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Research on the Urban Population Carrying Capacity and Risk Management Based on Possibility-Satisfiability Method —Take the City Proper in Northern Jiangsu as an Example

Fengjuan Liu*

Associate Professor

Wuxi Environmental Science and Engineering Research Center, Jiangsu, 214153

Lixin Qu

Professor Nanjing University of Aeronautics and Astronautics, Nanjing 210016

Abstract:

There is a certain gap between urban construction in Northern Jiangsu and requirement of modernization construction in Jiangsu Province. Therefore, urban areas' economies, resources and environments and the population carrying capacities in Northern Jiangsu need to be analyzed by the decision makers in order to regulate and perfect it. This paper selects some indicators of representing economics, resources, the public infrastructure, environments and quality of the population health to analyze the population carrying capacity of urban areas in Northern Jiangsu by means of single-factor and multiple-factor possibility-satisfiability method. Then, according to the above result and the existing data of the selected indicators, this paper gives some advices about risk management in the population carrying capacity such as strengthening infrastructure construction, improving the park green area per capita, driving the development of the industry chain by means of ecological agriculture and reinforcing the innovation in science and technology to enhance the attractive power for the non-native population.

Keyword: The city proper in Northern Jiangsu, Modernizing construction, The population carrying capacity, Possibility-Satisfiability Method, Risk Management

1. INTRODUCTION

China government deliberated and passed a coordinated plan for deepening the reform of fiscal and taxation system(Xinhua,2013) and the opinions on further promoting the reform of household registration system on June 30, 2014(Luan and China.org.cn, 2014). They are guided documents for the allocation problems about fiscal and tax between the central and local government and the settlement about transfer population of rural labor working in the city(Xinhua,2013; Luan and China.org.cn, 2014). It shows that the government has expanded the registration of rural migrant workers as permanent urban residents to the normal plan and management. However, the amount of population that a city accommodated is limited by some factors such as economy, resources, environmental sanitation, public infrastructure and the guarantee of the people's health quality in different urban area. But the measure of the limitation needs to use some indicators related to the population carrying capacity to make estimation. Therefore, it is very important for the policy makers to analyze the population carrying capacity of these urban areas under the condition of the existing or future index data.

The document about the plan of the new type urbanization and the integrated development in urban and rural regions in Jiangsu Province (2014-2020) puts forward to conduct registration of rural migrant workers as permanent urban residents in an orderly way, optimize the urban and rural space layout and form, enhance the level of urban and rural social development and strengthen the ability of urban and rural sustainable development. Meanwhile, it mentioned system and mechanism, especially system reform measures concerned with the development of urban population to promote the reform of management rule of the population service, to deepen land management reform and improve urban housing system and reform the urban management system and so on (Xinhua, 2014). In order to realize the plan, index system of the basic realization of the modernization in Jiangsu province (revised in 2013, the trial) can be applied to analyze the development status of certain urban area. They are real GDP per capita, invention patent ownership per 10,000 persons, pension institutions bed possession per 1000 elderly people and doctors per 1000 persons(The Planning Office in Jiangsu Development & Reform Commission,2013). Therefore, it is very important and vital for economic development, environment protection and the sustainability of resources of the different urban area in the northern Jiangsu to predict their population carrying capacity to make the corresponding polices.

However, it is not suitable for researching about the urban population of the northern Jiangsu to use some methods of measuring the population bearing capacity such as the carrying capacity of land resources, ecological footprint (Zhang et al. 2011; Wackernagel and Rees, 1997; Wang et al. 2007) and emergy analysis(Wang et al. 2007; Odum and Nilsson, 1997) because their scope of application are limited to the closed strong area. But the Possibility-Satisfiability (P-S) method (Wang et al. 2007) can be applied to research on the population carrying capacity of urban area of the northern Jiangsu because it can set possible function and satisfaction function according to the optimal goal (WANG, 1986).

In china, a lot of scholars use the P-S method to calculate the population carrying capacity of certain region. For example, Feng lei use some index like GDP, government revenue and expenditure, investment in fixed assets, retail sales and value-added of the tertiary industry, area of green land in urban district, enrollment, the total electricity consumption and licensed (assistant) doctors per 10000 persons, etc. to analyze the population carrying capacity of Tianjin, Beijing-Tianjin-Hebei Metropolitan Region and Shandong Peninsula Agglomerations by means of the P-S method (Feng, 2009). Some authors use some indicators that illustrate food, land, water, energy, GDP, the dynamic process of population and international competitiveness of population to analyze the optimum scale of China's population by means of the P-S method (WANG et al. 2011). Some researchers use some index that illustrate economy, employment, air quality, water resources, water quality and life congestion to analyze the population carrying capacity of Wuhai City in Inner Mongolia Autonomous Region by means of the P-S method(ZHANG et al. 2009).

In this paper, the P-S method and some indicators like reflecting economic development, energy consumption, land use, transport facilities, the population quality and environmental protection are applied to measure the population carrying capacity of the urban area of the Northern Jiangsu. The population refers to urban resident population.

2. RESEARCH ON THE POPULATION CARRYING CAPACITY OF THE URBAN AREA AND ITS RISK MANAGEMENT IN THE NORTHERN JIANGSU BASED ON THE MODERNIZATION INDEX IN THE 13TH FIVE YEAR PLAN

2.1 The analysis of urban population in the Northern Jiangsu

The urban area in the Northern Jiangsu includes the urban district in Xuzhou City, Lianyungang city, Huaian city, Yancheng city and Suqian City.



Figure 1 The distribution diagram of urban resident population in the Northern Jiangsu

As shown in Figure 1, the number of urban resident population in the Northern Jiangsu slowly climbed to 10.09 million people in 2013 from 9.88 million people in 2001. It grew at an annual rate of 1.05%. Among them, urban resident population of Lianyungang City increased by 2.21% because the population had a 3.96% rise from 2011 to 2012; urban resident population of Suqian City went up by 2.29% because the population in 2013 increased by 3.74% over 2012; urban resident population of Xuzhou City increased by 0.88% because the population in 2013 increased by 1.05% over 2012. Urban resident population of the other cities in the Northern Jiangsu had very small change. These data imply that the economic progresses of the urban areas in the Northern Jiangsu are very slow during the 12th Five Year Plan. Therefore, their attractions for the foreign population are less.



Figure 2 The distribution diagram of urban resident population in the Northern Jiangsu in 2013

As illustrated in Figure 2, urban resident population of Xuzhou City, Huaian City respectively accounts for 31.39%, 26.51% of that of all cities in the Northern Jiangsu in 2013,; urban resident population of Yancheng City was 1% higher than that of Suqian City, the proportion of that of Lianyungang City is the smallest, 10.93%. Thus, the distribution of urban resident population of cities in the Northern Jiangsu is sparse.

2.2 Research on the Population Carrying Capacity of the Urban Areas in the Northern Jiangsu and their Risk Management Based on the Modernization Index

2.2.1 Selection of indicators and their valuation of the Population bearing Capacity of Urban Area in the Northern Jiangsu

As indicated in Table 1, the city proper of cities in the Northern Jiangsu includes 5 urban areas as is that in the Southern Jiangsu. And urban areas of cities in the Middle of Jiangsu only consist of three urban districts. But the nominal GDP of urban districts of cities in the Northern Jiangsu that is 6110.15 billion yuan is 727.83 billion yuan higher than that in the Middle of Jiangsu, the nominal GDP of urban districts of cities in the Southern Jiangsu is 2.83 times higher than that in the Northern Jiangsu in 2013. The data indicate that urban districts in the Northern Jiangsu need to strengthen its industrial restructuring and upgrading to promote its soft power and raise the speed of economic development. However, the growth rate of the real GDP per capita of urban area in the Northern Jiangsu is higher than that in the Middle of Jiangsu, but lower than that in the Southern Jiangsu in the first three years of the 12th Five Year Plan. It implies that the economic status of urban districts in the Northern Jiangsu began to be on the mend. Therefore, as shown in Figure 1, its resident population had an increase than before.

As far as resource factors are concerned, as given in table 1, water resources in the Northern Jiangsu are rich. But its water consumption for residential use per capita is only 79.96 litre, 17.99 litre lower than that in the Middle of Jiangsu, 81.03 litre lower than that in the Southern Jiangsu; its electricity consumption of urban and rural residents per capita went up 16.43% in 2013 over 2011, is 606.9 (KWH/Person), lower than that in the Middle of Jiangsu and the Southern Jiangsu. These data show that the quality of life of urban residents in the Northern Jiangsu is much lower than that in the Southern Jiangsu. Nevertheless, for land resources, area of land used for urban construction per capita in the Northern Jiangsu increased to 76.99 sq.m. in 2012 from 68.69 sq.m. in 2011. It is similar to that in the Middle of Jiangsu and the Southern Jiangsu and the Southern Jiangsu.

Area	Name of Urban district	Nominal GDP in 2013 (billion yuan)	The growth of Real GDP per capita during 2011and 2013	water consumption for residential use per capita(litre/Person)	electricity consumption of urban and rural residents Per capita(KWH/Person)	area of land used for urban construction per capita in 2012(square meter/Person)
The Northern Jiangsu	Xuzhou Lianyungang Huanan Yancheng Suqian	6110.15	8.3%	79.96	606.9	76.99
The Middle of Jiangsu	Nantong Yangzhou Taizhou	5382.32	6.79%	97.95	680.6	77.37
The Southern Jiangsu	Nanjing Wuxi Changzhou Suzhou Zhenjiang	23422.14	9.15%	160.99	830.37	78.87

Table 1 index data of urban districts in the Northern Jiangsu, the Middle of Jiangsu and the Southern Jiangsu

As far as sanitation factors are concerned, the growth of area of parks and green land per capita of urban districts in the Northern Jiangsu reaches 6.33% in the first three years of the 12th Five Year Plan. In 2013, it is 7.37 sq.m., 1.18 sq.m.lower than that in the Middle of Jiangsu. It makes clear that the green environment of urban residents in the Northern Jiangsu is improving. But the volume of garbage disposal per capita had little change, and it increased from 0.45 kilograms in 2011 to 0.46 kilograms in 2013. It suggests that the quality of life of urban residents in the Northern Jiangsu has no remarkable improvement.

For transport facilities, area of paved road per capita is 11.6 sq.m. in 2013, increased by 9.44% in the first 3 years of the 12th Five Year Plan. Its growth is higher than that in the Middle of Jiangsu and the Southern Jiangsu. It illustrates that infrastructure construction of urban districts in the Northern Jiangsu had improved. But its data per capita is much lower than data per capita of urban districts in the Middle of Jiangsu and the Southern Jiangsu. Jiangsu.

In addition, in the first three years of the 12th Five Year Plan, the number of beds in health institutions per 1000 persons in urban district in the Northern Jiangsu increases at an annual growth rate of about 11.63% and reached 6.02 by 2013. It is 0.74 more than that in the Southern Jiangsu. However, the number of licensed (assistant) doctors per 1000 persons is 2.41, close to that of urban district in the Southern Jiangsu, 0.2 less than that in urban district in the Middle of Jiangsu. These data illustrate that medical facilities and software strength of urban district in the Northern Jiangsu were better than those in the Middle of Jiangsu and the Southern Jiangsu. It implies that health protection of urban district in the Northern Jiangsu.

In brief, in recent years, some government units have taken some measures about the sustainable development of regional economy. Namely, they paid high attention to the improvement of the people's health while they stimulated the local economy through infrastructure construction. Therefore, all things considered, the selection and assignment of indicators based on P-S method are shown in table 2 for urban district in the Northern Jiangsu.

Index Name	Property	Low Value	High Value
Economic aggregate GDP(billion yuan)	Possibility	11169.59	18893.69
GDP per capita (ten thousand yuan)	Satisfiability	8.7	14.5
Water resources (10000 tons/day)	Possibility	121.34	172.9
Water resources per capita (litre/day)	Satisfiability	101	112.51
the electric power consumption of residents (million kilowatts)	Possibility	86.19	173.11
electricity consumption of urban and rural residents Per capita (Gigawatts)	Satisfiability	690	1230
area of land used for urban construction (square kilometers)	Possibility	1067.34	1530.29
area of land used for urban construction per capita (square meters)	Satisfiability	80	95
area of parks and green land (hectare)	Possibility	10815.54	16436.42
area of parks and green land per capita (square meters)	Satisfiability	9.3	12.1
area of paved road (square kilometers)	Possibility	16478.05	22820.72
area of paved road per capita (square meters)	Satisfiability	13.6	17
volume of garbage disposal (10 000 tons)	Possibility	0.57	0.95
volume of garbage disposal per capita (kilograms /day)	Satisfiability	0.49	0.7
the number of beds in health institutions (10000 beds)	Possibility	8.55	13.03
the number of beds in health institutions per 1000 persons (beds)	Satisfiability	6.5	9.9
licensed (assistant) doctors(10000 persons)	Possibility	3.42	5.54
licensed (assistant) doctors per 1000 persons (persons)	Satisfiability	2.95	4

Table 2 Indicators and their Assignment Based on P-S Method

2.2.2 Research on the Population Carrying Capacity of the Urban Area in the Northern Jiangsu and its Risk Management Based on P-S method of certain indicator of the Modernization Index

The meaning of the P-S method is expounded as follows according to documented data.

1) possibility and satisfiability : if a goal can be achieved, its possibility is the biggest, denoted by $p(\le)=1$; if a

goal cannot be achieved, denoted by $p(\ge r_B)=0$; if the value of the possibility that a goal can be achieved is

uncertain , denoted by $p \in [0,1]$. And it can be expressed by three-broken-line function in equation 1. Also , if the satisfiability for attaining a goal is denoted by q, full satisfaction is denoted by $q(\leq s_A)=1$, totally

dissatisfaction is denoted by $q(\ge s_B)=0$ and it can be expressed by three-broken-line function.

$$p(r) = \begin{cases} 1 & r \le r_{A} \\ \frac{r - r_{B}}{r_{A} - r_{B}} & r_{A} < r < r_{B} \\ 0 & r \ge r_{B} \end{cases}$$
(1)

2) the mathematical definition of the possibility-satisfiability Suppose

 $r = a * s, \forall r, s, a \in \mathbb{R}$ (set of real numbers)

Then

p(r) and q(s) are three-broken lines, their weak merger solutions are expressed in equation 2:

$$\mathbf{w}(a) = \begin{cases} 0 & \text{solution} \le 0\\ \frac{-r_B + as_B}{(r_A - r_B) - a(s_A - s_B)} & 0 < \text{solution} < 1\\ 1 & \text{solution} \ge 1 \end{cases}$$
(2)

The population carrying capacity of urban districts in the Northern Jiangsu is calculated by means of the equation above and data in table 2 and the results are shown in table 3.

 Table 3 the Population Carrying Capacity of Urban Area in the Northern Jiangsu Based on different P-S

 degree of single indicator (10000 persons)

Index	0.9	0.8	0.7	0.6	0.5	0.4
GDP	1286.85	1289.49	1291.84	1293.94	1295.83	1297.54
Water resource	1238.32	1274.44	1309.76	1344.31	1378.11	1411.19
electric power consumption of residents	1275.30	1297.92	1317.68	1335.08	1350.52	1364.32
area of land used for urban construction	1366.42	1397.51	1427.49	1456.42	1484.36	1511.36
area of parks and green land	1187.64	1210.92	1232.92	1253.73	1273.46	1292.17
area of paved road	1227.57	1242.76	1257.24	1271.06	1284.27	1296.91
volume of garbage disposal	1189.82	1214.29	1236.89	1257.84	1277.31	1295.45
the number of beds in health institutions	1315.50	1315.60	1315.69	1315.78	1315.85	1315.93
licensed (assistant) doctors	1188.87	1216.46	1242.27	1266.47	1289.21	1310.61

As shown in table 3, different index have different effect on the population bearing capacity based on different P-S degrees. For instance, when the P-S degree is 0.5, for different index like GDP, Water resource, electric power consumption of residents, area of land used for urban construction, area of parks and green land, area of paved road, volume of garbage disposal, the number of beds in health institutions and licensed (assistant) doctors, their population carrying capacities are respectively 1295.83, 1378.11, 1250.52, 1484.36, 1273.46, 1284.27, 1277.31, 1315.85 and 1289.21 (ten thousand persons). Expanding those data listed in table 3, the P-S (0-1) curve of population carrying capacity of urban district in the Northern Jiangsu is gotten in Figure 3.

The data in table 3 shows that two index "area of parks and green land" and "volume of garbage disposal" are the main limiting factors; area of paved road and GDP are the second limiting factors; licensed (assistant) doctors is the third limiting factors; next, the number of beds in health institutions and electric power consumption of residents are the limiting factors in sequence; water resources and area of land used for urban construction are the last limiting factors because land and water resources in the Northern Jiangsu are rich.

The results of analysis for the limiting factors demonstrate that green environment of urban districts in the Northern Jiangsu remains to be further improved, infrastructure construction and industrial transformation and upgrading need to be further promoted to advance its sustainable economic development.

Nevertheless, as exhibited in Figure 3, the population bearing capacities of different index based on the same P-S degree had intersection points. For example, when the P-S degree equals 0.9, the population carrying capacity of GDP that is 1286.85 ten thousand persons is more than that of licensed (assistant) doctors that is 1188.87 ten thousand persons. However, when the P-S degree is set as 0.4, the population carrying capacity of GDP that is 1295.45 ten thousand persons is less than that of licensed (assistant) doctors that is 1310.61 ten

thousand persons. Therefore, the identification of element a_{ij} of judgement matrix in Analytic Hierarchy Process (AHP) is confirmed by impact of different index on the population carrying capacity and expert scoring method.



Figure 3 the relationship diagram between the P-S degree and the population bearing capacity of urban districts in the Northern Jiangsu

2.2.3 Research on the Population Carrying Capacity of multi indicators of Urban Area in the Northern Jiangsu and its Risk Management Based on P-S method

The results of the population carrying capacity of multi indicators of the city proper in the Northern Jiangsu Based on P-S method are listed in table 4. There are three solutions as follows.

The first scenario is to calculate the population carrying capacity of urban districts in the Northern Jiangsu under the condition of different P-S degree when all index factors are simultaneously satisfied. For instance, when the P-S degree is set as 0.5, its population bearing capacity is 1273.46 ten thousand persons. That is to say, the selected value is the minimum among different population bearing capacity of the same P-S degree.

The second scenario is to calculate its average population carrying capacity of the same weight of index under the condition of different P-S degree. For example, when the P-S degree is 0.5, its population carrying capacity is 1327.66 ten thousand persons.

The third scenario is to calculate its weighted average population carrying capacity of different index factors under the condition of different P-S degree. However, the weights of index are determined by AHP when the eigenvalue λ is 9.45. what's more, the value of element of judgement matrix in AHP is confirmed by the sequence of the limiting factors above, the significance of impact of indicators on the population carrying capacity and expert scoring method.

As shown in table 4, the total population bearing capacity of urban districts in the Northern Jiangsu is 1301.94 ten thousand persons by 2020 when the P-S degree equals 0.5.

Conditions	P-S degree						
Conditions	0.9	0.8	0.7	0.6	0.5	0.4	
Simultaneously satisfying	1187.644	1210.925	1232.92	1253.732	1273.456	1292.174	
Equal weight	1252.922	1273.265	1292.418	1310.514	1327.658	1343.943	
Proportional compensation	1234.268	1252.818	1270.201	1286.539	1301.936	1316.481	

Table 4 the Population Carrying Capacity of multi indicators of the city proper in the Northern Jiangsu

Overall, the population bearing capacity of urban districts in the Northern Jiangsu is between 1273.46 ten thousand persons and 1327.66 ten thousand persons in 2020 when the P-S degree equals 0.5. Nevertheless, the number of its urban resident population is comparatively less than its population carrying capacity that is calculated by means of the selected data and the P-S method. Therefore, the present development tasks for the Northern Jiangsu are to take effective measures, attract the foreign population to settle down, protect the local resources and environment while it develops, push forward the innovation development of ecological industry, reduce the quantities of companies that pollute the environment, save land resources, protect cultivated area, improve the rate of utilization of residential use of land and inefficient use of land in area of land used for urban construction and change the status that the value of net immigration is negative. Finally, it attains the coordinated development among the number of its population, economy, resources and environment.

3. CONCLUSION

The economy of the city proper in the Northern Jiangsu was in the backward situation in Jiangsu province. However, many improvement measures are carried out.According to the lack of water consumption for residential use per capita and electricity consumption of urban and rural residents per capita, the Northern Jiangsu should develop its ecological agriculture to arouse the development of the relative processing industry, service and even high-tech industry to implement industrial upgrading and raise the utilization ratio of its resource and environment. What's more, area of paved road per capita and area of parks and green land per capita are comparatively lower than those in the Middle of Jiangsu and the Southern Jiangsu, transport facilities will have direct impact on the local economic development, and green environment have great effect on the public health. Therefore, perfection of infrastructure construction and protection of ecological environment are needed to be carried out to enhance the attraction of the Northern Jiangsu. Of course, it is necessary that land resources especially agricultural land and ecological land are needed to save and protect, and supervision and administration of real estate system are needed to establish and perfect to decrease the concentration of housing property and the inefficient use of the land area of industrial enterprises to avoid risk of its housing market.

Because an increase of the population will bring an rise of the volume of garbage disposal, living garbage processing capacity needs to be improved to avoid the decrease of quality of life of residential population; because the number of beds in health institutions of urban district in the Northern Jiangsu is more than that in the South and the Middle of Jiangsu and has realized the requirement of modern index, the investment for it can be reduced during the 13th Five Plan. However, the number of pension beds and intermediate and senior nursing workers needs to be improved.

In addition, advanced educations in urban area like Xuzhou and Huaian city are better than those in Wuxi in the southern Jiangsu. Therefore, it is feasible and effecitive for the Northern Jiangsu to utilize the professional resources of advanced educations to promote the local industrial development, strengthen scientific and technological innovation, intake medium-level and higher-level talents to work or start a business in Southern Jiangsu to enhance the ability of its economic development and population bearing capacity.

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AUTHOR:

- Corresponding author: Fengjuan Liu,(1967-), Born in Tangshan City, Hebei Province, Female, Doctor's degree in Financial Engineering and Risk Management, Associate Professor in Wuxi Environmental Science and Engineering Research Center, Research Interests: Regional Economics, Risk Management Contact: Room 601, Building 15, Wanshun Road, Vanke Mingyue, Binhu District, Wuxi, Jiangsu, P.R China 214121. Email: holysaint12@126.com
- Lixin Qu, (1967-), Born in Shanghai City, Male, Master's degree in Management Science and Engineering, Doctor student in Nanjing University of Aeronautics and Astronautics, Professor in Wuxi Environmental Science and Engineering Research Center, Research Interests: Regional Economics