Chapter 9
Assessment of Degradration Causes and Development of Protection Strategies for the Poyang Lake Wetlands

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9.1 Characteristics and Trends of the Poyang Lake Wetland

9.1.1 Wetland Characteristics

9.1.1.1 Diversity and Internal Variability of the Ecosystem

Poyang Lake is a typical example for an seasonal fluctuating lake. Hence the lake's size depends on the season which leads to changes in the ecosystem. For example, the increasing amount of water during the rainy season is conducive to the growth of aquatic organisms in the ecosystem. The abundance of water leads to a dilution of contaminated parts of the water system, which has a positive effect on water quality [1]. In addition, the internal dynamics of the ecosystem makes it possible to conserve species and to provide valuable animal habitats in Poyang Lake [2].

Poyang Lake is a transition zone between land and water with abundant terrestrial and aquatic animal and plant resources. Aquatic organisms include mainly zooplankton, bottom benthic animals and fishes. Among them, there are 154 genus of phytoplankton, 8 phylums, 13 categories of bottom benthic animals and 122 species of fish [3]. In addition, animals and plants such as shellfish, shrimp, crabs, waterfowls, lotus and lake grass are abundant in the Poyang wetland ecosystem [4]. Plenty of different bird species exist in the lake area in different habitats distributed over the water surface, beach, grassland or the lakefront. 10 species of birds are listed as first class national protected animals. Among the mammals, more than 100 individuals of the freshwater finless porpoise population can be found in Poyang Lake.

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9.1.1.2 Zonal Wetland Distribution

The area in Poyang Lake covered by wetland vegetation is about 2262 km^2 accounting for 80.8% of the total area of the lake. The distribution of vegetation is governed by the environmental gradients and the varying water depth. Under normal circumstances, the plant population can be divided according to their main habitats into four plant belts, namely the wet plant belt, the emergent plant zone, the floating plant zone and the submerged plant zone.

9.1.1.3 Variability of the Ecosystem

Variability due to external changes illustrates the fragility of the Poyang Lake wetland ecosystem. Factors such as hydrology, soil and climate are the major external elements for the wetland ecosystem of Poyang Lake. Changes of these factors affect the biomes and the ecosystem structure of the wetlands. For example, the start of the rainy season, the amount of rainfall, the temperature, the soil sedimentation/abrasion patterns and the variability in water turbidity all may significantly affect the food web of the ecosystem. Hence, if the ecosystem is fragile, a small change in the external factors may easily break the ecological balance, but the recovery is very difficult and may requires a long period of time.

9.1.2 Wetland Trends

9.1.2.1 Shrinking Lake Area

According to the statistics covering the years from 1950 to 2014, extraordinary floods in Poyang Lake occurred in 1954, 1983, 1995, 1998 and 1998–1999 [5, 6]. Among them, the largest surface of Poyang Lake was more than 5100 km^2 during the year 1954 flood. In contrast, on July 31, 1998, at the peak time of the last large Yangtze River flood, the flooded area of Poyang Lake was only 4,070 km^2. After 1998, the maximum annual surface area extension of Poyang Lake is gradually decreasing. In 1999, the maximum surface area of water was less than 4,000 km^2. Until 2013, the maximum water surface decreased to only about 2,800 km^2. Although some years show an increase in maximum water surface area in comparison to the previous year (e.g. the year 2012), in general, maximum annual water surface areas are decreasing.

Similarly, the minimum water surface area in Poyang Lake decreases every year. After 1998, the problem of longer seasonal low water levels appeared in the basin, which became even worse after 2003. The severe winter droughts in 2008 and 2009 led to difficulties in obtaining domestic water along some parts of the lake and caused drinking water problems. Although the situation slightly improved in 2012, the drought appeared again and water levels dropped to a historical minimum of less than 500 km^2 in March 2014 and many former water covered lake areas and rivers

could be crossed without a boat. Summarizing, in the recent past, Poyang Lake shows a consecutive history of rare low water level and the water levels continue to decline, dry season continues to extend, which all together will severely challenge future water resources management.

9.1.2.2 Expansion of Dried-Out Plain Areas

The size of the temporally dry land areas of Poyang Lake depends on the water level. In 2013 these areas covered 1092.4 km^2 in the dry season and 91.38 km^2 in the wet season, which means that most of the floodplain was inundated in the wet season. The amount of dried-up land in winter increased slightly in recent years due to the generally declining water levels in Poyang Lake.

9.1.2.3 Decreasing of Desertified Land and Challenging Management

The proportion of desertified land in the natural wetland landscape of Poyang Lake is small and accounts for less than 2% of the total area. It mainly concentrates in Pengze and Duchang County. Under normal circumstances, sandy land will be exposed in the dry season. Strong winds during this season led to a gradually advances of the desertification to the periphery of the lake. However, after starting to actively manage the sandy land areas, the total area of sand desertification could be reduced in recent years. Hence, the desertification of the area is temporarily controlled, but the major factors are not completely eliminated and continue to exist. The current management strategy promotes planting of adapted vegetation on sandy land to achieve sand fixation. However, the vegetation fixed on the sand dunes is often extremely fragile and the external environment is harsh. Furthermore, these vegetation is difficult to maintain and can be destroyed easily.

9.1.2.4 Threatening of Biological Resources

In the early 1990s, the State Fisheries Department had carried out a survey of fish in Poyang Lake. At that time, Poyang Lake had 158 species of fish. However, in the census of 2008, there were only 122 species of fish left in Poyang Lake. In less than 20 years, 36 species of fish disappeared. Furthermore, species such as Lipotes vexillifer, Reeves shad and Chinese sucker are on the verge of extinction and the fish stocks of Black Carp, Grass Carp, Silver Carp and Bighead Carp are continuously decreasing. Nowadays, caught fishes are younger, smaller and have a worse quality than in previous decades. Some important migratory fish, such as Anchovies and Reeves Shad are rare or even near extinction in Poyang Lake.

Man-made projects damage the wetland and illegal hunting has reduced the abundance of birds tremendously. The degradation of wetland functions severely affects the migratory birds in terms of habitat, seeking food and temporal appearance.

According to the statistics by the Wildlife Conservation Administration for migratory birds, 107 species of waterfowl and more than 460,000 waterfowl were counted in the Poyang Lake area during the winter 2006/2007. These were about 20,000 migratory birds less than in the previous winter. In addition not only the number of birds but also number of species is decreasing. 326 species of birds were counted during the first Poyang Lake survey. However, according to the results of the second Poyang Lake survey in 2008, there were only 236 species of birds left.

In the past 50 years, the Poyang Lake wetland vegetation has been affected by both natural and man-made factors. The general trend shows that the wetland area is decreasing. The main features are as follows: the wetland area is continuously decreasing; the integrity of wetland vegetation belt is destroyed; the biomass of wetland vegetation declines year by year; the numbers of endemic species decrease and the numbers of alien invasive species increase.

Focusing on the aquatic system, the production of benthos, such as Alocinma longicornis and plankton is decreasing. Some benthos species such as Lamprotula scripta and Acuticosta chinensis became rare in Poyang Lake. Considering that the benthic environment is the bottom of the biological food chain and the most important producer, the entire wetland ecosystem is seriously threatened by a decrease in benthic production.

9.2 Causes of Wetland Degradation

The causes of wetland degradation are both natural and man-made [7]. At present, the research on wetland degradation mainly focuses on the status quo and driving forces of wetland degradation, as well as changes in soil structure and biological diversity in degraded wetlands [8].

9.2.1 Changes of the Climate

Poyang Lake is a subtropical humid monsoon climate zone. However, climate change is one of the factors leading to the degradation of Poyang Lake wetlands. Global warming provides the conditions for invasive alien species. It leads to changes in growth patterns and a deterioration of water quality. Another factor is the intensification of abnormal climate conditions. The extremely hot and dry conditions in 2003 and the drought in 2006–2007 exposed part of the lakes and lake beds of Poyang Lake. Additionally, the occurrence of snowstorms such as in 2008 causes large grassland freezing and damages the wetland ecosystem.

9.2.2 Drying up of the Lake

As mentioned above, the decreasing water levels of Poyang Lake, particularly in winter, affect the Poyang Lake Ecosystem. The prolonged withering of the aquatic vegetation causes damage to aquatic plants and disrupts the community structure. Large areas of turf dry up and are lost as habitats, especially for carps such as Carassius auratus.

The inundation time of natural lake embankments at the boundary between the main wetlands, rivers and small sub-lakes is shortened due to the prolonged time with low water level. Consequently, the number of fish, shrimp, mussels, snails and other small aquatic animals entering these sub-lake has dropped substantially. Considering their role in the food web, a significant reduction of these species impacts the migratory birds during winter.

9.2.3 Soil Degradation

The Poyang Lake wetland mainly consists of alluvial soils, meadow soils and swamp soils. The alluvial plain of the five main rivers and the dryland of Poyang Lake is covered by fluvo-aquic soil, Magan Soil and yellow soil, which generally have good soil properties. Paddy soil is the main cultivated soil in this area, which is fertile and has a good farming performance. However, compaction and erosion of soil is an increasing problem in Poyang Lake as well as the pollution of soils by fertilizer overuse.

9.2.4 Population Growth

The population of Poyang Lake Basin approximately tripled between 1950 and 2012 which led to a massive increase of human activities in the area of Poyang Lake. The growth rate of the population in the Poyang Lake Core Region is much faster than the population growth in the whole basin, with an average growth rate of 10%. In the next 20 years, this growth rate is assumed to remain constant [9] . Hence, more natural resources will be needed to meet the needs of an increasing population which will e.g. negatively impact the soil fertility of the area.

Since ancient times, land reclamation and utilization measures are applied in the area of Poyang Lake to meet the growing demand of the population and to improve the production and living environment. Reclamation has become the main form of development and utilization of land resources in the lake area and according to the statistics, the total reclamation area in Poyang Lake area reached 1210 km^2.

Poyang Lake wetland ecosystem degradation and overuse of resources are inseparable. Inefficient use of resources will inevitably lead to poverty. Poverty also restricts

the improvement of living conditions at the lakeshore which again leads to a more unsustainable exploitation of resources. As a result of these interactions, the damage to the ecological environment can only aggravate.

9.2.5 Agricultural Practices

Inefficient single-crop based agricultural production increases the extent of diffusive source pollution in the Poyang Lake area. The planting of rice monocultures over a long period decreased the soil fertility significantly. In order to increase production, fertilizers are widely used in the area. Frequent crop failures due to large scale appearance of pest led to an increase of pesticide usage. Hence, both pesticides and mineral fertilizers demand is increasing. From 1990 to 1995, pesticide use increased by 3% annually. From 1995 to 1999, the annual increase rate reached 7.5% annually. Following the distribution of mineral fertilizers on the field , about 60–70% of the fertilizer enters the environment and pollute water and soil. Excess N, P from the fields and the soils flows into the river and eventually to the Poyang Lake wetlands.

9.2.6 Exploitation of Wetland Resources

Although cutting wood in the upper reaches is scarce, the development of the fruit industry has caused large losses of endemic vegetation, soil and clean water, a problem which has not been adequately handled yet.

Due to generally low levels of economic productivity in many rural areas along the lake, lakeside communities often plunder natural resources of the Poyang Lake that create economic value. As an example, the long-term ongoing predatory operations on several species led to the depletion of these resources. Despite the strengthening of fishery management, e.g. by establishing protection areas and defining periods with a fishing ban, the phenomenon of overfishing and catching fish during the protection periods and in protection areas remains due to the large area of the wetland system and limited management efforts. Furthermore, the degradation of wetland vegetation has caused the destruction of spawning grounds of main economic fish species like carp and crucian carp.

9.2.7 Policy Impact

After 1998, sand mining in the Poyang Lake area and river channels intensified. Mining activities, irregular waste disposal, navigation and coastal wading safety of the rivers as well as threatening the aquatic resources and the ecological safety.

Unreasonable land-use patterns are another important reason for the degradation of the ecological environment in Poyang Lake. Public unstructured planting of poplar caused the appearance of so-called "green deserts" in the basin. Since 2000, large-scale planting of poplar at the wetland banks in 11 counties (cities and districts) around Poyang Lake has not only affected flood discharge, but also resulted in a drying up of the soils in these wetland bank areas which resulted in a loss of biodiversity. Although rectification actions were carried out in 2007, they achieved limited success.

At the same time, the construction of cofferdam lakes also lead to a fragmentation of the wetland ecological environment. Investigations show that the number of cofferdam lakes is spreading in the Poyang Lake area. This behavior not only leads to a destruction of the ecological and fisheries production, but also lead to conflicts on ownership disputes in the Lake District.

In addition, the construction of the Three Gorges Dam has a certain impact on the hydrological regime of Poyang Lake. The water level is lengthened in the flood season and the reduction of water levels is more severe in winter. It leads to the aggravation of the vegetation degradation in the Poyang Lake wetland, the desertification of land, the shrinkage of lakes and the destruction the biodiversity.

9.2.8 Urbanization

Urbanization is another major cause of wetland loss and degradation. The expansion of urban areas is associated with an increasing discharge of industrial waste water, waste residue, domestic sewage and fertilizers, pesticides and other harmful substances into the wetlands [10]. These harmful substances not only cause serious damage to biodiversity, but also affect the surface water, groundwater and soil environment, deteriorating water quality, causing water shortage and parasitic epidemic. In fact, many wetland areas have been transformed into industrial, intense agricultural areas or into polluted discharge areas for domestic wastewater.

The construction of roads, buildings and parking lots resulted in soil sealing and compaction of many areas. Due to the increasing soil impermeability, precipitation is prevented from infiltrating into the soil and instead flows as urban runoff into the wetlands transporting municipal waste and pollutants with it. Subsequently, increasing salinity, turbidity, toxicity, as well as reduced dissolved oxygen levels affect the aquatic food web. In addition, excessive nutrients lead to eutrophication, algae outbreaks, and widespread death of aquatic communities.

9.3 Current and Recommended Wetland Protection Measures

Based on the principle of having a positive connection between environmental protection and economic development, the Poyang Lake ecological environment protection agency developed a comprehensive resource development and utilization plan based on the long-term observation and tracking data to positively combine the ecological

environment protection with the resource utilization. This takes into account the richness and diversity of resources as well as the resilience of the ecosystem. In order to protect the wetlands, several suggestions are given in the following sections.

9.3.1 Improvement of Laws and Regulations

Main future improvements should include the laws and regulations itself but also adapt the lake and wetland management system in accordance with the law. It is necessary to revise and reformulate various types of the current lake-wetland protection regulations based on the results gained from practical experience. Concurrently, the introduction of new specific laws and regulations on water resources protection as well as the establishment of ecological compensation should be studied. Currently the administration dealing with the wetland management is fragmented and divided into many different authorities which limits the success of the current lake-wetland management. To overcome these shortcomings, the responsibilities of all involved departments need to be integrated and a more authoritative Poyang Lake protection and management system needs to be established. As a high-standard management body, the set-up of a higher-level coordination agency is suggested. Furthermore, the supervision and management of the wetland biodiversity should be strengthened.

Strengthen information campaigns, education and legal supervision on wetland conservation offers new opportunities to improve the wetland protection. Using public media such as radio, newspapers and newspapers can be actively used to educate the public on wetland conservation. Additional public reports and touring exhibitions will further raise public awareness of conservation and make the public aware of the structure of wetland ecosystems, the ecosystem services they provide and the serious situation of the current wetland degradation.

9.3.2 Application of Modern Science and Technology

The health of the Poyang Lake ecosystem maintains the ecological security of the middle and lower reaches of the Yangtze River. The structure of the Poyang Lake basin integrates mountains, rivers and lakes. The area of the basin and the administrative borders of Jiangxi Province are highly consistent making it an ideal study area for basin-wide ecology. Although research on the level of Poyang Lake Basin has reached a certain level, it is still not sufficient in terms of holistic system understanding and research depth.

Key scientific issues in the fields of hydrology, water environment disciplines and aquatic ecology should be applied to strengthen both the protection of the ecological environment in the Poyang Lake Basin and the comprehensive utilization of resources. This combined research activities should investigate the control mechanism of nitrogen and phosphorus loads, the status of Poyang Lake Basin ecosystems,

the succession of the Poyang Lake water resources and hydrological processes to the succession of Poyang Lake wetlands and its influence on the middle and lower reaches of the Yangtze River. Further research topics may include the migratory birds, the risk assessment of habitats of rare species and an integrated management approach for the Poyang Lake Basin [11].

Strengthening the scientific and technological support of the Poyang Lake management system cannot solely focus on the single lake itself. Poyang Lake has a unique and irreplaceable important role in economic construction, social development and ecological environment protection in the middle and lower reaches of the Yangtze River. The existence of mountains, rivers and lakes is one of the main characteristics of Poyang Lake. Mountains, rivers and lakes are forming a comprehensive hydrological system, which needs to be studied together. In addition, interactions with the Yangtze River Basin need to be included as the hydrology of Poyang Lake partially controls the water resources on the middle and lower reaches of the Yangtze River and vice versa. Therefore, it is necessary to strengthen the scientific and technological support for the management of Poyang Lake wetlands. A sustainable development of the Poyang Lake system in accordance to science must always adhere to the development concept of "pollution first and post-treatment" and needs to look on the water resources from the perspective of the entire catchment. Hence, future management of the Poyang Lake basin should be guided by in-depth scientific proof and careful decision-making.

9.3.3 Establish and Improve the Poyang Lake Monitoring and Early Warning System

Hydrology is the most important ecological element of wetland ecosystems. The monitoring of hydrological parameters provides the foundation for the judgment of wetland ecological environment and the diagnosis of its health status. Hence, hydrological monitoring is indispensable for the maintenance of the wetland ecosystem structure and function.

Although systematic monitoring, analysis and evaluation activities of six major projects on the natural environment of Poyang Lake, the hydrological climate, water level and sediments, storm floods, water quality and water quantity and experimental research go back until 1959, much work has been added in more recent years. However, the current monitoring frequency still does not meet the requirements [12].

To better cope with the adaptive ecosystem management strategy of the Poyang Lake Basin, it is proposed to further improve the monitoring and early warning system for the hydrological and ecological systems in the five main rivers of Jiangxi Province as well as in Poyang Lake [13]. Improved monitoring networks will be established to monitor meteorological and hydrological data, the soil moisture content, the groundwater level as well as the water quality [14]. The establishment of automatic collection network, transmission and computer application system will

form a comprehensive information database for the Poyang Lake Basin which allows to adjust the Poyang Lake ecosystem management measures and to adopt emergency protection measures.

9.3.4 Pollution Control

In order to protect the aquatic environment of Poyang Lake, the control and reduction of pollutants into the lake need to be improved. Firstly, the construction of modern sewage treatment facilities in Poyang Lake and the upper reaches of the city needs to be accelerated to achieve a better treatment of sewage water before entering the lake. The reclamation of urban sewage is an effective way to alleviate urban water shortage, control the total discharge of pollutants and to reduce pollution. It is proposed to actively develop and introduce zero waste and water saving technologies to the industry to further reduce the discharge of sewage.

For sediment and non-point source pollution appropriate measures need to be adapted on local conditions. In areas with sparse population, ecological restoration is a suitable method. In agricultural production areas where population is relatively concentrated, the channel protection project, soil and water conservation measures for forest, grass and soil conservation should be implemented. Besides, measures such as energy alternative construction and animal husbandry, adjusting agricultural planting structure, developing water-saving irrigation schemes and reducing fertilizer and pesticide use should be introduced.

9.3.5 Improving Ecological Environmental Ability of Regulation and Control

To improve the ecological environmental ability of regulation and control in Poyang Lake, most important is ecological regulation which is suggested to include the following three aspects:

1. Establish Poyang Lake water conservancy hub project: Establishing of the Poyang Lake water conservancy hub project can realize hydrological regulation and control. Proper regulation and control of the water level in Poyang Lake improves the conditions for the species and communities so that the structure and function of the Poyang Lake ecosystem can be maintained and biological integrity and ecosystem health can be protected.
2. Strengthening Ecological Hydraulic engineering: Water is the key factor of wetland ecology. Strengthening ecological water conservancy construction and Hydraulic engineering are key points to protect wetland resources and to prevent the degradation of the wetland ecosystem. Water resources management should

actively play a regulatory role on management. It is important to promote water conservation, water-saving irrigation technology research and promotion.

3. Coordination of the relationship between wetland resource protection and agricultural development: Wetland protection and agricultural development have interactions and mutual restraints. Regional agricultural production requires the support of land and water resources and a less frequent occurrence of disasters. Wetlands are important sources of regional water resources and can mitigate floods and regulate the regional microclimate. They are of great significance to regional agricultural production. Furthermore, efforts should be untertaken to rationally adjust the structure of the agricultural industry and promote high-yielding and stable-cropping techniques, which are conducive to the rational utilization of wetland resources and are conducive to the implementation of the key protection of agricultural wetlands.

9.3.6 Developing Communities with the Characteristics of Poyang Lake Wetland

1. Wetland products should be rationally developed and exploited: Poyang Lake wetland has abundant plant resources, with 476 species of higher plants. Among them, more than 200 species with economic use are known. If the rich plant resources in Poyang Lake can be properly utilized, for example als medicinal herbs, the economic benefits will be very significant.
2. Promoting the Development of Ecotourism: Poyang Lake is the most important international wetland that serves as a habitat for waterfowls in China. With beautiful natural scenery, beautiful ecological environment, rich tourism resources, the basic conditions for developing ecotourism are excellent.
3. Creating a process of regional ecologically friendly industry: Industrial access requirements for the Poyang Lake ecological economic zone should be strictly formulated. A number of high-tech industries, modern processing industries and related industrial projects should be established to achieve the development of an emerging industrial chain in the wetlands.
4. Establishing long-term wetland protection rewards and compensation mechanism for wetlands: It is suggested that factors should be included in the examination contents of local governments and relevant departments, such as assessment results of wetland ecological protection, discharge of major pollutants, environmental quality, environmental input and capacity. The governmental agencies and departments being most successful in environmental protection should be rewarded. Besides, a policy of paid use of natural resources and the environment should be formulated.

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