Exploitation of the Lakeshore Districts under the Guidance of Healthy Lake Concept

Planning Practices of Wutong Lake Ecologically Creative City in Wuhan Urban Agglomeration, China

Kai Peng, Institute of Digital city and Urban planning, Huazhong University of Science & Technology, China
Junqing Zhou, Institute of Digital city and Urban planning, Huazhong University of Science & Technology, China
Junlei Yang, Institute of Digital city and Urban planning, Huazhong University of Science & Technology, China

1. China's Urbanization and Its Impact on Lake Environment

Since the reform and opening up in 1978, China has made great advancement in urbanization: the urbanization rate has soared from 17.9% in 1978 to 45.7% in 2008; the number of cities have increased dramatically, totaling 655 by the year of 2007; and several large-scaled and well-connected metropolitan agglomerations have been formed around the Yangtze River Delta, the Pearl River Delta and Jing-jin-ji Area.

Urbanization is a process of population agglomeration associated with the increase in the number of population gathering point and the expansion of individual gathering point. Either forms of agglomeration will bring about double effects: on one hand, it accelerates rural-urban migration, and the scale effect brought about by the concentration and interaction of all kinds of activities can boost regional economy; but on the other hand, frequent and intense human activities involved in urbanization may bring damages to natural resources and ecology.

Lakes, which provide human beings with resources necessary for survival and sustainable development, are the most fragile ecosystems in the nature. With the acceleration of China's industrialization and urbanization, the invasion of human activities, particularly the development of lakeside regions, have aroused serious environmental concerns, such as water pollution, eutrophication, etc. These problems break the ecological balance of lakes and degrade their natural functions. It is unrealistic to ban all development activities for the purpose of protecting environment because residents near the lakeside harbor wishes for relying on lake resources to develop economy and improve living standard. Therefore, how to reconcile the urbanization with the protection of population, resource and environment, and how to initiate construction projects within the carrying capacity of lake ecosystem to bring the value of resources into full play without violating natural rules and stability is the problem to be explore in this paper. In order to address this problem, the paper introduces the concept of "lake ecosystem health" to serve as a guiding principle that must be observed in the planning and construction of lakeside regions.

2. The Concept of "Healthy Lake"

Drawing on the Ecosystem Health Theory, the paper introduces a new concept Healthy Lake. Taking the lake and its ecosystem as an organism, the state of being healthy refers to a state in which a balance is kept between the economic benefits and the ecological returns. In other words, the lakeside regions can not be overdeveloped beyond the ecological carrying capacity limits of the lake; all the activities should be carried out on the premises of guaranteeing ecosystem health.

2.1 The Connotation of Ecosystem Health

Ecosystem Health is an interdisciplinary theory developed on the basis of natural science, social science and health science. It was popularized in 1980s' North American countries as a response to the deteriorating global natural ecosystem at that time.

Applying the notion of human health to ecosystems, Ecosystem Health integrates researches on human activity, social organization, natural system and human health. This concept emphasizes the ability of an ecosystem to restore its vigor and maintain organization and autonomy over time after external shocks, and aims at protecting and enhancing the resilience capacity of an ecosystem and regulating human activities within the carrying capacity of an ecosystem.

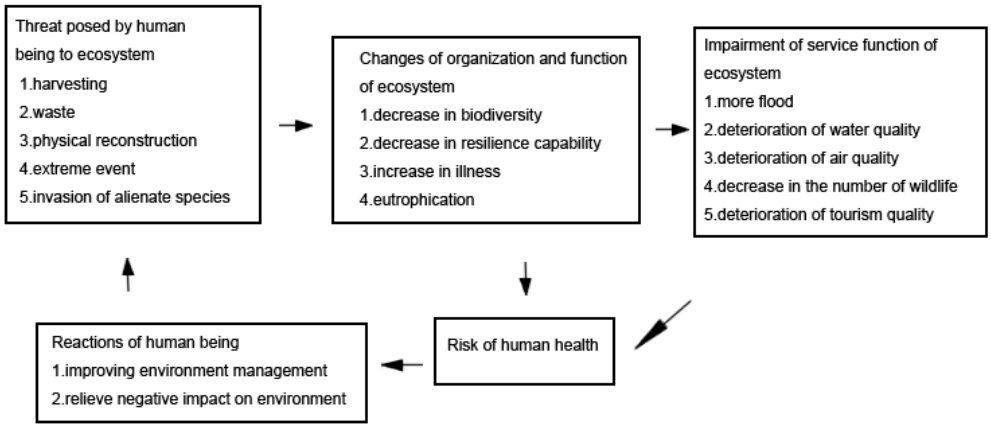

Figure 1:Linkages between human activity and ecosystem health
Source: Rapport D J,Costanza R,McMichael A J.(1998)"Assessing ecosystem health", Trends in Ecology&Evolution,Vol.13 No.10(Oct.)

2.2 The Concept of "Healthy Lake"

"Lake health" is the extension of the concept of ecosystem health to the sphere of lakes. It has two theoretical foundations, one is the ecosystem health theory and the other is the theory of material circulation of lake ecosystems. The former theory includes a set of assessment techniques and indicator system, and three main indictors to describe the ecosystem state are: vigor, organization and resilience. The latter theory highlights the unique characteristics of lake ecosystem. Formed in a variety of ways, different lakes exhibit different ecological functions and organizations. Lake ecosystem, as a nature-society-economy compound system, has complicated system structure, with system components interacting in a complex manner.

The concept of healthy lake should not be understood literally as healthy state of lake ecosystem. It should be understood as an extension of the concept of sustainable development, which focuses on striking a balance between reaping economic benefits and protecting lake ecosystem

2.3 Feasibility of Applying Lake Ecosystem Health in Planning and Construction of Lakeside New City

The aim of analyzing the lake ecosystem health is to judge whether an ecosystem is healthy or not with multiple measuring indexes and criteria. This is a descriptive and evaluative process, in which theories in ecology and environmental science are needed.Though the assessment of ecosystem health, as a new branch of science, is still on the experimental and initial stage, and there is a vast deal of dispute over a host of issues, researchers have reached wide consensus over one issue, that is human activities in various forms, such as

waste emission, non-point source pollution, overfishing, land reclamation from lakes are the major cause undermining the stability of ecosystem health. Therefore, introducing the concept of "lake ecosystem health" into urban planning, to be specific, the planning of lakeside regions, suggests a transition from old human-centered planning conception to lake-centered conception. In fact, human-centered planning and lake-centered planning are not two concepts in stark opposition. As is shown in Figure 1 above, human being are the integral part of ecosystem, so the impact of human activities on ecosystem will eventually find a way to act upon human being. Therefore, to improve the performance of several indexes of lake ecosystem health and to achieve the ultimate objective of "healthy lake" by controlling planning factors is theoretically feasible. These controlling measures include limiting population capacity, dividing lakeside regions into different ecological sensitive zones, regulating developing intensity and introducing industries with little impact on lake environment, etc.

We used to take a materialistic outlook in developing the lakeside regions by merely focusing on economic and social benefits while neglecting ecological efficiency. Even if we put ecological environment into account, we seldom planned and designed the project entirely from the perspective of lake ecosystem health in the first place; instead what we usually do is to first decide the industrial development pattern and then make efforts to restore ecological system. The costs and effects of this compensation scheme are less than desirable. But it is also wrong to go to the other extreme, refraining any kind of construction work by the lakeside to "protect" the ecological environment. We believe that development activities should be allowed near the lakeside so long as they are conducted within the ecological carrying capacity and resilience limits of lakes in dynamic situations. And it is based on this notion that we will begin our discussion about organizing and guiding development planning near lakeside in this paper.

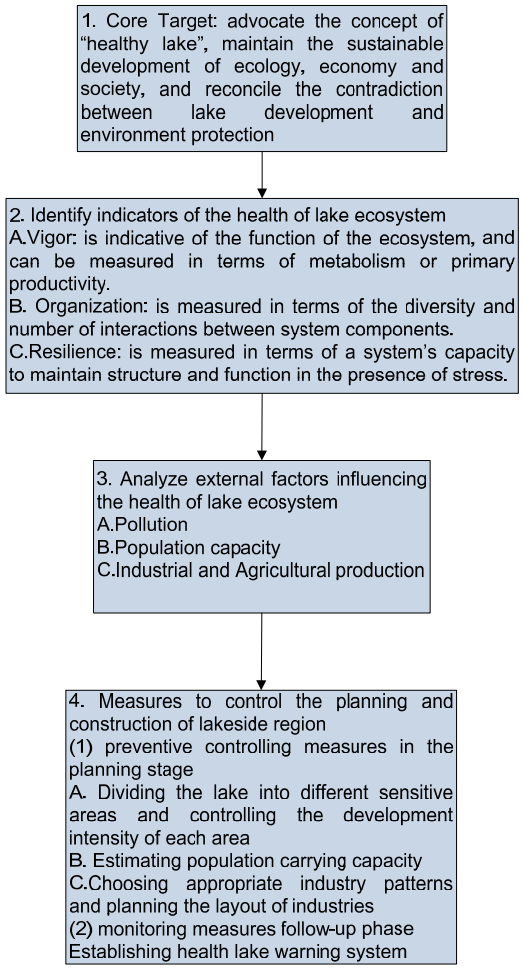

Figure 2: Technology Roadmap of planning and construction of lakeside region with the objective of maintaining healthy lake
Source: The author's own study

3. Case Study: Planning and Construction of Wutong Lake Ecologically Creative City in Wuhan,China

3.1 Implication of establishment of Wuhan Urban Agglomeration for protection and development of lakes

In December, 2007, the State Development and Reform Commission(SDRC), issued, upon the consent of the State of Council, a circular on Authorizing Wuhan Urban Agglomeration and Chang-Zhu-Tan Urban Agglomeration as National Comprehensive Experimental Zone Supporting the Building of Resource-saving and Environment-friendly Society. Wuhan Urban Agglomeration is a regional economic union centered on Wuhan and radiated to 8 neighboring cities within 100 kilometers, Huangshi, Erzhou, Xiaogan, Huanggang, Xianning, Xiantao, Qianjiang, Tianmen. According to the requirements of building resource-saving and environment-friendly society, Wuhan Urban Agglomeration advance reforms in all fields and is committed to finding a new urbanization and industrialization path.

However, Hubei Province of China is known as the "province of thousand lakes". Accompanied by industrialization, urbanization and global climate change, it faced with

several problems such as degradation of the lake ecosystems, rapid reduction of lakes. It is the key issue to handle the relations between lake protection and urbanization correctly for building Resource-saving and Environment-friendly Society.

Since being officially approved as experimental zone for building resource-saving and environment-friendly society, Wuhan urban agglomeration has made unremitting efforts to achieving “five integrations”: the integration of infrastructure development, the integration of industrial development and layout, the integration of rural and urban development, the integration of banking services, and the integration of resource ecology development.
The proposal of the Wuhan Greater East Lake Ecological Water Network Project and the River-Lake link Project represents government’s initiative to develop and preserve the ecological environment in Wuhan Urban Agglomeration.

We believe that the establishment of Wuhan Urban Agglomeration would provide a good policy environment for using the concept of “healthy lake” in the development of lakeside areas.

3.2 An Overview of Research Area

Development Background and Site Selection

The Research site is located within Liangzi Lake District. Liangzi Lake, the second largest freshwater lake in Hubei Province, is located in the southeastern part of Hubei and situated in the south bank of the middle reaches of Yangtze River. It passes through the central part of Wuhan Urban Agglomeration(Wuhan, Erzhou, Huangshi and Xianning), with a drainage area of 2085 km^2 .

With the acceleration of Wuhan Urban Agglomeration development, it is inevitable that more and more human activities will invade into the lake district. The development of industry ,agriculture and tourism around the area have polluted the Liangzi Lake. Under the guiding principle of “Protection First” and “Sustainable and Concentrated Development ”, we need to conduct a comparison analysis of different sites in the lake district and select the sites with greatest development advantages as the anchor of development. In this way not only can we gather up strength to develop one site, but also can strengthen the protection over larger water areas.

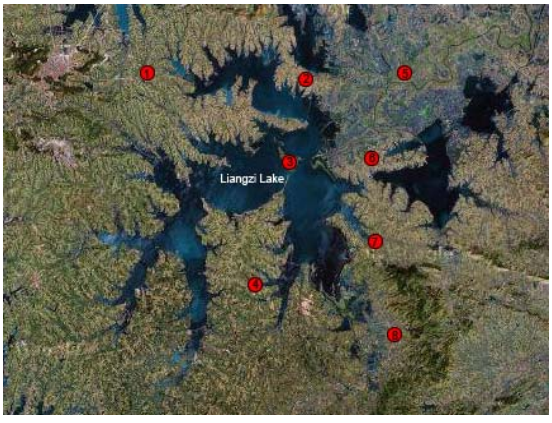

Figure 3:Site Distribution Map of Wutong Lake Eco-friendly city
Source: Google Earth and Author self-drawn

By comparing the advantages and disadvantages of different sites, we can sift the sites with superior aquatic resources and greatest development potentials. Then by referring to the description of function orientation and planning of each site in the “Ezhou Rural-Urban Master Planning Outline (2009-2020) ” and the “Master Planning for Great Liangzi Lake

Ecotourism Resort（2010-2030）", we shortlisted the second candidate site for the final project site.

Condition Analysis of Planning site

The planning area is bounded by Changgang town to the east, Liangzi Lake to the south, Honglian Avenue (Connecting Miaoling Town and Liushi Village of Donggou District) to the north, and Fenglian Avenue(Connecting Phoenix mountain and Liantai bank in Wuhan) to the west. Administratively, the planning area covers four villages Yueshan, Liushi, Zhazhou, Dalong in Donggou town, with an area of 41.23 km^2.

Figure 4: Location map of Wutong lake eco-city
Source: Google Earth and Author self-drawn

The condition of land resource in the planning area is superior, with no liability for geological hazard. The land resources available mainly include basic farmland, general farmland, woodland, garden plot, construction land in villages and towns, reclamation area.
Lying south to the Wutong Lake and north to the Liangzi lake, the planning area is integral in lake ecosystem, rich in biodiversity and superior in water quality. It is also an important habitat for many rare and endangered wild aquatic animals and plants. Therefore, it satisfies all the conditions required for experimental resource-saving and environment-friendly development zone.

Existing Problems and Challenges in the Planning area

The first problem is that the industries in the planning area are unevenly developed, with the primary industry well developed, while secondary and tertiary industry relatively backward. Secondly, though located in the hinterland of Wuhan-Ezhou corridor and Linking industrial zone along Yangtze River and Wuhan East Lake high and new technology development zone, the unique geographic advantage of the planning failed to stimulate the economic development effectively for so long. Besides, when developing the planning area, we must try out best to appropriately handle the relationship between construction work and lake protection and we must focus on developing industries that match the resource advantages of lakes.

3.3 Implementation of Technology Roadmap

Setting Up Core Target

The orientation of developing an innovative and ecological new city is in consistency with the ultimate objective of maintaining "healthy lake". "Innovative city" highlights the pioneering and creative developing ideology incorporated in the planning of Wutong Lake City; and "Ecological city" is a manifestation of the priority given to the "healthy lake" in the process of lakeside region development.

Analysis of Current Lake Ecosystem Health State and External Influencing Factors

First of all, we will carry out an assessment analysis of the current health state of lake ecosystem with three indicators mentioned above: vigor, organization and resilience.

The organization index can reflect the community structure of aquatic organisms inside the lake. According to the Liangzi Lake Ecological Environment Protection Plan （2010-2014）, the Liangzi Lake well conserves the rich biodiversity and genetic diversity and is a habitat for many rare species. There are more than 280 kinds of vertebrates and about 92 advanced aquatic plants in the lake. It can be assessed that the organizational structure of Liangzi Lake is stable.

If the energy and matter of a natural ecosystem can provide sufficient sustenance for organisms living in the system, and can repair and adjust automatically to maintain dynamic balance, we say that this system has a high level of resilience and vigor. Thanks to the low exploitation rate and the abundant water grass, the water pollution of Liangzi Lake is not severe and the self-purification capability of water is high. The water quality of the eastern part of the Liangzi Lake, where the planning site is located, reaches the third class. But we also have to be aware that the trophic state of Liangzi lake has degraded from oligotrophic level to mesotrophic lake, with part of water area even approaching eutrophic level. To sum up, the resilience and vigor of planning area is in generally good state, but has a tendency toward worsening.

Currently the factors that influence the ecosystem health in planning area include:

（1）Increase of pollutant emission from land

As most of small towns along Liangzi Lake do not have standard domestic sewage treatment facilities and waste landfills, large quantity of domestic sewage organic waste was discharged into nearby rivers and finally flowed into Liangzi Lake.

(2) Undesirable effect of agricultural production

On the farmland within the Liangzi Lake, fertilizers and pesticides are used excessively. As a result, when the rain falls, pollutants like nitrogen and phosphorus will flow into Liangzi lake with surface runoff, resulting in the high concentration of nitrogen and phosphorus in the lake.

(3) Dispersed pollution sources

Alongside the Liangzi Lake scattered a number of small towns. Because of the lack of proper industrial and domestic sewage treatment facilities, these towns have become hotbed for multi-point pollution sources. Based on this fact, we propose the plan of Wutong innovative and ecological city in the expectation of centralizing dispersed population. Of course, it should be kept in the mind that the population capacity should not exceed the ecological carrying capacity of the lake.

Controlling measures in the planning of Wutong Innovative and Eco-friendly city

(1) Preventive controlling measures in the planning stage

a. Division of ecological sensitive zones and Control of Development Intensity

An ecological sensitive area is a designation for an area which is of great significance for urban ecological environment because it has ecologically important elements or entities, which needs special protection because of its comparatively poor capability to counter against external disturbance and poor self-restoring capability. Considering the following factors like the distance to the lake, the self-restoring capacity, the distribution of population aggregates, and the distance to the major transport corridor, we divide the planning area into extremely sensitive area, sensitive area, less sensitive area and insensitive area. What's more, by giving full consideration to the ecological environment conditions in lakeside regions, the potential and availability of water resource and the actual economic development demand, we make an initial decision about the development intensity and industry patterns allowed by areas with different sensitive degrees.

Grade of sensitive area	Categories	Scope	Land planning	Construction industries	Exploitation intensity
Extremely sensitive	Absolute protection area	—	Water area	No industry suggested	Preservation first, development banned
Sensitive	Key protection area	<0.3KM	Water area, garden, land for tourism and sightseeing, land for touring facilities	Eco-agriculture, eco-tourism	Plot ratio<0.6
Comparatively sensitive	Preservation area	0.3KM - 1.5KM	Land for urban residential area can be added, land for public facilities, land for service industries	Agriculture, tourism, scientific and educational industry, low-density residence	Plot ratio <1.2
Insensitive	Key developed area	>1.5KM	The first class of industrial land can be added, land for commercial service	Clean industry and cultural creative industry	Plot ratio <2

Table1: Grade and construction suggestion of lakeside sensitive area
Source: The author's own study

Extremely sensitive area should be designated as absolute protection area because of its great ecological significance. These areas include surface of lake, wetland, etc, where development activity of any kind should be strictly prohibited.

Sensitive area should be designated as key protected area. These areas are of medium ecological significance and mainly include the ecological buffer area within 0.3 km around the lake, and the ecological buffer area around mountain and water area. These areas should be moderately exploited for sightseeing and touring, but high-intensity development activities should be banned.

Comparatively sensitive area should be designated as controlled exploitation area. In these areas, on the premise of controlling exploitation scale and intensity, we can moderately exploit tourism projects and introduce educational and scientific industries. Besides, domestic and industrial sewages can be centralized for treatment and emission here. These

areas can be developed into different functional areas, such as residential area, touring area, sports and leisure activities area and area for modern science and technology exhibitions. Insensitive area should be designated as key development areas because these areas face few ecological constraints, have strong development demand and convenient transport facilities. These areas can be developed into business conference center and enterprise incubators.

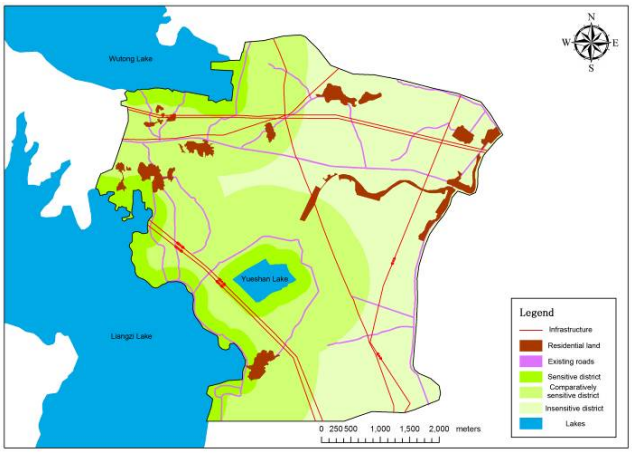

Figure 5: Dividing of lakeside sensitive area
Source: The author's own study

b. Estimation of population carrying capacity

The population estimation is conducted in two ways in this paper, which is to estimate proper population size based on ecological environment protection and estimate based on the water resource carrying capacity

(1) estimation of proper population size based on ecological environment protection

① calculating according to national requirements on the ratio of urban green space in construction land and per capita green space

It is regulated that the ratio of urban green space in construction land is 8% -15%, with per capita green space ≥9m². According to this requirement, we can get the formula to calculate the proper population size and optimum population size of the new city,

Cm=(100×QL×gm) /Gm

among which, gm is proper ratio of urban green space in construction land(%)

Gm is the proper green space per capita (m²)

QL is the total area of construction land (m²)

Let QL=27km², Gm=9m², gm=15%, the proper population size is 450,000.

② Calculating according to national standard for Garden City

It is regulated in 2010 that urban open space coverage rate should not be lower than 30%. The average green space per capita nationwide is 21 m2 , in contrast, The average green space per capita in 12 garden cities is 44m2. By referring to these two data and considering the fact that Wutong Lake Ecologically Creative City has rich open space and water system, we set the green space per capita in the future Wutong Lake area at 40m2, and the green space coverage rate at 30%, so we have the empirical equation:

Cm= (100×QL×30%) / Gm from which we get that the optimum population size of Wutong Lake new city is 200,000.

(2) estimate of population size based on the water resource carrying capacity

Ecological environment is biggest advantage owned Wutong Lake Innovative and Eco-friendly New City, but it is also the most fragile element in the development, to which

irreversible damages may be caused by extensive and excessive development. Therefore how to reconcile the development with the protection of water resource and environment is the top issue on the planning agenda.

According to the water environment capacity we can decide the environment capacity taken up by domestic sewage in the residential area; and by referring to relevant indexes in the Comprehensive Discharge Standard Of Sewage In Urban Sewage Treatment Plant , we can decide the domestic sewage discharge amount allowed in residential area q_V . According to the fixed domestic sewage discharge amount regulated in the planning area, we can calculate the population carrying size with the following formula,

$$N = \frac{q_V \times 24 \times 3600}{q_{Vn} \times K}$$

among which N is the population carrying size in the planning area (person)

q_V is the domestic sewage discharge amount allowed in residential area (L/s)

q_{Vn} is the fixed domestic sewage discharge amount regulated in the planning area(L/person•d)

K is the general variation coefficient, which is decided by the discharge amount of domestic sewage in the residential area.

The planning area have multiple different function areas, such as the recreation and resort area, the farmland surrounding the lake, sport facilities and parks and residential and office areas, etc. Therefore, in the planning area is subject to non-point source pollution. The environment capacity taken up by domestic sewage in residential area is: COD=21.5 t/d ; NH3-N=0.6 t/d. Depending on different degrees of treatment of domestic sewage, the population carrying size in different cases can be estimated

The fixed discharge amount of domestic sewage in the planning area is 270 L/person·d. With different control factors of COD and NH3-N, the population carrying sizes are estimated as in Table2.

Basic control items	First-class standard		Second-class Standard	Third-class Standard
	A standard	B Standard		
Chemical Oxygen Demand（COD)	50	60	100	120
ammonia nitrogen（N）	5（8）	8（15）	25（30）	——

Table 2: Maximum allowed discharge concentration of basic control items(mg/L)
Source: Discharge standard of pollutants for municipal wastewater treatment plant (GB 18918－2002)

Sewage discharge condition and standard		Third class	Second class	First class B	First class A	Emission
population carrying size （10,000）	Control factor COD	51	61	102	122	＞ 122
	Control factor NH3-N	-	6.8	21	34	＞ 34

Table 3: Estimation of population carrying size in different cases of sewage discharge
Source: The author's own study

It can be seen from the above table that the estimation of population carrying size by control factors COD and NH3-N in differs greatly in the different cases of sewage discharge. As Wutong Lake is a body of water cut off other waters, the eutrophication phenomenon is apt to occur when chemicals N and P accumulates. Therefore, we must use NH3-N as the control factor to decide the population carrying size of Wutong Lake planning area. With different drainage amount, the population size in the planning area should be controlled within the range of 6.8 to 34 thousand people.

According to the Comprehensive Discharge Standard Of Sewage In Urban Sewage Treatment Plant（GB18918-2002）, the water discharged from urban sewage treatment plant should fall into Grade Ⅲ surface water (drinking water source zone and swimming pool excepted), and should be treated by First class B standard. By this standard, the population size in the planning area should be controlled below 210,000.

Combining the above two estimations, it can be concluded that the proper population size in the planning area is 200,000.

c. Choice of Industry patterns and layout of Industry distribution

The choice of industry patterns in the planning site must conform to the objective of “healthy lake”. Four industries are chosen as leading industries in the lakeside region, which are the environment protection industry, high science and technology industry, cultural originality industry and tourism industry.

Environment protection industry

Environment protection industry engages in a range of activities from the product development, commercial circulation, resource utilization to information service with a purpose of preventing and controlling environmental pollution and improving ecological environment. Wutong Lake Ecologically Creative City can serve as a pilot area for the development of environment protection industry. In this experimental zone, the production, research and learning processes are integrated to create a win-win situation, with the R&D results of industry being applied to improving lake ecosystem directly. As for the businesses run by environment protection industry, besides conventional businesses such as manufacturing and selling environment protection equipments and providing environment protection services, we can also derive other forms of business such as opening up environment protection exhibition center, etc.

Scientific and Technological pilot test

As far as the development of Wutong Lake Ecologically Creative City is concerned, the Scientific and Technological pilot test can effective promote the establishment of incubators and attract modern manufacturing and research institutions to join. There are a lot of modern manufacturing enterprises, research institutions and universities located in Wuhan, equipping Wuhan with strong research power. But because of the lack of communication and cooperation platform for research institutions, universities and enterprises, each unit is conducting scientific and technological pilot tests independently, which is unfavorable for the integration of technology resources. Therefore, establishing the largest scientific and technological pilot test base of Central China in Wutong Lake innovative and eco-friendly new city provide a golden chance to integrate product research and test resources, to organize large research teams to make technological breakthroughs, which is not only conducive for the sustainable development of Wuhan’s modern manufacturing, but also provides a platform to transform research results into productivity as quickly as possible.

Cultural Creative Industry

Cultural creative industries refer to a range of economic activities which are concerned with the creation and elevation of cultural resources by high technologic means and by use of the wisdom, skills and gift of human being and the generation of high-added value products by

developing and exploiting intellectual property rights. Internationally recognized as low-pollution and high-profit industry, Cultural creative industries can yield great fortunes and create job opportunities are, and thus extremely suitable to be introduced in the lakeside region. Wuhan East Lake high science and technology zone and many universities and colleges located near the Wutong Lake area can provide specialized talents to promote the development of regular industries like design, advertisement exhibition, software and computer service, theme residence, tourism and specialized service.

Lake tourism

Taking full advantage of rich lake resources, beautiful natural scenery, unique lake and wetland landscape, and convenient land and water transport conditions inside the planning area, we can build Liangzi Lake tourism brand by building the vacation resort, and developing water sports industry as well as special aquatic products cultivation industry.

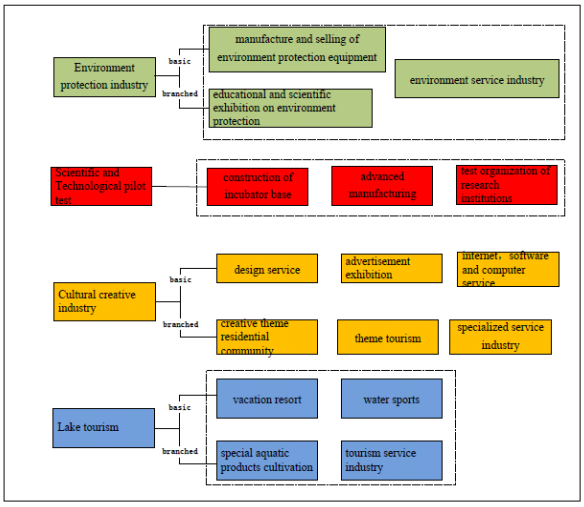

Figure 6: Industry pattern of Wutong Lake Ecologically Creative City
Source: The author's own study

(2) Establishing long-term warning mechanism to protect lake health

In order to maintain the lake health ecosystem, we not only need to take cautions in initiating development, but also have to establish a long-term monitoring and warning system to assess the impact of the development on ecosystem health continually and give prompt feedback and to establish a set of effective contingency plans to minimize the negative effect in case that events hazardous for environment break out.

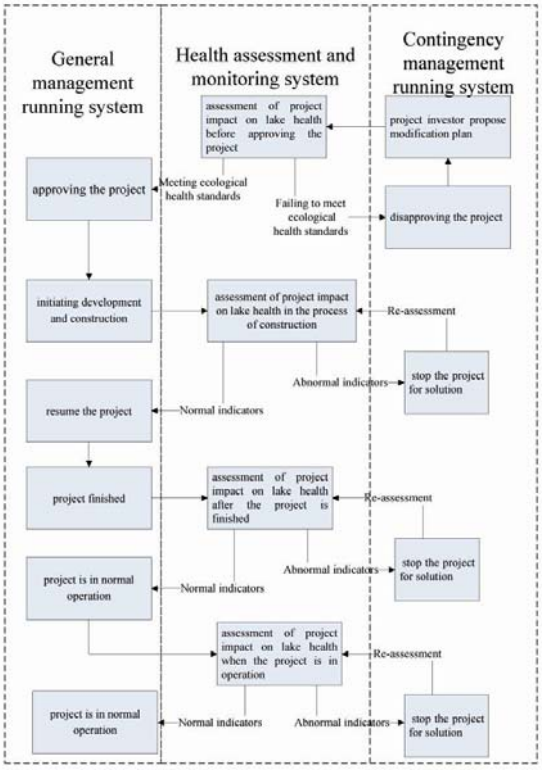

Figure 7: Healthy lake monitoring and warning system
Source: The author's own study

4. Conclusion

With the rapid urbanization of China, lake environment faces severe ecological challenges. In order to address the contradiction between economic development and lake protection, the paper proposes the concept of "healthy lake", and uses this concept as an orientation to direct the planning and construction of lakeside regions. The lake-centered planning mode that differs from the traditional human-centered planning mode complies with the sustainable development conception and can accelerate the transition and development of lakeside regions scientifically and successfully. The Wutong Lake innovative and eco-friendly new city has now been under construction and the author will follow the development of the project to make prompt adjustment and modification to the theory and methodology proposed in the paper.

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