

THE FEATURES OF THE NATURAL RESOURCES AND THE RENOVATION STRATEGY OF POYANG LAKE

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ABSTRACT: The present paper made an analysis of the features of the land, water, climatic and biological resources of Poyang Lake, the largest body of fresh water in China, whose water-covered area shows great variation between the flood and the dry seasons. It is a lake of transit water, the maximum recorded annual runoff, being $1,457 \times 10^8 \text{m}^3$. Yet the great fluctuation of its runoff in different months and different years renders its function in storing and regulating the water of the Changjiang River limited and inopportune. On the other hand, the Poyang Lake is a high-valued district in sunshine hours, water evaporation and wind energy, it serves as a temperature moderator. Abundant in bioresources, the lake formed an integrated water ecosystem and a water-land alternated landbeach-grassy sandbar ecosystem. Finally, the author put forward the strategy of renovating Poyang Lake by harnessing its water system; bringing the lake level under artificial control; harmonizing the relationship between Poyang Lake and the Changjiang River and making full use of the comprehensive advantages of the lake's resources.

KEY WORDS: Poyang Lake, features of natural resources, renovation, strategy

The Poyang Lake is the largest body of fresh water at present in China. But it is in urgent need of protection and renovation, due to the many problems existed in the exploitation of its natural resources that are caused by the natural factors as well as the influences of human activities. As a result, it is of significant practical value and academic interest to ascertain the present conditions of the natural resources of Poyang Lake and make an overall appraisal^[1]. Based on the vast amount of data and the large number of materials form the Studies on the Comprehensive Survey and the Renovation of Poyang Lake District, a state science and technology program organized by the Jiangxi Province People's Government during 1983-1988^[2], this paper discusses the features of the natural resources of Poyang Lake and the strategy of its renovation.

I. THE LAND RESOURCES OF POYANG LAKE AND THEIR FEATURES

Poyang Lake lies on the south bank of the Changjiang River, within the northern territory of Jiangxi Province, between $115^{\circ} 49'$ — $116^{\circ} 46'$ East longitude and $28^{\circ} 24'$ — $29^{\circ} 46'$ North latitude. It is divided at Shongmenshan island into the North lake and the South Lake. The South lake is vast and the main body, the North lake is a narrow water passage leading to the Changjiang River. The whole lake looks like a gourd hanging onto the Changjiang River, with Hukou as the gourd's mouth opening to the Changjiang River. The whole lake stretches 173km from north to south and 70km from east to west. The general shoreline of the lake reaches about 1,200km. Poyang Lake bears the following physical features.

1. Poyang Lake is the Largest Body of Fresh Water in China, but Its Water-Covered Area Varies Greatly with Flood and Dry Seasons

The shoreline of Poyang Lake serves as the boundary between the water-covered area and the lakebank. The boundaries between the lake and the rivers that drain into it lie at the rivers' mouths in a V shape. At 21.69m (Wusong Elevation System), the highest level ever recorded at Hukou Hydrometric station, the water-covered area of the lake directly connected with the Changjiang River amount to 3210.22km^2 , the corresponding volume being $252 \times 10^8\text{m}^3$, which ranks first among China's fresh water lakes (See Table 6). If the areas of the sublakes and the river branches that have been secluded by artificial means are added, the total water covered area will reach 4646.64km^2 , the corresponding volume $333 \times 10^8\text{m}^3$.

The water-covered area and the volume of Poyang Lake change greatly as the lake's water level fluctuates. When the lake water fell to 5.40m, the lowest level ever recorded by Hukou Hydrometric Station, its water-covered area was not larger than 146km^2 , the corresponding volume being $4.5 \times 10^8\text{m}^3$. The ratio of its water-covered area between the maximum and the minimum water levels is 22, the ratio of the volume being 56. Such a wide variation constitutes a unique sight of "An endless sheet of water in flood season, a narrow strip in dry season".

The monthly fluctuation of the water level is relatively large (See Table 1). According to the observation data from years of the lowest mean monthly water level appears in January, which is 7.81m, the highest comes in July, which is 17.53m. The mean annual water level is 12.92m. The water-covered area and the water volume varies as the fluctuation of the lake's level. Their correlativity is shown in Table 2.

Table 1 The monthly mean water level at Hukou Hydrometric Station of Poyang Lake

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
Water level (m)	7.81	8.03	9.45	11.93	14.78	16.15	17.53	16.70	16.02	14.88	12.33	9.38	12.92

Note: Based on the station's data of 45 years (1931–1937, 1947–1984).

Table 2 The relationship between water-covered areas, volumes and water level of Poyang Lake

Water level (m)	Water-covered area (km ²)	Volume (× 10 ⁴ m ³)	Water level (m)	Water-covered area (km ²)	Volume (× 10 ⁴ m ³)
-5	0.28	24	9	216.62	45946
-4	0.53	64	10	692.06	80464
-3	1.04	141	11	947.14	151196
-2	1.58	271	12	1643.10	279124
-1	2.69	182	13	2369.72	478704
0	5.03	862	14	2746.85	734340
1	8.76	1543	15	2974.07	1020308
2	14.36	2687	16	3070.55	1322504
3	21.94	4489	17	3112.55	1631716
4	28.69	7013	18	3144.20	1944583
5	37.63	10321	19	3177.94	2260726
6	47.73	14580	20	3218.29	2580559
7	70.19	20441	21	3252.86	2904146
8	115.19	29617	22	3286.34	3231134

Note: This table is based on Yellow Sea Elevation System

2. Poyang Lake is an Integrated Water System and a Water-Land Facies Ecosystem

Poyang Lake collects the water from the five large rivers—the Ganjiang River, Fuhe River, Xinjiang, Raohe River and Xiuhe River. It drains through Hukou into the Changjiang River, thus forms an integrated Poyang Lake water system, whose drainage area amounts to 162,225km², of which 96.8% lies within the boundaries of Jiangxi Province, and accounts for 94.17% of the province's total territory. Almost all the material flow, energy flow and information flow can converge upon the Poyang Lake, which gives the lake's water quality, silt, and biological species considerable representativeness in the whole province. It forms a comparatively integrated water-land facies ecosystem that is basically in accord with the administrative boundaries of the province. Such an integrated

ecological unit is rare in the whole China and therefore of unique value to the study of ecosystem.

3. Poyang Lake is Made up of a Number of Sublake Groups

When the lake's level rises to or above 16 metres at Hukou Hydrometric Station, Poyang Lake appears to be a continuous water body. But when at or below 12.92 metres, its normal level, the lake is divided into groups of large and small sublakes.

These sublakes fall into two types according to their physical appearance and their hydrological characteristics(See Table 3). One is the perennial lakes, whose basins are separated from the main body of Poyang Lake by dykes. Most of the lakes of this type are formed by cutting off the mother lake with dykes or by blocking the mother lake ends. Their level do not follow the fluctuation of the mother lake directly. Junshan lake, Chenjia Lake, Zhuhu Lake, Xinmiao Lake and Nanbeigang lake, etc. belong to this type. The other is the seasonal lakes, whose basins are included in the main body of Poyang Lake. They become a continuous part of the mother lake during the flood season. During the dry season, their basins emerge out of the water, thus become lakes within a lake. Hanchi Lake, Dalianzi Lake, Dashafang Lake, Chenjianchi Lake, Chaowan Lake and Jingxi Lake, belong to this type.

Table 3 The types and names of sublakes of Poyang Lake

Parannial lakes				Seasonal lakes			
Name	Area (10 ⁴ mu)	Name	Area (10 ⁴ mu)	Name	Area (10 ⁴ mu)	Name	Area (10 ⁴ mu)
Kangkan L.	53.82	Donghu L.	6.20	Linchong L.	1.86	Hanchi L.	7.92
Junshan L.	39.27	Changhu L.	1.17	Jiyu L.	0.48	Taiyang L.	0.83
Zhuhu L.	17.96	Beijia L.	0.98	Chenjiachi L.	2.25	Xihu L.	4.35
Xinmiao L.	11.54	Shenhu L.	1.21	Caowan L.	1.77	Nanjiang L.	4.00
Nanbeigang L.	4.39	Sanhu L.	2.45	Wangluo L.	1.39	Zhonghuchi L.	0.29
Qinglan L.	2.19	Dashafang L.	2.13	Sanzhou L.	0.50	Shahu L.	0.80
Jishan L.	1.95	Tuanhu L.	0.45	Liulao L.	1.20	Dahuchi L.	3.60
Daming L.	1.71	Bianhu L.	0.35	Jinxi L.	0.40	Banghu L.	9.74
Raofengnei L.	1.34	Nanhu L.	0.51	Wanhu L.	0.45	Dacha L.	9.12
	1.22	Beikouwan L.	0.90	Dalianzi L.	0.31	Jiaotan L.	5.18

Note: ① The calculation of the area of perennial lake is based on the water-level of 21.69m. seasonal lakes on 14.5m.

② 1m = 1/ 15ha

4. Poyang Lake Is a Young Lake and Its Water-Covered Area still in Expansion

Historical records show that, the great water body of the contemporary Poyang Lake is the result of the gradual southward expansion of the ancient Penli Lake. The formation of the main water body is but 1500-plus years old. The basin of the main lake body was the once agriculturally developed Qiaoyang Plain, upon which the ancient Qiaoyang County as late lay the seat of as 421 A. D.

The evolution of the basin of Poyang Lake has been conditioned by such factors as its geological structure, silt deposit and the rise of its water level. Among them the influence of the geological factor is comparably slow, the rate of the silt deposit is also low. The annual mean amount of the suspended load, if calculated on the basis of a uniform deposition all over the lake, is only 1.7mm in many years. On the other hand, for many reasons the flood level of the Changjiang River has been continuously going up. For example, the maximum mean annual flood level at Hukou Hydrometric Station between 1950-1969 was 18.473m. It was raised to 19.202m between 1970-1984, which registers an increase of 72.9mm in 20 years. The flood in Poyang Lake is to a large extent influenced by the flood in the Changjiang River. As a result, the lake's flood level has also been going up accordingly. The rate of the up-going of the lake level exceeded in many years that of the silt deposit, hence the rise of the water level became the dominant factor in the evolution of Poyang Lake. Calculated at a high water level, each 10mm's rise of the lake level will result in an expansion of 1.35km² in the lake's water-covered area. As its level continues to go up, the water-covered area of Poyang Lake is still extending.

5. Land Reclamation Has Decreased the Poyang Lake's Water-Covered Area Immensely

There are two kinds of dykes in the Poyang Lake district. One was built to protect the farmland against the flood. Because with the rise of the water level, the ancient Qiaoyang Plain became submerged. For example, the Record of Donghu Dyke of the Boyang County noted "There used to be a dyke on the Donghu Lake, Mr Li, district magistrate of the Tang Period, rebuilt it, regarding the protection of river as part of the town defence". The other was built for reclaiming land from the lake by secluding or blocking. According to an investigation, within the section between Poyang Lake and the hydrometric controlling stations of the five rivers (Ganjiang, Fuhe, Xinjiang, Xiuhe, Raohe), there are altogether 560 dykes of different sizes, 247 of which are with a reclaimed area of over 1000 mu each, or 621.6×10^4 mu in total. According to their topography and geological positions, these reclaimed areas can be divided into 3 types^[3]: One is the reclamation of the overlapping sections of the rivers and the lake, which stretches from the lowland at the rivers' endsections rivers until

the rear side of the delta at the rivers' mouths. With 143 dykes, its overall area amounts to 411.6×10^4 mu. Another type is the reclamation of the sections extending from the forward sides of the delta at the rivers' mouths to the submerged delta. With 39 dykes, its total area reach 112.2×10^4 mu. The third type is the reclamation of the large and small sections of the lake and the lake's ends. With 65 dykes, its whole area adds up to 97.8×10^4 mu. According to the total results drawn on the calculation based on photoelectric scanning, the water-covered area of Poyang Lake at the elevation of 18 metres decreased by 151.7×10^4 mu between 1954–1984. Reclaiming land from the lake is beneficial to parts of the district, but it has brought about many negative results to both the ecology and the economy of the whole lake^[4].

II. WATER RESOURCES AND THEIR FEATURES

According to the data from 1950 to 1984, the average annual runoff of the water of Poyang Lake water system into the Changjiang River through Hukou, after it has converged in Poyang Lake, is $1457 \times 10^8 \text{m}^3$. This accounts for 15.6% of the average annual runoff of the Datong Hydrometric Station of the Changjiang River in many years, which is $9335 \times 10^8 \text{m}^3$. It is also greater than the total volume of the water emptied into the sea from the Huanghe River, Huaihe River, and Haihe River together. Thus we can see, Poyang Lake is rich in water resources. An analysis of the present conditions of the water resources of Poyang Lake presents the following features.

1. Poyang Lake Is a Transit Water lake and the Runoff of the Transit Water Varies Greatly annually and Interannually

The minimum annual volume of water discharged into the Changjiang River through Hukou is 575×10^3 (in 1963). In contrast, the maximum is $2343 \times 10^8 \text{m}^3$ (in 1973), which is 4.08 times of the minimum volume. The fluctuation of the runoff between the months within a year is also very large (See Fig.1). The maximum monthly inflow of the water into the lake appears in June, which is $306.5 \times 10^8 \text{m}^3$ and accounts for 21.04% of that of the whole year. The minimum inflow arises in January, which is $38.43 \times 10^8 \text{m}^3$ and accounts for only 2.64% of the whole year. The inflow of the water in June is 7.98 fold that in January. The volume of the water flowing into the lake is concentrated in April through July. The volume of these four months together makes up 66.0% of the year.

2. Under Natural State, the Poyang Lake's Role in Regulating the Water of the Changjiang River Is Limited and Inopportune

At the high water level of 21.69m, the volume of Poyang Lake reaches $252 \times 10^8 \text{m}^3$.

But the lake is a swallow-and-spit style lake, so during the flood season when the Changjiang River needs Poyang Lake to divert its flood, the lake is nearly full already, and thus can accept only a limited volume. Among the 35 years between 1950–1984, Poyang Lake took in water from the Changjiang River in 31 years (except 1950, 1954, 1972 and 1977). That is 86 times or 478 days in total. The average annual water acceptance is 2.46 times or 14 days. The accepted volume amounts to $25.22 \times 10^8 \text{m}^3$. The minimum accepted volume is $0.1 \times 10^8 \text{m}^3$ (in 1955), the maximum volume is $93.80 \times 10^8 \text{m}^3$ (in 1958). As a result, it is generally thought that Poyang Lake is a natural reservoir for regulating and storing the water of the Changjiang River. What deserves our notice, however, is that by the time when Poyang Lake received the water from the Changjiang River, only twice was the water level at Hukou above 19 meters. That was 20.10m in 1983 and 19.77m in 1969. Ninety-four percent of the times were below 18 meters, whereas the warning line for flood control at Hukou is 18.5 m. This shows us that the role of Poyang Lake in weakening the flood peaks of the Changjiang River is both limited and inopportune.

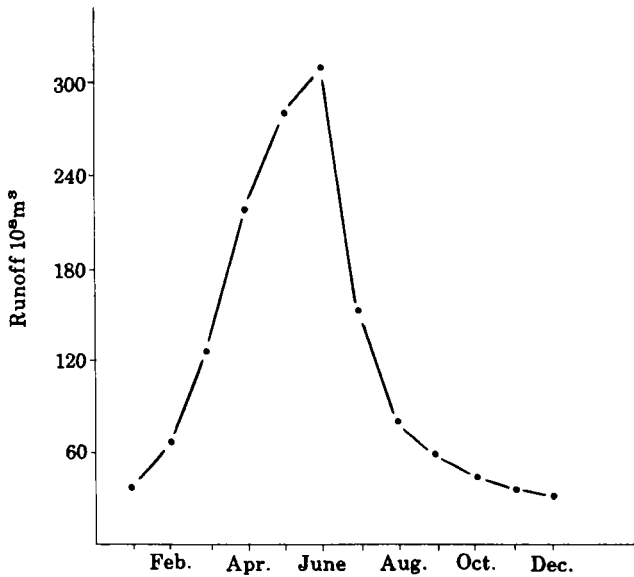


Fig.1 The monthly fluctuation of the water discharged into the Poyang Lake (1950–1984)

A comparison of the monthly fluctuation of the water discharged into the Changjiang River from Poyang Lake (Fig.2) and the monthly fluctuation of the water discharged into Poyang Lake (Fig.1) shows that, Poyang Lake plays a certain part in regulating the water drained into the Changjiang River, but it concentrates in the flood season of April to July, which accounts for 55.7% of the whole year. During the time (November–February) when

the Changjiang River wants water, the water discharged into it from Poyang Lake only accounts for 15.7% the whole year, There is a minor peak in October.

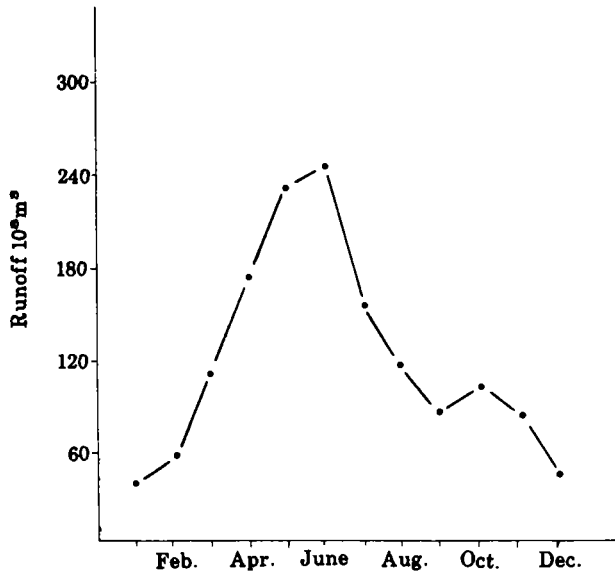


Fig.2 The monthly fluctuation of the water discharged into the Changjiang River from the Poyang Lake (1950-1984)

3. The Overall Water Quality of Poyang Lake Remains Good, but Has Been Polluted.

According to the investigations on the water quality of Poyang Lake, the average annual pH of the lake is 7.0-7.6, dissolved oxygen 6.9-8.3 mg/ L, chemical oxygen consumption 1.1-1.8 mg/ L, biochemical oxygen demand 1.14-2.27 mg/ L, ammoniac nitrogen 0.067-0.122 mg/ L, general hardness 13.6-23.0 mg (CaO)/ L, chloride 0.8-2.1 mg/ L, phenol 0.001-0.005 mg/ L, Cynide 0.001-0.004 mg/ L, arsenide 0.001-0.005 mg/ L, mercury, unfounded, oil 0.019-0.113 mg/ L, total phosphorus 0.012-0.408 mg/ L, total nitrogen 0.1444-4.736 mg/ L. These data tell us that the overall water quality of the whole lake remains fine. But there are cases that the contents of heavy metals like copper and zinc have surpassed the water quality criteria for fishery (See Table 4). With a tremendous volume and great water body, huge amount of transit water and short water replacement cycle, Poyang Lake retains a strong auto-purifying and deluting ability against the pollutants^[5]. So the overall water quality should stay confirmed to the criteria for clean water. But at present, the contents of copper and zinc have transcended the criteria and in parts of the lake the content of oil also excels the criteria. This should arouse the close attention of the departments concerned.

III. CLIMATIC RESOURCES AND THEIR FEATURES

Taking the averages of the observatory data of the four hydrometric stations surrounding Poyang Lake as the representative data for the climate of the lake, the annual average air temperature is 17.3°C; accumulated temperature (>10°C) is 5461°C; frost-free period 265 days; total solar radiation 444–481 × 10³J/ cm², sunshine 1942 hours, precipitation 1470 mm. It belongs to humid subtropic monsoon climate. Under the influence of the great water body, there formed a lake area subclimate with the water body as the center. After an analysis of the relative climatic data, we believe that the climate of Poyang Lake possesses the following features.

1. The Central Section of Poyang Lake Is a High-Valued Area in Mean Annual Sunshine Hours

The isoline chart of the annual sunshine hours of Poyang Lake (Fig.3), quoted from the book Studies on Poyang Lake, shows that in Poyang Lake and its surrounding area, the section with the highest mean annual sunshine hours appears in the lake itself, which reaches as high as 2105 hours in the central section of the lake. The length of the sunshine hours is not only closely connected with the angle of the sun, but also closely related to the amount of the cloud, the topography and so on. The existence of Poyang Lake may cause these factors to change.

Table 4 The contents of copper and zinc in the water of Poyang Lake

Item	Month	Sample numbers	Numbers found	Rate %	Concentration (mg/ L)			Fishery water standard (mg/ L)
					Mean	Max	Min	
Copper	Dec	36	36	100	0.083	0.012	0.0022	<0.01
	Apr	51	51	100	0.025	0.096	0.0013	<0.01
	Aug	145	145	100	<0.007	0.188	<0.0008	<0.01
Zinc	Dec	36	36	100	0.263	0.97	0.03	<0.1
	Apr	51	51	100	0.298	1.01	0.019	<0.1
	Aug	145	145	100	1.229	3.23	0.025	<0.1

2. Poyang Lake District and the Bordering Nanchang Area Is a High-Valued Area in Water Body Evaporation

The chart of the isoline of the annual evaporation volume of the great water body of Poyang Lake, quoted from the book Studies on Poyang lake (See Fig.4), shows that there exists a high-valued area covering Poyang Lake area and the adjacent Nanchang area. The volume of evaporation as well as its time and position is closely bound up with the

hydrometeorologic factors. According to the data of Duchang Evaporation Experimental Station of Jiangxi Province, the monthly evaporation of Poyang Lake (E_m) depends on the number of the days of the month (n), monthly mean vapor pressure at the water surface and 150mm above the water surface (e_0 and e_{150}), mean monthly solar radiation (Q , J/cm^2), mean monthly wind speed at 150mm above the water surface (\bar{W}_{150} m/s). Their interrelated formula is,

$$E_m = 34.4n[(e_0 - e_{150}) + 23.45 \cdot 10^{-5} Q + 1.294 \cdot 10^{-2} \bar{w}_{150} - 0.04]$$

Owing to the existence of the great water body, there appears a high-valued area of evaporation. The mean annual evaporation for the period from 1962 to 1982 was as high as 1235.6 mm.

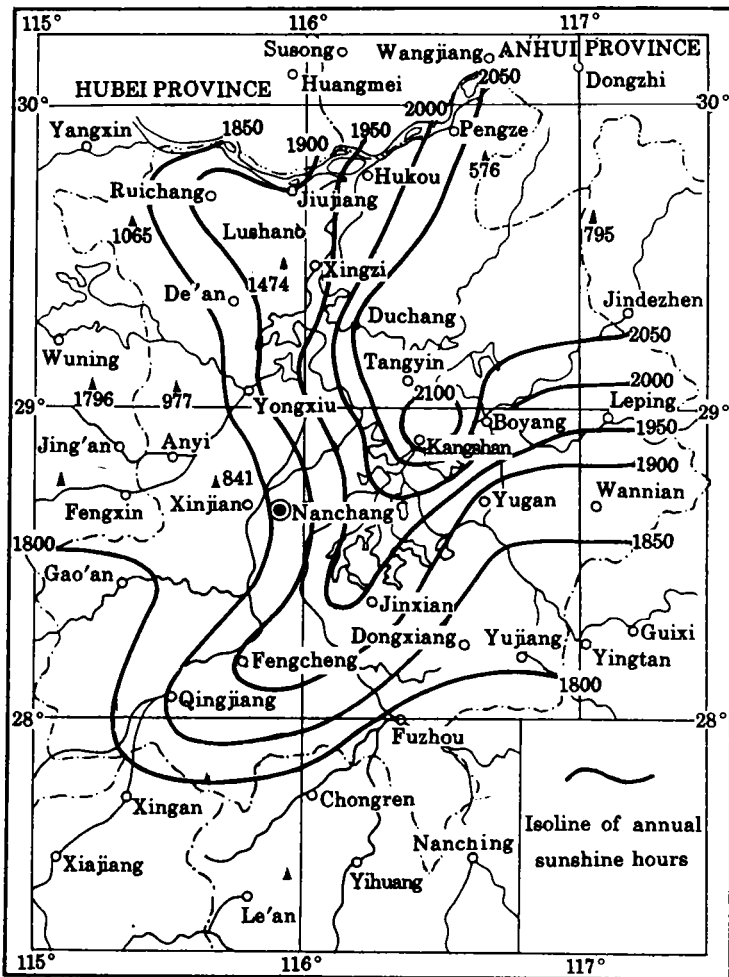


Fig.3 The isoline of annual sunshine hours of Poyang Lake

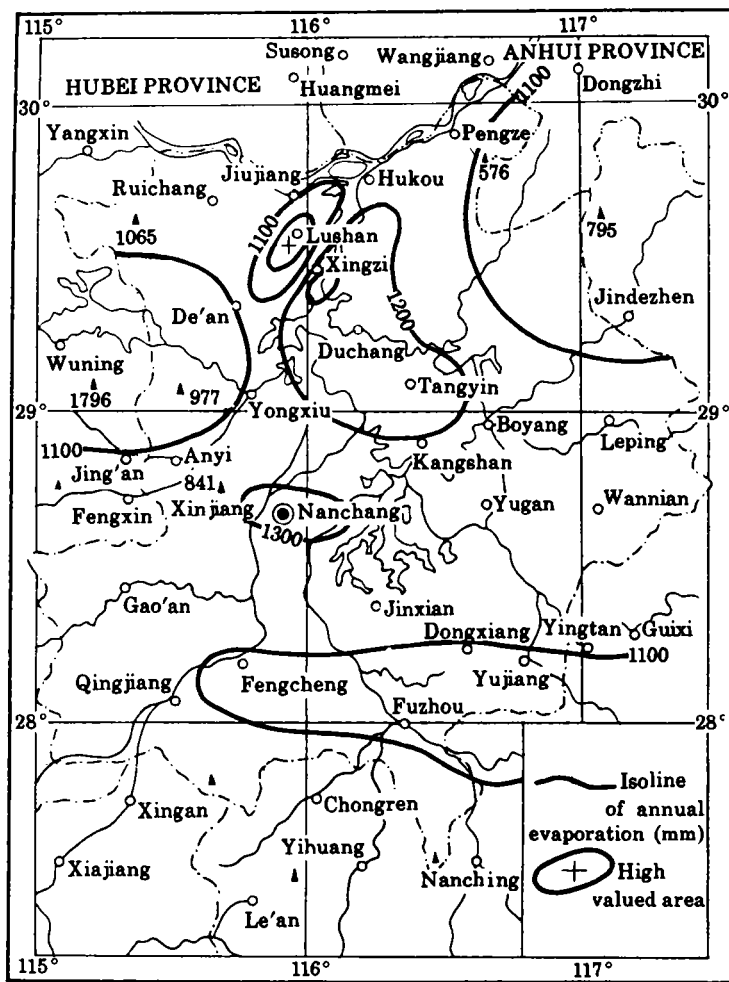


Fig.4 The isoline of annual evaporation volume of Poyang Lake District (1962-1984)

3. Poyang Lake Is an Air Temperature Moderator

According to the observation of Poyang Lake Hydrometeorologic Experiment Station (Table 5), during spring, summer and winter, the mean daily water temperature at Tangyin Station on an island in the center of Poyang Lake in sunny days is 1.1–6.5°C higher than that of the air temperature, the daily temperature difference of the water is 2.7–8.9°C lower than that of the air. The lake body exerts a regulating effect on the air temperature. Take the mean annual air temperature as an example, Tongyin Station is 0.2°C higher than Boyang Station on the east bank of the lake, 0.5°C higher than Duchang Station and De'an Station on the north bank and 0.7°C higher than Yongxiu Station on the west bank. This warming effect is due to the release of the potential heat from the evaporation of the water body, and the mean annual evaporation of the water body of the Poyang Lake is as high as $28.5 \times 10^8 \text{ m}^3$. In contrast, during the scorching deep autumn, the mean daily temperature of

water at Tangyin Station is lower than that of the air. The lake body plays a role of cooling the high air temperature. For example, the mean monthly air temperature during the hot season is 32.6°C at Tangyin Station, but 23.5°C at Boyang Station and 33.1°C at Yongxiu Station.

This moderating action of the lake body makes the accumulated temperature >10°C of Poyang Lake district 80–200°C higher than that of the adjacent areas, the accumulated temperature >15°C of the lake district 90–260°C higher, frost-free period 6–9 days longer, which improves the lake district's climatic conditions for agriculture.

Table 5 The daily fluctuation of the water and air temperature in the four seasons of the Tangyin Station of Poyang Lake

Hour	Spring		Summer		Autumn				Winter			
	1962-03-27		1964-07-28		1962-09-22		1979-10-29		1962-11-28		1979-01-09	
	Temperature (°C)											
	Water	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water	Air
0	12.6	11.2	31.6	29.3	28.2	28.5	14.9	7.3	7.9	3.9	10.6	7.4
2	12.8	8.8	31.8	30.0	28.2	27.8	14.5	5.7	7.8	3.1	10.6	6.6
4	13.0	8.4	31.5	29.8	27.6	27.2	14.1	4.9	7.8	2.2	10.3	6.1
6	13.2	8.8	31.5	29.6	27.5	26.5	13.9	4.4	7.8	2.0	10.2	5.8
8	13.4	9.2	31.4	29.7	27.5	27.9	13.9	6.6	7.6	1.6	9.8	3.9
10	13.6	11.6	31.5	30.1	27.9	29.0	14.4	9.3	8.0	5.2	10.1	6.4
12	13.5	13.7	31.8	31.2	28.2	30.1	15.3	11.6	8.4	5.2	11.4	12.7
14	14.2	16.0	32.0	32.4	28.5	30.4	16.0	13.0	8.7	8.2	11.3	15.6
16	15.0	17.5	32.0	29.9	28.0	29.8	16.5	12.9	8.6	8.1	11.4	16.3
18	14.8	16.9	31.8	29.1	28.7	30.3	16.2	10.3	8.4	6.9	10.8	14.0
20	14.0	13.6	31.6	28.2	28.5	29.7	15.7	9.0	8.2	6.2	10.8	11.2
22	13.6	14.0	31.5	28.2	28.4	29.1	15.6	8.2	8.0	6.2	10.7	9.6
Mean daily value	13.7	12.5	31.7	29.8	28.1	28.9	15.1	8.6	8.1	5.1	10.7	9.6
Daily temperature difference (°C)	2.4	6.3	0.6	4.2	1.2	3.9	2.6	8.6	1.1	6.5	1.6	10.5

4. Poyang Lake Is a High-Valued Area in Wind Energy in Jiangxi Province

According to the data from the investigation, the average total time of effective wind over the water area, the islands and the bordering area of Poyang Lake is over 3500 hours. The average annual wind speed is 2.4–4.8 m/s. At Laoyemiao it is 7.0 m/s; average an-

nual wind energy density is 293 J/ m^2 , effective wind energy density 670 J/ m^3 , effective wind energy over $2093 \times 10^3 \text{ J} \cdot \text{H/ m}^2$. The period with wind above fresh gale or 17 m/ s is 32.0 days for Xingzi Hydrometric Station by the Poyang Lake's waterway to the Changjiang River, and 2.15 days for Tangyin Station in the center of the lake. Thus we can see, Poyang Lake is a district with richest wind energy in Jiangxi Province, which is favorable for exploitation. but because of the interaction of the windpower, water current and the huge waves raised by the strong wind navigational accidents take place from time to time at Laoyemiao, a section of the waterway connecting the Poyang Lake with the Changjiang River.

IV. BIOLOGICAL RESOURCES AND THEIR FEATURES

Poyang Lake lies in the subtropic zone. The moderate climate, vast water-covered area, high content of such nutrient salts as nitrogen and phosphorus etc. in the water, as well as the seasonal alternation between the land and the water, all contribute to the development of the biological resources in the lake. So not only is the aquatic life great in amount and numerous in species, the wetland biological resources are also abundant. The aquatic life found so far includes phytoplankton 54 families, 154 genera; zooplankton (excluding protozoa) 24 families, 112 species; vascular plant 38 families, 102 species; molluscs 8 families, 50 species; fish 21 families, 122 species; animal 9 families, 13 species^[6]. The wetland life found includes, meadow, wetland plant 28 families, 79 species; bird 37 families, 150 species. According to the composition of their species, the amount as well as the fauna and flora, the relationship between the biological resources of Poyang Lake and the environments indicates the features as follows.

1. Poyang Lake Is an Integrated Water Ecosystem

The lake basin, the water body and the primary producers, the primary consumers, the decomposers of the aquatic life make up the Poyang Lake water system. Closely related to the internal relationship within this system is the formation, development and the variation of the fishery of Poyang Lake. Test results put the primary productivity of the Poyang Lake's water ecosystem at $510.3 \text{ J/ cm}^2 \cdot \text{a}$ which includes the productivity for phytoplankton 335.2 J/ m^2 and the productivity for vascular plant. $175.1 \text{ J/ cm}^2 \cdot \text{a}$. This accounts for about 0.1134% of the total solar radiation ($4499 \times 10^3 \text{ J/ cm}^2 \cdot \text{a}$) of Poyang Lake^[7]. Based on this, the estimated annual fish productivity of Poyang Lake comes to 44144 t. But at present the catch of the lake is still very low. According to the statistics from 1950–1984, the average annual catch of the natural fish of the whole lake amounts to merely 18060 t, which ranks second among the five largest freshwater lakes in China (See Table 6). Obviously, Poyang Lake bears a tremendous potential in natural fish productivity. If

such measures as propagation, farming and planting are taken, the potential will become even greater.

Poyang Lake is an integrated water ecosystem with strong self-adjusting capacity. Though the five rivers (Ganjiang river, Fuhe River, Xinjiang River, Raohe River and Xiuhe River) and the runoff of the section between the lake and the five hydrometric controlling stations of the five rivers have brought large quantities of pollutant, the water remains basically good in quality and belongs to clean water after self-purification which depends on the adjusting function of the system. This function, however, is limited in capacity. Once surpassed there will be pollution. Table 4 shows that in April the mean copper concentration of the whole lake is 0.029 mg/ L, which is 2.5 times of the standard for the water quality of fishery; mean Zinc concentration in April, August and December is 0.298 mg/ L, 1.229 mg/ L and 0.263 mg/ L respectively, which is 2.6–12.3 times of the standard for the water quality of fishery. This should arouse enough attention.

Table 6 The annual mean amount of fishing in five freshwater lakes in China

Lake	Amount of C fishing ($\times 10^4$ kg)	Year	Area ($\times 10^4$ mu)	Elevation (m)	Data source
Poyang Lake	1806	1950–1984	482	21.69	Studies on Poyang Lake
Dongting Lake	2258	1950–1980	441	33.50	Taihu Lake Aquaculture
Taihu Lake	981	1952–1982	351	2.99	Taihu Lake Aquaculture
Hongze Lake	977	1956–1980	341	12.5	Taihu Lake Aquaculture
Chaohu Lake	240	1971–1982	113	8.0	Chaohu Lake Records

2. Poyang Lake Is a Water–Land Alternated Lakebeach and Grassy Sandbar Ecosystem

The water level of Poyang Lake rises in summer and falls in winter. Such a hydrologic condition constitutes a peculiar lake facies at high waterlevel, land facies at low waterlevel, water–land alternated lakebeach and grassy sandbar ecosystem or wetland ecosystem^[8]. The abiotic environment of this system is mainly the silt brought by Poyang Lake's water system, which forms 143×10^4 mu (1mu = 1/15ha) of lakebeaches and grassy sandbars at the elevation of 14–19 metres. The primary producer of this system is the meadow plants and the wetland plants that fit in with such surroundings. From the lower part upward there appear successively plant groups like *Polygonum crioplitanum*, *Carex*, *Miscanthus floridulus*/ *Carex*, *Phragmites* and *Miscanthus sachariflorus* etc. Their primary productivity can reach 169.2–3446.7 J/ $\text{cm}^2 \cdot \text{a}$. The consumers of this system are the birds and animals. With such an excellent and stable wetland ecosystem, there appears near Wuchen town in the west part of the Poyang lake the world's largest winter habitat for *grus leucogeranus*.

A multidisciplinary scientific survey in 1983 discovered that there were hundreds of *Grus leucogeranus* gathering there to live through the winter. In recent years the number has increased to over one thousand. Whereas an international conference on cranes held in India in 1983, which was sponsored by the International Crane Foundation, put the estimation of *Grus leucogeranus* at merely 320. Besides, each winter there are a great number of rare, migratory birds like *Ciconia ciconia*, *Grus monacha*, *G · vipio* and *C · nigra* etc., coming to the Poyang lake to roost and pass the winter. This has aroused interests of the persons both from home and abroad who work either on birds or on wetland ecosystem. To protect the birds and the wetland environments, the Poyang Lake to roost and pass the winter. This has aroused interests of the persons both from home and abroad who work either on birds or on wetland ecosystem. To protect the birds and the wetland environments, the Poyang lake Migratory Birds Reserve was set up in June, 1983 with the ratification of Jiangxi Province People's Government.

The calculation based on the fixed point measurement concludes that the annual yield of the grass on the lakebeaches and sandbars of the Poyang lake can be 154×10^4 t. To exploit the grassy sandbar resources reasonably, we should develop the industries of livestock raising and poultry raising in light of the local conditions, according to the elevation of the sandbars and its time of staying above the water (November through the following April). The natural carrying capacity of grassy sandbars is about 0.05 head/ mu (buffalo) for livestock and about 5.9 pieces/ mu (goose) for poultry. During the flood season when the sandbars are submerged, they become the feeding grounds for the grazing fishes and excellent spawning beds and nursery areas for the breeding grassphila fish. To protect and propagate fish resources, Jiangxi Province People's Government has designated a total area of 39×10^4 mu of the Poyang lake's spawning ground of carp and crucian carp as No-fishing Zone.

But the alternation of the grassy sandbars being above and under the water in winter and summer constitutes an excellent environment for the multiplication of oncomelania, the intermediate host of schistosomiasis, which has become a major factor in the lakebeach and grassy sandbar ecosystem that harms the health of the people living in the Poyang lake District. Investigation found out that 93×10^4 mu of the lakebeaches and grassy sandbars of the Poyang Lake has been invaded by oncomelania. The density of living oncomelania is under 5.4 pieces/ m^2 . An investigation on 6-5 grassy sandbars showed that the appearance rate of the schistosomiasis-infected oncomelania in the grassy sandbar is 29.01%, its density being 0.009-0.018 piece/ mu. As a result, it is an outstanding problem in the Poyang Lake ecosystem to get rid of oncomelania and to prevent and cure the schistosomiasis.

3. The Poyang Lake's Fish Resources Are on Grave Recession.

In the past 35 years between 1950 to 1980, the average annual catch of the Poyang lake were: 1.91×10^4 in the early 1950s, up to 2.10×10^4 in the late 1950s, and 2.18×10^4 in the early 1960s, then down to 1.74×10^4 in the late 1960s, 1.43×10^4 in the early 1970s, and 1.36×10^4 in the late 1970s. Not only did the amount of catch decrease sharply, the youngalization and miniaturization in the catch composition were also serious (Tab.7). This shows that the fish resources of the poyang lake is on an obvious decline. The major cause for this is the excessive and indiscriminative fish decrease sharply, the yougalization and miniaturization in the catch composition were also serious (Tab.7). This shows that the fish resources of the Poyang lake is on an obvious decline. The major cause for this is the excessive and indiscriminative fishing and the widespread adoption of the fishing tackles and fishing methods that are harmful to fish resources. For example, with its strong capacity of catching young and small fish, fixed net belongs to a ruinous fishing gear. But in recent years the number of such net soared in the Poyang Lake. It went from 27 in 1978 up to 809 in 1981, then to 1975 in 1982, and 1889 in 1986. Besides, other fishing methods such as poisonous fishing, explosive fishing, electric fishing and the "cut-off" fishing etc. are all of great destructiveness to the fish resources. In addition, building dykes to reclaim land from the lake and the seclusion or blocking of the lake's ends have damaged the spawning ground and the feeding ground of the economic fish. The pollution of the environment also bears a share in ruining the fish resources. The condition of fish resources is an important index for the water ecosystem. The recession of the fish resources in the Poyang lake proves that the Poyang lake ecosystem has already suffered damage. This should evoke enough attention.

Table 7 The age composition (%) of Carp catch in Poyang Lake

Year	0	1	2	3	4	5	6	7	8
1963			66.6	20.1	8.3	3.4	1.2	.2	0.2
1974	1.1	14.6	59.7	15.9	5.7	1.4	1.6		
1984	25.3	37.6	24.5	9.4	2.1	1.1			

V. THE STRATEGY OF THE RENOVATION OF POYANG LAKE

In view of the above analysis on the features of the Poyang Lake's natural resources, the author believes that, the overall strategic aim in renovating the lake should be; harness the five rivers; bring the lake level under artificial control; harmonize the relationship between the lake and the Changjiang River; give full play to the comprehensive advantages of the lake's resources; develop the Poyang Lake district into an area that bears the features of water-land facies ecoeconomic system, an area that is not only good at storing and regulating the water of the Changjiang River but also good at flood prevention and drought re-

sistance, an area that relishes prosperous economy, advanced science and technology, beautiful environment and happy life.

The Poyang Lake is the convergence of five big rivers . It is a swallow-and-spit style lake with transit water that is connected with the yangtze River through one opening. The lake lies in the subtropic zone and possesses a vast drainage area. The natural calamities in the lake district such as the flood, waterlogging and soaking during the flood period as well as the drought, and the hot dry air have all been a huge threat to the life and production of the local residents. Because it is a lake with transit water, an average annual runoff of $1457 \times 10^8 \text{m}^3$ of precious water is lost, which constitutes a peculiar sight of "an endless sheet during the flood period but a narrow strip in the dry season". This has greatly hindered the development of the industrial and agricultural production, navigation, water supply, hydraulic electrogenerating and the prevention and cure of schistosomiasis in the lake district. To turn the above harmful factors into advantages, the fundamental principle in the renovation of the Poyang lake should be: To harness the five rivers, practice artificial control over the lake and harmonize the relationship between the lake and the yangtze River.

To harness the "five rivers" means the renovation of the Poyang Lake's drainage area. This includes: Developing the five rivers in the sequence of their terrace, to store the water in the rivers through engineering means; Planting trees and grass in the Poyang Lake drainage area, to store the water in the mountains through biological means, thus millgate the up-pushing caused by the flow of the Poyang Lake water system against the backward flow of the Changjiang flood, and alleviated the flood in the lake district. This is also beneficial to the storage and diversion of the water form the Changjiang River. Because the flood of the Changjiang River exerts the greatest influence on the flood and waterlogging in the Poyang lake district, the renovation of the lake should be unified with the overall planing and arrangement for the tenovation of the Changjiang River and its valley, so as to effect a permanent solvation.

Under the natural state, the flood of the Changjiang River and the Poyang lake poses obvious harmfulness to the lake district. What about the Poyang Lake's function in storing and regulating the water of the Changjiang River? When the lake level is below that of the Changjiang River, the lake can to a certain extent store and regulate the water from the Changjiang River, mainly in that it holds the flood of the Poyang Lake water system, thus reduces the water discharged into the Changjiang River. But when the lake level rises above that of the Changjiang River, the outflow of the Poyang lake water system produces an up-pushing against the flood of the Changjiang flood, on the contrary, it impedes the discharge of the Changjiang flood. So we can see, under natural state, the Poyang Lake is passive in regulating the flood of the Changjiang River as well as the five big rivers. Though

the lake possesses a volume great as $252 \times 10^8 \text{m}^3$, its regulating function is limited and inopportune. It can not play the role of a natural water regulating and storing reservoir assumed by people. To effectively prevent the flood in the Poyang Lake district as well as better regulate and store the flood of the Changjiang River and the five big rivers, we must practice artificial control on the lake; manage the water in a scientific way; relatively stabilize the lake level; harmonize the relationship between the Changjiang River, the Poyang Lake and the five big rivers; make it truly beneficial to the Changjiang, the lake and the five big rivers; turn the Poyang lake into a real regulating and storing reservoir of the Changjiang River. An artificial control of the Poyang Lake is not only good for the prevention of the flood, but also good for making full use of the water resources in generating electricity; improving the navigation conditions of the lake district; replenishing the Changjiang water during the dry season, it is also beneficial to a rational overall arrangement of water consumption in the lake district and the lower reaches of the Changjiang River thus lessen the silt deposit at the mouth of the Changjiang River due to the backward flow of the sea water. A relatively stabilized lake level under artificial control is not only beneficial to the aquaculture, propagation, planting industry and the eradication of schistosomiasis, it is also good for strengthening the lake's function in moderating the climate, and improving the weather conditions of the lake district. In this way, the comprehensive advantages of the lake and its water resources can be brought into full play. An artificial control over the Poyang lake not only benefits the lake itself but also the yangtze River, hence the comprehensive renovation of the yangtze River should be coordinated into an overall arrangement. on the other hand, we shall not fail to notice that, an artificial control on the Poyang lake may produce various effects on the lakebeach-grassy sandbar ecosystem, the water ecosystem, farmland ecosystem and the social economic system in the lake district. For this reason, we must work out counter measures and put forward alternative programmes so as to make the Poyang lake ecoeconomic system as a whole yield its best comprehensive benefit.

After the harness of the "five rivers " and the artificial control of the Poyang lake, a comprehensive renovation of the mountains, the Poyang lake and the Changjiang River can be achieved. Thereby the ecoeconomic design for a reasonable-structure and optimum functioned land water facies ecosystem of the Poyang Lake drainage area can be realized, which in turn will greatly push forward the harmonious development between economic construction and environmental protection in the whole of the Jiangxi Province. A controllable, relatively stabilized water level of the Poyang lake will provide excellent conditions for the establishment of a fine-circled water-land facies ecosystem in the Poyang Lake district, thus makes it possible for us to achieve the strategic aims in renovating the Poyang Lake, which have been defined by "Studies on the Comprehensive Survey and the Renovation of the Poyang Lake District", a national major achievement in science and

technology, These aims include: Bringing under control the natural calamities such as flood, waterlogging and drought etc., utilizing the land resources scientifically: Readjusting the economic structure rationally: Giving full play to the agricultural advantages as well as the comprehensive advantages of the lake, the ports and the water resources; with the market as the guide, Developing an industrial system focused on foodstuff, light industry, textile, building materials, forage and tourism: Building the Poyang Lake district into an area that bears the features of water-land ecoeconomic system, an area that is technically advanced, environmentally graceful, an area where people enjoy a happy life.

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