Poyang Lake basin: a successful, large-scale integrated basin management model for developing countries

Meiqiu Chen, Xiaohua Wei, Hongsheng Huang and Tiangui Lü

ABSTRACT

Protection of water environment while developing socio-economy is a challenging task for lake regions of many developing countries. Poyang Lake is the largest fresh water lake in China, with its total drainage area of 160,000 km^2. In spite of rapid development of socio-economy in Poyang Lake region in the past several decades, water in Poyang Lake is of good quality and is known as the "last pot of clear water" of the Yangtze River Basin in China. In this paper, the reasons of "last pot of clear water" of Poyang Lake were analysed to demonstrate how economic development and environmental protection can be coordinated. There are three main reasons for contributing to this coordinated development: 1) the unique geomorphologic features of Poyang Lake and the short water residence time; 2) the matching of the basin physical boundary with the administrative boundary; and 3) the implementation of "Mountain-River-Lake Program" (MRL), with the ecosystem concept of "mountain as source, river as connection flow, and lake as storage". In addition, a series of actions have been taken to coordinate development, utilisation, management and protection in the Poyang Lake basin. Our key experiences are: considering all basin components when focusing on lake environment protection is a guiding principle; raising the living standard of people through implementation of various eco-economic projects or models in the basin is the most important strategy; preventing soil and water erosion is critical for protecting water sources; and establishing an effective governance mechanism for basin management is essential. This successful, large-scale basin management model can be extended to any basin or lake regions of developing countries where both environmental protection and economic development are needed and coordinated.

Key words | integrated basin management, Poyang Lake, protection of water environment, successful model

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INTRODUCTION

Resolving the conflicts between economic development and environment protection is a challenging task that we often have to face in the long history of human development. Lake regions have their unique ecological features, and water is vital to the environment protection and economic well-being. However, social economic development can affect water resource in various ways. For example, regional land-use changes, particularly the changes of vegetation, can directly influence the watershed hydrological processes, river morphologies, nutrient cyclings, sediment loading levels etc. Industrial development and agricultural productions can be the major factors causing point- and non-point source pollution, which leads to deterioration of water quality.

In the past, many lake regions or basins generally followed the path of "pollute first and clean up later". This path is costly and some resultant environmental problems are even irreversible, such as species extinction and permanent habitat lost. Lake Biwa of Japan is such a typical case (Japan can be

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viewed as a developing nation around the 1960s). As the Japanese economy took off in the 1960s, the wastewater released from industrial plants and residence areas surrounding the lake resulted in decrease of lake water quality. By the end of 1970s, water quality deteriorated sharply, and the lake eutrophication generated a serious red tide phenomenon. In order to deal with the Lake Biwa pollution, the Japanese government launched "Lake Biwa River Basin Comprehensive Development Project" with a total of 375.34 billion US dollars, or 560 million US dollars every km^2. And it took 35 years for water quality to be recovered (Fu *et al*. 2009). This example clearly shows the tremendous cost of the "pollution first, clean up later" approach. Another example is Taihu Lake in China (Mao *et al*. 2009; Qian & He 2009). Since the 1980s, the township industries have developed very fast in the surrounding areas of Taihu Lake. Such a rapid development has caused all kinds of damage to Taihu Lake environment. The vast blue-green algae exploded in a large area of Taihu Lake in 1990, which led to the water supply systems being shut off for half a month in Wuxi city. In August of 2006, another blue-green algae explosion occurred over the entire Taihu Lake, and consequently led to water being undrinkable for an extended period. According to the Environmental Quality Evaluation Standards for Surface Water (Ministry of Environmental Protection 2002), 7.4% of water in Taihu Lake was classified as Grade IV, 27.2% as Grade V, and 65.4% below Grade V in 2008 (according to Chinese Water Quality Classification System, Grade I is the best while Grade V is the worst). For many years, the Chinese government has invested significant resources to restore the Taihu environment, but the restoration efforts have not generated satisfactory results. The water quality in Taihu Lake still remains poor, and many other water related environmental issues (e.g., habitat loss, species extinction) are still severe.

The above two examples clearly highlight a critical question to many lake regions or basins in developing countries: how to coordinate social-economic development with environmental protection? If the path of "pollution first, clean up late" is not appropriate to developing countries, are there any other alternative paths?

A SUCCESSFUL BASIN-WIDE MANAGEMENT MODEL

Poyang lake: a unique basin ecosystem

Located in the north part of Jiangxi Province, China and on the south bank of the middle-lower reaches of Yangtze River, Poyang Lake is China's largest freshwater lake. It receives water from Ganjiang River, Fuhe River, Xinjiang River, Raohe River and Xiuhe River, which then flows into Yangtze River, China's largest river (Figure 1). The total water input into Yangtze River exceeds that of Yellow River, Huaihe River and Haihe River combined. The annual average runoff is 152.5 billion cubic metres, about 16.3% of the annual runoff of the Yangtze River. It plays an important role in maintaining drinking water supply and flood control for the middle-lower reaches of the Yangtze River, and it provides critical aquatic habitat and wetlands for various species.

As one of the five largest freshwater lakes in China, Poyang Lake is the only one which has never experienced eutrophication problems. Because of this, Poyang Lake is called the "last pot of clear water". According to the Water Conservation Report of Jiangxi Province, water with the Grade III category accounts for 82.1%, and water below Grade III accounts for 17.9% in Poyang Lake. In addition, Poyang Lake still provides a habitat for many world major migratory birds. From late autumn to early winter (November) every year, thousands of migratory birds fly from Siberian region of Russia, Mongolia, Japan, North Korea and Northwestern and Northwestern China to Poyang Lake for over-wintering. Currently, there are more than a million birds of over 300 bird species in the designated conservation area of Poyang Lake, of which over 20 species are rare birds. The largest white crane flock is found here, and more than 4,000 white-nape cranes, white-headed cranes and grey cranes live here, and their population accounts for 95% of the total white cranes. As a result, Poyang Lake was known as "a world of white crane" or "kingdom of rare birds" (Wang & Ye 2007). In short, Poyang Lake has become one of the largest bird conservation areas in the world.

There are two unique basin characteristics in the Poyang Lake ecosystem. Firstly, Poyang Lake has unique geomorphologic features, and its water residence time is short. Poyang Lake is a kind of flushing lake with dramatic seasonal water level changes. The renewal period of lake water is particularly short (the period of water renewal is just 59 days) (Cheng & Li 2006), and consequently, the eutrophication process is not easily established. The water levels range from 9.79 metres to 15.36 metres, with the maximum water level of 16.69 metres. In late spring and early summer, the water level dramatically increases and consequently the lake water surface incrementally expands. However, in the winter the water level drops sharply, exposing the beaches and making the Lake look like networking of several winding water channels. Under low water level conditions, the luxuriant aquatic plants and fishes as well as shrimps etc. are good food sources for migratory birds in winter. Therefore, it

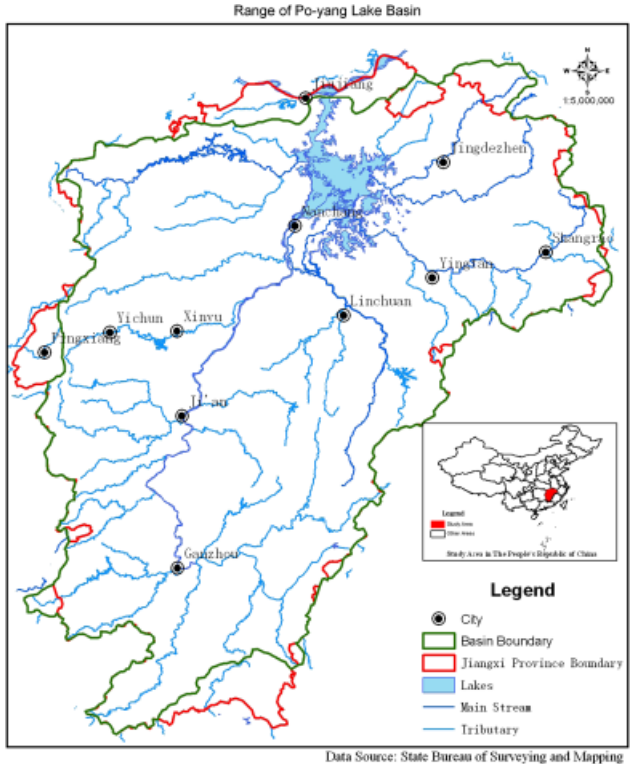

Figure 1 | The Poyang Lake Basin: fully matching between administrative and basin physical boundaries

becomes the paradise for migratory birds during low flow seasons.

Secondly, the matching of the Poyang Lake Basin physical boundary with the provincial administrative boundary enables effective management of the entire Poyang Lake region. The Poyang Lake basin covers an area of 162,000 km^2, accounting for 97% of total area of Jiangxi province (China Nature Resource Series Editor Committee 1995; Wang & Li 2008) (Figure 1). The highly matched boundaries of the natural river basin and administrative entity are very beneficial to execution of the administrative functions in order to deal with the conflicts between economic development and ecological protection within the basin. The comprehensive arrangement through industrial distribution or functional zoning can be effectively coordinated to minimise negative environmental effects while developing economy.

Implementation of ''Mountain-River-Lake Program'' (MRL)

In the early 1980s, the water and soil erosion problems in Jiangxi province were very grave. In the mountain areas of Southern Jiangxi the annual sediment loss reached 53.35 million tons from a total of 1.10 million hectares, which accounted for over 35% of the total mountain area. The severe water and soil erosion caused frequent drought and flooding disasters, and sediments overloaded the Poyang Lake. Since the 1980s, Poyang Lake region has experienced a rapid development. For example, two major cities, Nanchang and Jiujiang, are located nearby Poyang Lake. From 1978 to 2007, Nanchang's annual average GDP growth was 12.5% (Jiangxi Provincial Statistics Bureau 2008), while Jiujiang's was 11.3%. Both exceeded the nationwide average of 9.9% (Zhang 2009). In spite of rapid economic development and severe environmental problems in the early 1980s, water quality in the Poyang Lake remains stable and good as compared with many other lakes in China. This is mainly due to implementation of the basin-wide MRL Program.

The implementation of the MRL Program started in the early 1980s, with the ecosystem concept of "mountain as source, river as connection flow, and lake as storage". In this ecosystem concept, mountain, river and lake are considered as an indispensable entity. The systemic management idea of "better management of lakes requires better management of rivers, and better management of rivers needs better management of mountains; and finally better management of mountain requires better control of poverty" was adopted. In addition, a series of systemic, coordinated and comprehensive actions have been taken to coordinate development, utilisation, management and protection in the Poyang Lake basin (Wang *et al.* 2006).

Since implementation of the MRL Program 20 years ago, remarkable results have been achieved: from 1985 to 2008, 5.5 million people were pulled out of poverty in Jiangxi Province; the water and soil erosion area dropped from 3.3 million hectares to 1.3 million hectares; non-forested mountains were generally eliminated, and the forest coverage was changed from 31.5% to 60.1%; the total sediment input from the "Five Major Tributary Rivers" (Ganjiang River, Wuhe River, Xinjiang River, Raohe River and Xiuhe River) to Poyang Lake fell from 20 million tons to 8 million tons annually. The "barren mountain, infertile soil and poor people" commonly featured mountain villages in the basin were now turned into "green mountain, fresh water and rich people" villages (Wang 2009). The following are the key actions in the MRL program.

Legitimisation of the Jiangxi Provincial Mountain-River-Lake Development and Strategic Planning

Based on the comprehensive scientific investigation and macroscopic strategic research of the basin's resources and

environment, together with application of the ecosystem concept and principles, the Jiangxi Provincial Mountain-River-Lake Development and Strategic Planning (Outline) was formulated and legitimised in 1992. This enforcement mechanism guides and coordinates development and protection activities in every region of the basin. With this legal mechanism, the Province further empowers its governance capacity through establishment of the Jiangxi Mountain, River and Lake Integrated Management Office to oversee the basin-wide conservation, development and management. A high-level committee composed of heads of different provincial departments was also constituted in the same year. Such a committee plays a critical role in providing guidance and coordination at strategic levels.

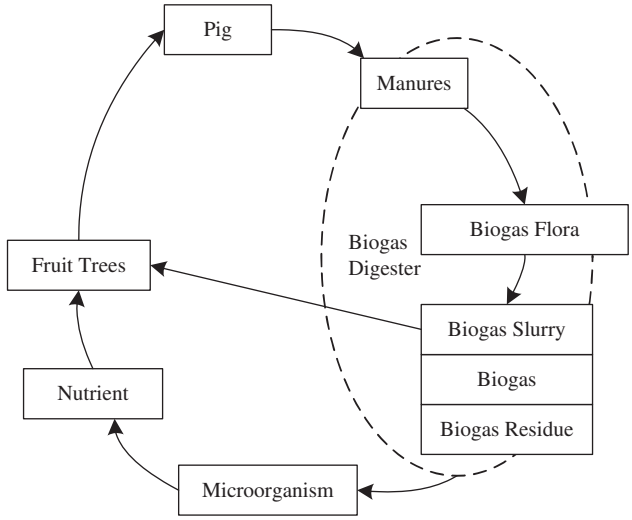

Figure 2 | The "Pig-Biogas-Fruit Trees" Eco-Agricultural System

Establishment of a series of eco-economic demonstration models

The MRL Program has set up 10 types of experimental demonstration bases, hundreds of promotion stations, 112 agricultural comprehensive development bases and six small river basin management models in major regions. The representative models include: small river basin comprehensive development and management models; vertical development model in red soil hilly regions; mountain ecological forest management and development model; integral agro-forestry ecological economic model in paddy fields of Southern China; large water surface comprehensive development model; pest control (Schistosomiasis) and poverty control model; windy and sandy soil development and management model; forest-grass-pigs-marsh-fruit eco-economic circling model; small credit poverty-alleviating model; and lake region industry substitution development model. These successful models provide powerful means to show local people how to achieve economic development while minimising negative environment effects (Wang & Chen 1998; Hu & Hu 2006).

For example, the "Pig-Biogas-Fruit Trees" model (as shown in Figure 2) uses manure from pigs to generate biogas as fuel for energy consumption of households. The residuals of biogas systems can be used as fertiliser for fruit trees or vegetation, which are food sources to pigs. The key components include constructing one biogas unit (about 6–8 m^3 in size) per household, raising two pigs per capital, growing 0.25 ha fruit orchard per capital and covering exposed, eroded soil with fast growing grass if any.

The "Pig-Biogas-Fruit Trees" model provides significant, positive environmental-economic benefits. To illustrate the benefits, we used the Ganzhou City, Jiangxi Province as an example. The city constructed a total of 300,000 biogas units. Implementation of those units has generated significant benefits. For example, they have greatly reduced energy consumption (equivalent to 9,700,000 tons coal per year), grown 1,200,000 pigs per year, and reduced usage of chemical fertilisers (saving 3,000 Chinese dollars per ha per year on fertiliser). The total economic benefit is about 3.0 billion Chinese dollars per year (or 0.4 billion US dollars). In addition, the model provided significant ecological benefit. It protected about 93,000 ha of forestland from human disturbance, reduced 1.4 million ha area of soil erosion, and increased forest cover rates from 43.6% in 1984 to 68.6% in 1997. This model clearly shows how economic development (production of pigs) and environmental conservation (utilisation of pig manure and growing vegetation) can be coordinated. The model is very effective to promote economic development while minimising negative environmental impacts in under-developed regions (Hu & Hu 2006).

Another example is a more complicated model, but with a similar concept or principle, as shown in Figure 3. The model is specially designed for the red-soil, hilly region where both environmental and economic problems are severe. Red soil is common and accounts for 70% of the Poyang Basin. The soil is vulnerable to human disturbance and has potential for severe soil erosion. The critical concept is to grow commercial or fruit trees and grasses, which can provide short-term economic benefit as well as protect soil from erosion. Their byproducts such as leaves, branches, dead woody debris etc. can then be utilised for growing pigs or mushrooms or being used as fuel or fertiliser. By doing this, long-term and short-term benefits for both environment and economy are coordinated and balanced. There are many variations to this general

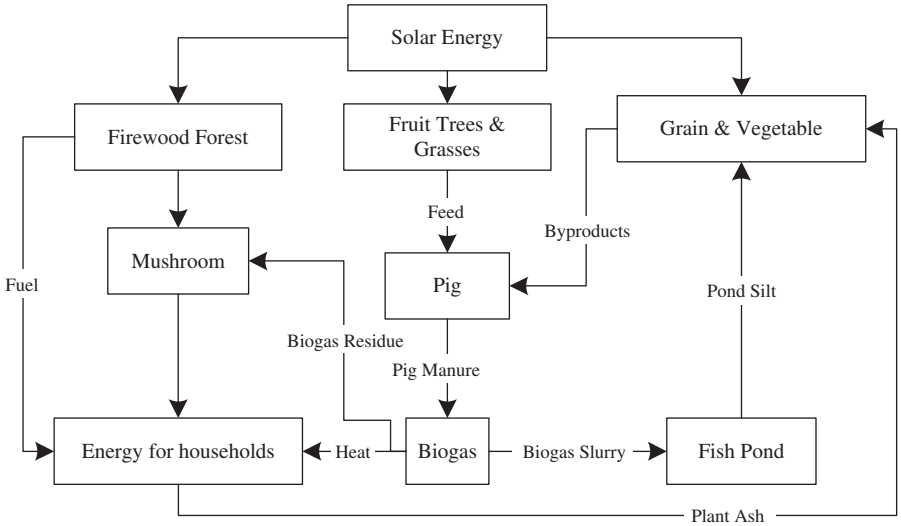

Figure 3 | Vertical Development Model in Red soil Hilly Regions

model. Based on long-term practices, this model is believed to be the best model for hilly regions in Southern China. However, the detailed analysis on nutrient cycling, energy cycling and biodiversity associated with this model is not conducted, and must await further assessment.

The pooling of the wisdom and investments

In order to rapidly form an effective development and management model, the MRL project follows the principle of opening up to the outside world, and attracts ideas and financial resources domestically and internationally in the fields of river basin management. The Province through the MRL projects has maintained close cooperation and communications with numerous countries, regions and organisations to learn their methods and experiences: for example, the Murray-Darling river basin commission in Australia, American Tennessee Valley Authority (TVA), to name a few. Through communications, more than 10 types of relatively improved natural resource development and management models dealing with problems from mountain areas to the lake region have been established, and significant research and development funds have been gained: for example, the support from the World Bank on the red soil first and second term development projects; the aid from Germany on various projects including the Central-South Jiangxi agricultural development projects, Jihu Lake agricultural development project, large water surface development projects and forestry development projects etc. These external financial supports have provided needed resources to implement management and protection strategies.

CRITICAL EXPERIENCE

Inclusion of all basin components with a focus on lake environment

The environment around the Lake strongly relies on environment of the entire river basin. The lake and the river basin constitute an inseparable and complete ecological system. One of the key elements responsible for the success of the MRL Program is that the project considers all components of the entire river basin and treats the lake-river basin system as an ecological entity. Because the lake and river basin constitute a causal relation, changes in the lake ecological system are caused by changes in the rivers. Integrated basin management prevents the separation of the lake and the river basin as well as the separated management of the river and lake systems. It also avoids the phenomenon of "partial treatment, overall deterioration".

Raising the living standard of people in the basin as the most important strategy

The people's environmental awareness and their behaviours are the decisive factors of the regional environment protection; however, people's environment protection awareness must be based on certain economic conditions. Poor people have less interest and motivation in environmental protection as they need to survive and develop first. When people fight with poverty, economic development is the most important priority of all social activities. On the contrary, when people's living standards are improved, they demand better physical

environment. The "zero economic growth" proposed in the 1970s has some positive aspects, but people's continuous material needs are more reality, especially for most developing countries. Although some people once suggested the "Lifeboat Ethics" (Hardin 1974), they consider the birth of the poor as the consumption and damage of the natural resources, and only the rich can think of their generations to come. In spite of some prejudices, "Lifeboat Ethics" indicates that only when the basic needs of survival are met, can people have the far sight to consider the sustainable development in the long run. The MRL Program in the Poyang Lake basin has successfully implemented various poverty-alleviation strategies. These strategies are easily accepted and implemented by local people.

Treating the water and soil erosion problem as the key to manage mountains and rivers

Water and soil erosion is the cancer of the river basin environment. It not only takes away fertile soil, but also impacts the local agricultural production. A large amount of silt enters the river, which can increase the river bed, block the river, and cause frequent floods. The river with high content of silt can lead to the shrinkage of the lake, reduction of the lake quality, and decrease of the aquatic functions. Therefore, prevention of water loss and soil erosion is crucial for long-term sustainability of the basin.

The direct reason of water loss and soil erosion is the result of deforestation and intensive agriculture activities in the upper reaches of mountain areas. In a move to prevent the water loss and soil erosion, it is required to address both the symptoms and root causes. We have not only to change people's behaviours in utilising the mountain resources, prohibit deforestation and improve people's income in the mountains, but also to guide local people to use resources rationally, and promote "use while protect".

Establishment of an effective basin governance mechanism

The reason for the smooth implementation and success of the MRL Program is largely due to the establishment of an effective governance system in Jiangxi Province. The matching of the Poyang Lake basin physical boundary with the administrative boundary provides conditions to effectively develop a governance system and to deliver government regulations.

In the Poyang Lake basin, the upper reaches share greater responsibilities in ecological protection. When implementing social economic strategies, the upper-reach areas often face more constraints mainly because those areas are more sensitive to environmental changes and bear more important responsibility to environment in the lower reaches of the basin. As a result, when carrying out social production behaviours, people in the upper reach of the river basin have to sacrifice some development opportunities, that is to say, have to pay more for the environment protection (including opportunity cost) than those in the middle and lower parts of the river basin. Thus, a typical economic externality is created, especially when a certain region in the upper reach of the river is designed as a restricted or prohibited development zone. When an entire river basin is under the same administrative jurisdiction, such a mechanism can be effectively utilised to increase the financial support in the upper reaches of the river basin in order to provide a fair social and economic share among all regions of the river basin. In reality, a river basin is usually under different administrative jurisdictions, and there are always clashes between different administrative jurisdictions. As a consequence, an organisation is needed to take leadership to coordinate all planning and operation activities. In the Poyang Lake basin, the MRL Committee led by the governor of Jiangxi Province is the high-level decision-making body who coordinates strategic planning and management directions.

CONCLUSIONS

From the results of this study, three reasons for Poyang lake keeping the "last pot of clear water" were concluded: 1) the unique geomorphologic features of Poyang Lake and the short water residence time; 2) the matching of the basin physical boundary with the administrative boundary; and 3) the implementation of the MRL Program, with the ecosystem concept of "mountain as source, river as connection flow, and lake as storage". For any basin or lake regions of developing countries where both environmental protection and economic development must be coordinated, the following experiences are important: considering all basin components when focusing on lake environment protection is a guiding principle; raising the living standard of people through implementation of various eco-economic projects or models in the basin is the most important strategy; preventing soil and water erosion is critical for protecting water sources; and establishing an effective governance mechanism for basin management is essential.

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