Origin of the Livelihood Dilemma for Local Fisherman in Poyang Lake Wetland: a Ramsar Site in China

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Abstract. Poyang Lake is one of the first Ramsar sites in China; it has plenty of natural resources that support the survival of local residents. However, local fisherman have encountered a livelihood dilemma, as natural resources have declined, obviously because of the change in the ecological environment and anthropic disturbance. We seek to explain what lead to livelihood dilemma to the local fishermen, so semi-structured interviews, questionnaire surveys, Geographic information system (GIS), Remote sensing (RS), Global position system (GPS), and department data were used to analyze the internal and external factors for these dilemmas. The results explained the external factors including the exhaustion of natural resources, the drying up of wetlands, landscape fragmentation, water contamination, and disturbance through anthropic behavior; the internal factors included the ageing of fishermen, poor cultural quality, conservative ideas, and unreasonable fishing practices. Eco-compensation, industry transformation, and capacity innovation may help to resolve livelihood dilemmas for the local fisherman of the Poyang Lake wetlands.

1. Introduction
Poyang Lake is the largest freshwater lake in China and an internationally important wetland, it was the first area to join “The List of Wetlands of International Importance” in China. In recent years, due to a rapidly growing economy and extensive use of natural resources, many human actions (such as reclaims lake to crop, sand excavation, grazing, economic tree planting) have played a significant role in changes to the wetland. Such actions have resulted in decreased biodiversity, and most of fish have been disappeared and body size became smaller and smaller. The livelihoods of local residents are facing an unprecedented level of threat, such as less and less yield and their incomes decreased year by year. The local fishermen are frustrated when they have no choice but to find better jobs or to capture more resources; the fisherman often face extreme poverty (Liu, 2011a). We seek to explain what lead to livelihood dilemma to the local fishermen, furthermore we analyzed the origin of the livelihood dilemma and put forward some countermeasures to allow the local fishermen to achieve sustainable livelihoods.
2. Data and Methods

2.1. Study Area
The study area was Poyang Lake, China, the largest freshwater lake in the country. Poyang Lake is located between 115°47′ and 116°45′ longitude east, and 28°22′ and 29°45′ latitude north. The lake is located in the northern part of east China’s Jiangxi Province on the southern bank of the Yangtze River. Water feeds into the lake from the Ganjiang, Fuhe, Xinjiang, Raohe, and Xiuhe rivers and flows out again into the Yangtze River (Compile Committee of study on Poyang Lake, 1988). The climate of the region is humid subtropical and is strongly influenced by the East Asian monsoon. The mean annual temperature is 17.6 °C. The July and January mean temperatures are 29.6 ° and 5.0 °C, respectively. Annual precipitation is about 1,528 mm, with most of the rain falling between April and September (Jiang and Piperno, 1999). Poyang Lake is seasonal, so every year it undergoes an extreme variation of 10 m or more in its water levels (the largest variation was 16.69 m, Wusong altitude system). It is known for its wide expanse of clear water in times of flood, but, during the dry season, it shrinks dramatically to become little more than a river.

2.2. Data
Data on daily water levels from Poyang Lake were obtained from Jiangxi Hydrographic Bureau for the period 1954~2013. In order to investigate the landscape pattern and analyze landscape fragmentation to effect on ecosystem in Poyang Lake wetlands, we purchased the Landsat ETM data, which was acquired on July 8, 1998, September 23, 2000, February 4, 2003, and February 12, 2009. The pixel size of Bands 1-5 and 7 was 30 m × 30 m, and the amount of cloud over the study area was less than 1%, so the data satisfied research needs. Fishing industry data were obtained from the Research Institute of Science & Technology of the aquatic industry in Jiangxi Province.

2.3. Methods
Questionnaire was executed in Kangshan Township of Yugan County, Duobao Township of Duchang County and Baishazhou Township of Poyang County, where was 70 percent of local residents being dependent on the wetland to sustain their livelihoods. The Questionnaire consisted of personal information (such as name, age, sex, culture, family), income (such as total fishing income, investment, expenditure), fishing mode (such as fishing tools, work hours, team structure), and suggestions (such as standpoint, criticism, aspiration), and they were set with 11 questions in total. Fragestate 4.0 and Arcgis 10 were used to analyze the landscape indicators in Poyang Lake wetlands. Landscape indicators provide quantitative information about landscape pattern.

3. Results and Analysis

3.1. Livelihood Dilemma for Local Fisherman
A report from the Jiangxi Fishery Bureau has stated that there were 18076 fishing boats, the fishermen with business licenses were 28136, and the volume of natural product from the Poyang Lake wetlands has been very low in recent years. The average annual volume was 3.2 ~ 3.6 × 10^4 ton from 2003 to 2008, but only 1.6 × 10^4 ton in 2009 during a period of drought; however, natural product volume was 3.1 ~ 3.6 × 10^4 ton in 2010 when there was sufficient water in the wetlands, however, natural product volume was also less than 2 × 10^4 ton per year from 2011 to 2014. At the same time both the population and the number of fishing boats increased, which has led to destructive tools and fishing methods being used; resources have therefore declined sharply, along with the income of the fishermen. According to a report from the Shangrao Statistics Bureau of Jiangxi Province, revenue of per capita net income was 4,000 Yuan RMB in 2009, 6,600 Yuan RMB in 2010, and 1,600 Yuan RMB in 2011. Due to a rapidly falling water level, most boats and fishing nets were discarded in the marshland of Poyang Lake wetlands. This left local fishermen having to purchase new boats and nets for the next fishing season so that their properties were seriously damaged. Greater eco-environmental changes (seeing the chapter Cause for livelihood dilemma) have made the achievement of a fisherman’s livelihood harder and more complex in the Poyang Lake wetlands (Sun, 2012; Li, 2015).
3.2. Cause for Livelihood Dilemma

3.2.1. Outer cause for livelihood dilemma. **Resources depletion.** Fish are the greatest local resource of the Poyang Lake wetlands; however, the quantity and quality of fish has declined because the ecosystem has fallen into disequilibrium, as it has been disturbed by the wetland’s complex driving forces (Wu, 2011). Species diversity and the size of individual fish have decreased due to the vicious circle of “less and less fish resources to fish, and more and more local fishermen to fish.” There were 158 species of fish in the wetlands before the 1990s. By 2014, there were only 89 species of fish according to the report by the Jiangxi Fisheries Research Institute. Therefore, almost 70 species of fish disappeared over a 30-y period. Individuals of the following species were mostly only 1-y-old: *Mylopharyngodon piceus, Ctenopharyngodon idellus, Hypophthalmichthys molitrix, Aristichthys nobilis, Cyprinus carpio, Carassius auratus, Silurus asotus, Siniperca kneri, Culter alburnus, and Parabramis pekinensis*; the ratio of 2-y-old, 3-y-old, and 4-y-old gradually decreased, and the 5-y-old and 6-y-old had almost disappeared. The population of fish in Poyang Lake wetlands is younger and smaller with fewer individuals and species. *Tenualosa reevesii* was a Chinese endemic species in the Yangtze River, and there was no being found more than 20 years.

**Wetlands drying.** More numerous periods of drought were experienced at the beginning of the 21st century. Drought was severe from 2003 to 2013 with the exception of 2005 and 2012 when water was abundant in Poyang Lake wetlands. The lowest recorded water level since records began in 1954 was found between 2006 and 2013. According to fisherman’s experience, their catch was disturbed when the water level was lower than 14 m (Xingzi hydrological station, Wusong fiducial elevation, same in next context), and when the water level was lower than 10 m, it became bare marsh with no fish to catch. Good fishing was possible when the water level was higher than 16 m (Liu and Wu, 2011). Unfortunately, the cumulative days per year when water levels were <10 m, 12 m, and 14 m have increased; on the other hand, the cumulative days per year when water level was >16 m show the same rhythm, i.e., there were few incidences of high water levels in Poyang Lake wetlands. High water level occurred most often from May to October, especially from June to September. A decreasing water area and increasing tidal-flat and marsh areas during droughts in Poyang Lake wetlands disturbed the fishermen’s catch. Most of fish, such as *Cyprinus carpio* and *Carassius auratus* (their product volume formed half of the total fishing volume in Poyang Lake wetlands), spawn in the waterweeds region, however, reproduction failed during dry periods so that the catch decreased markedly. The particularly dry year of 2011 led to the catch being reduced by 70% in Poyang Lake wetlands (Zhang, 2011; Yan and Zhong, 2015).

**Landscape fragmentation.** According to RS image analysis with Landsat ETM, changes in the wetlands landscape were obvious at the different water levels; when the water body decreased very markedly the area of tidal flats became greater in proportion to the water level; the area of water was 3617 km² on July 8, 1998 when the water level was 21.55 m, no tide flats were visible when the water levels were at this height. However, on February 12, 2009, when the water levels were 7.66 m, the area of water was only 1008 km² and the tide flats were large with an area of 1153 km². Landscape fragmentation was aggravated at low water level; this also caused loss of wildlife habitat, which resulted in many wildlife populations decreasing or dying out (Wagner and Edwards, 2001). At low water level, accessibility increased and human activity exacerbated disturbance so that landscape fragmentation increased.

**Water quality contamination.** Data were gathered from the *Bulletin of Water Resources Dynamic Monitoring in Poyang Lake* issued by the Hydrological Bureau of Jiangxi Province (2010–2014). The standard of water quality was classified according to the Environmental Quality Standard for Surface Water GB3838-2002 (The Ministry of Environmental Protection of P.R. China, 2002). The water quality was analyzed once every month for factors such as transparency, dissolved oxygen, pH, total nitrogen, total phosphorus, and ammonia nitrogen. The results revealed that the water quality has markedly worsened in recent years. Furthermore, in the dry season (generally from October to March), the water quality was more than 70% lower than the Class III standard, and Class IV and V water quality were recorded in 42 months out of a total of 60 months from January in 2010 to December in 2014. The contaminants were mainly total phosphorus and ammonia nitrogen, and they mostly
converged from industrial effluent and sanitary waste around Poyang Lake. As a result of the deteriorating water quality, the structure and function of the ecosystem in the Poyang Lake wetland is likely to encounter serious challenges.

**Human behavior disturbance.** Excessive human behavior has disturbed the Poyang Lake wetlands, such as grazing, sand excavation, illicit fishing nets, and fishing for spiral shells and clams. The fishery administration prohibited grazing, however, it frequently occurs. Since sand excavation was rejected in the Yangtze River watershed, thousands of boats entered the Poyang Lake wetlands. Sand excavation has destroyed wildlife habitat for foraging, reproducing, and resting, while oilers contaminated water to further disturb the ecosystem. Illicit fishing nets (including electrified nets, trawl nets, gill nets, cage nets, etc.) severely damaged the habitats of wildlife populations and communities. These can kill all fish including juveniles.

3.2.2. *Inner causes for livelihood dilemma. Fisherman aging.* The questionnaire clearly showed that the population of fisherman was aging. The greatest proportion of fishermen (41%) were aged 50–60, 29% were 40–50, 24% were >60, and just 6% were <40. Fishermen <30 y were not contacted according to the questionnaire survey. Older fishermen often fished by a way of “husband and wife”, their descendants generally worked outside.

**Conservative ideas.** Most of fishermen were located in remote areas where vehicular access was difficult, so they had little outside information, and up-to-date science and technology was not readily available to improve their techniques. Many of the fishermen depended on wetland resources to survive and they lacked or were reluctant to innovation according to questionnaire survey. For example, we set with a question “what do you hope to gain from the government”. You can select: A. Cash compensation, less than ten thousand RMB; B. Low interest rate loan, from ten thousand RMB to fifty thousand RMB; C. Normal interest rate loan, from fifty thousand RMB to one hundred thousand RMB”. However, no fishermen selected B and C. Fishermen’s revenues were unstable in the fluctuating ecosystem and environment of the wetlands; subsequently, their livelihoods were problematic.

**Skill deficiency.** The results of the questionnaire survey revealed that 80% of fishermen were illiterate or had only attended grade school, this was more evident in the older age groups; their low incomes resulted in their descendants being poorly educated. Especially they were skills deficiency except of fishing. Local residents with a higher level of education tended to quit fishing as a livelihood. Most fishermen worked in family units; individual fisherman ran a greater risk as they made large investments in purchasing fishing vessels, diesel oil, and fishing nets; however, their catch was generally too small to recover investment because of their traditional fishing mode, natural resource degradation, and abnormal climatope. Furthermore, their catch was crudely sold to local vendors at a low price leaving little profit.

4. **Countermeasures and Suggestions**

4.1. *Ecotourism*

Ecotourism has the benefit of protecting natural ecosystems and wildlife resources, by reducing the negative influence of human behavior and improving the welfare of local residents, therein, it achieved social, economic, and ecological collective success (Liu, 2011b). The trend for decline in the natural resources of the Poyang Lake wetlands was obvious, as traditional fishing could no longer satisfy local residents’ livelihoods and development. Fortunately, there are plenty of natural and cultural resources to meet the development of ecotourism, such as wildlife resources, landscapes, traditional heritage, historic events, and rural taste. Even if tourism has not been completely exploited, there have been a considerable number of tourists in recent years. It is very important to implement a scientific plan for the development of tourism resources in Poyang Lake wetlands.

4.2. **Ecological Compensation.**

Ecological compensation institutions play a key role in promoting ecological protection and coordinating regional development (Ouyang et al., 2013). Ecological compensation has been
implemented in different counties and for different aspects (Farley and Costanza, 2010). Local residents sacrificed their opportunities to exploit natural and wildlife resources in order to protect the ecosystem of Poyang Lake wetlands; therefore, they deserve compensation during the three month off-season when no fishing was allowed (Zhang and Zhang, 2013). Some countermeasures of ecological compensation have been applied to encourage local residents to protect the wetlands. The “More birds more bonus” activity and the “Regulation of the suitable water level” were innovative practices conducted by the Poyang Lake Nanji Wetland National Natural Reserve administration in Jiangxi Province to stipulate community participation and co-management. The results showed that there were more than 3-fold the number of migratory birds during the practice of the “more birds more bonus” period compared with the same period in previous years (Lai, 2014).

4.3. Improvement in the Fishery System
Younger fishermen hoped for more opportunities to find jobs. The fishery administration and government need to improve the current fishery system in order to create a greater number of new jobs. A clean aquaculture industry should offset natural resource degeneration and meet the continued requirement for aquatic products. A complete financial credit system should be built to serve those local residents who are willing to venture into investment and enterprise. National and local revenue systems should be favorable to younger entrepreneurs (Zhang et al., 2003).

5. Acknowledgements
This research was financially supported by the National Natural Science Foundation of China (Grant No. 31360120, 41561105, 71473113). We are also grateful to the reviewer for valuable comments on an early version of the paper.

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