with every measure for environmental water treatment in order to develop an optimal effect. The village sewage systems and the treatment of contaminants running into the lake are two important aspects.

Village Sewage Treatment

A lot of villages are distributed around and within the Erhai lake zone. Due to restrictions in the local economy and engineering conditions, the sewage systems in the village cannot be intercepted and diverted into the sewage treatment plant for treatment. Sewage can only be directly drained into the Erhai. The village sewage treatment technology has a low level of investment and has simple operational management. However in order to help with the promotion of ecosystem restoration significant efforts need to be made to solve the issues with village sewage in the Erhai watershed.

When the ecosystem in the Erhai lake wetland is restored, a great variety of biologic technologies can be used to treat the domestic sewage. These include artificial wetlands, gravel stratum and soil penetration and separation treatment. A good effect from these can be obtained. As these technologies are carried out successfully local governments and residents can also master these technologies and might have the economic power to gradually promote them further.

Control of River Pollution into the Lake

The rivers running into the lake are like a “tree-like” extension of the lake aquatic ecosystem into the terrestrial ecosystem. These are also the main passage of land-sourced pollutants into the lake. The pollutant sources, including town drainage and upstream runoff and eroded soil, flow into the Erhai. Generally, much of the pollutant load settles in the estuary and downstream sections of the river.

However, the river water at present directly drains into the Erhai. The contaminants associated with this water can create a big impact on the water quality and ecosystems of Erhai. When the ecosystem of lake wetland is restored in Erhai, the river course is to be dredged so that the runoff peak is delayed thus avoiding the concentrated contaminant peak experienced during the initial phase of any rainstorm. Also the water volume entering the lake will be distributed step by step throughout the wide wetland near the estuary and gradually, through this purification measure in estuary, run into lake. The purification function of wetland is to be developed sufficiently well so that the impact on the lake is significantly reduced.

8. Enhancement of Wetland Maintenance, Management and Environmental Consideration

The ecosystem restoration needs long-term effective management and compliance with the environmental protection laws and regulations. There is a need to publicize the importance of ecological environments and prohibit any behavior destroying the environment. Everyone must act to protect the environment, especially the ecosystem maintenance, as any restoration carried out only gradually becomes a healthy system after long-term tending and maintenance. It is impossible to achieve success by planting vegetation for only one or two years.

Guarantee of Farmer Benefits

The local farmers can develop the farmland or piscina but are not allowed to occupy the legal wetland protection zone. However, they can still obtain an economic benefit and the farmland or piscina can continue to play an important role in their rich living.

The farmer's benefit during the ecosystem restoration of Erhai lake wetland will be guaranteed from the following two aspects:

Farmers will be directly invited to participate in the ecosystem restoration and the farmer will be paid in line with the working results achieved.

Maintenance work will be distributed to any person who is willing to undertake this activity and periodically do maintenance checks. The person would be paid in line with the working results achieved. Some economic plants that are good for the ecological environment and scenery can be arranged in the wetland so that the farmer can get the profit from both the planting and harvesting.

These above measures deal with the relationship between utilization and protection.

Propaganda & Education

Based on above-mentioned works, Dali also has a fruitful effect by using propaganda and education aspects in relation to Erhai. Local residents provided the slogan “Protect Erhai as you protect the eyes”. The local population gradually recognizes the significant effect on the local economy and living conditions due to the ecological environment work. After continuous and effective propaganda and education, the environment-protection consciousness gets stronger and stronger and the local population actively participates in the environment renovation

and ecosystem restoration. The mutual promotion between human beings and the environment is being expressed as human beings realize environment protection is “heavy and the road is long with many responsibilities”. This work will certainly promote good feelings and gradually promote the ecological environment and make it better than before

CONCLUSIONS

The lakeside wetland is an important ecological “crossover” between the water and land ecosystems of the lake and it is a protection barrier for lake to a certain extent. The ecological environment of Erhai lake wetland has been seriously destroyed because of human interference.

We have grasped the structure of the lake wetland after investigation and analysis of its history, current condition, as well as its restoration condition. We have also put forward the principle of eliminating human interference and pollution loads into the lake. Also, the advantages of creating good conditions along with auxiliary manual measures to help promote natural restoration of the lake wetland have been recognized. When starting the restoration work, we locate the lake wetland at its proper level and undertake grading and subdivision restoration. Management includes comprehensive repair measures, and considers the use of environment-protection dredging, combined with ecosystem restoration as a way of adapting to local conditions. Therefore, a good effect can be obtained from ecosystem restoration at the Erhai lake wetland. At same time, the strengthening of environment-protection consciousness and guarantees of vital interest to farmers also becomes a possibility when considering long-term stability and maintenance for the Erhai lake wetland.

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