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A Dynamic Study on Urban Water Resources and Ecological Recreation Space in Ganjiang River Basin

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Abstract: *Urban ecological recreation space is an important part of overall urban ecological balance. The rational allocation of urban ecological recreation space is an important reference standard for urban livability. This paper analyzes the ecological footprint, carrying capacity, and deficit of water resources, as well as the basin city ecological stress situation, combined with a static panel data model to explore the intrinsic association between the ecological footprint of urban water resources and the urban ecology in Ganjiang River Basin. This research shows that the ecological footprint of urban water resources is within the water resource carrying capacity in Ganjiang River Basin and represents a long-term water resource ecological surplus. Ecological footprints of water resources have a positive impact on green space coverage area and park green area. The ecological footprint of water pollution has increased annually, and water pollution is the main cause of ecological pollution. On this basis, we propose to increase the prevention and control of water pollution by improving the quality of urban ecological recreation space, increasing the utilization rate of water resources and creating a new model of high-quality ecological cities.*

Keywords: *Water Resources, Water Resources Ecological Footprint, Water Carrying Capacity, Ecological Recreation Space*

1. Introduction

With accelerated urban scaling, urban ecological problems have become increasingly prominent. Restoring the urban ecological environment and creating sustainable urban development are important issues in the development of urban cities in the world today [1]. Urban development depends on rivers and lakes. Water resources are a basic condition of urban development, and they should be regarded as an important part of urban planning and urban construction. However, due to the rapid expansion of cities and global climate change, there has been an emergence of short-term rainstorms flooding urban areas, which has prompted a new focus on neglected problems in city planning. Urban construction and development has led to the destruction of the ecological environment, bringing problems such as urban floods and urban water pollution. Therefore, the core issue of urban development is the balance of urbanization and the ecological environment [3-5]. Urban development is closely related to water use [6-8]. Therefore, ecological recreation spaces for city residents are vital, and a deeper analysis of these spaces, as well as water resource usage, is needed. Urban ecological recreation space is the basis of urban ecological infrastructure, which mainly consists of green space coverage areas and park green areas. <National New Urbanization Planning (2014-2020)> notes: "Reasonable division of ecological red line expand urban ecological space...build a green ecological corridor in urbanized areas" are methods to improve and enhance the quality of urban ecological space [9]. Therefore, the ecological recreation space is the basis for the way of life of residents. Studies have shown that residents have a strong tendency to be close to nature [10-11]. This connection is an important factor in reflecting the livability of the city via the urban ecological recreation space [12-14].

Prior research shows that in the 1990s, the ecological footprint was a method for quantitatively evaluating the degree of sustainable development in a region. This concept was put forward by Canada's famous ecological economics professors Dr. William E. Rees and Dr. Mathis Kakenage. Their method can quantitatively determine whether the development status of a region is within the ecological carrying capacity of the region by calculating the degree of the human utilization of natural resources. This is a new way to evaluate regional development [15-16]. In recent years, research on the ecological footprint of water resources has received extensive attention. Most scholars analyzed regional water resource carrying capability via the ecological footprint method [17-22]. Most research on water resource carrying capacity incorporates the ecological footprint of water resourcesinto the theory of sustainable development [23]. Yang-jaan analyzed the utilization of water resources in Yulin, Taiwan by using ecological footprint method [24]. Harris studied urban water resource carrying capacity from the point of view of water supply and, based on this, included it in the overall urban development plan [25]. Jian Yin used the method based on the ecological footprint of water resources to calculate the water use efficiency of the Yellow River Basin in proportion to its input and output and applied this to the scientific management of water resources [26]. Rijsberman et al. used bearing capacity as a measure to safeguard and manage urban water resources in their assessment process [27]. F Pellicer-Mart ńez used the theory of water resources ecological footprint to assess the sustainable development of the water environment in the Yangtze River Basin [28]. Jianzheng Wang applied ecological footprint analysis in urban planning, then in analyzing the regional ecological environment impacts of urban planning [29]. Peifeng Yang and Yunnan Cai researched the water resource carrying capacity, water ecological footprint and urban development composition of Taiyuan. They also analyzed the degree of its nonequilibrium state, which was subsequently put in a steady-state urban development mode, and the viewpoint of steady-state construction mode [30]. At present, there are many studies on the ecological footprint of water resources, but they do not address the influence of water resources on urban development and the urban environment. This paper analyzes the impact of ecological footprint of water resources on the urban ecological environment, and it uses the water resources ecological footprint theory to analyze the urban water resource ecological footprint, ecological carrying capacity, ecological deficit and ecological stress situation in Ganjiang River Basin. We explore internal connections between water resources and urban ecological recreation spaces by using mainly static panel models. To conclude, we analyze the comprehensive impact of the ecological footprint of water resources on the ecological recreation space. This study provides a data-intensive basis for water resource allocation in Ganjiang River Basin. It also provides a reference for urban planning construction and the sustainable development of ecological resources.

2. Study area

2.1 Overview of Ganjiang River Basin

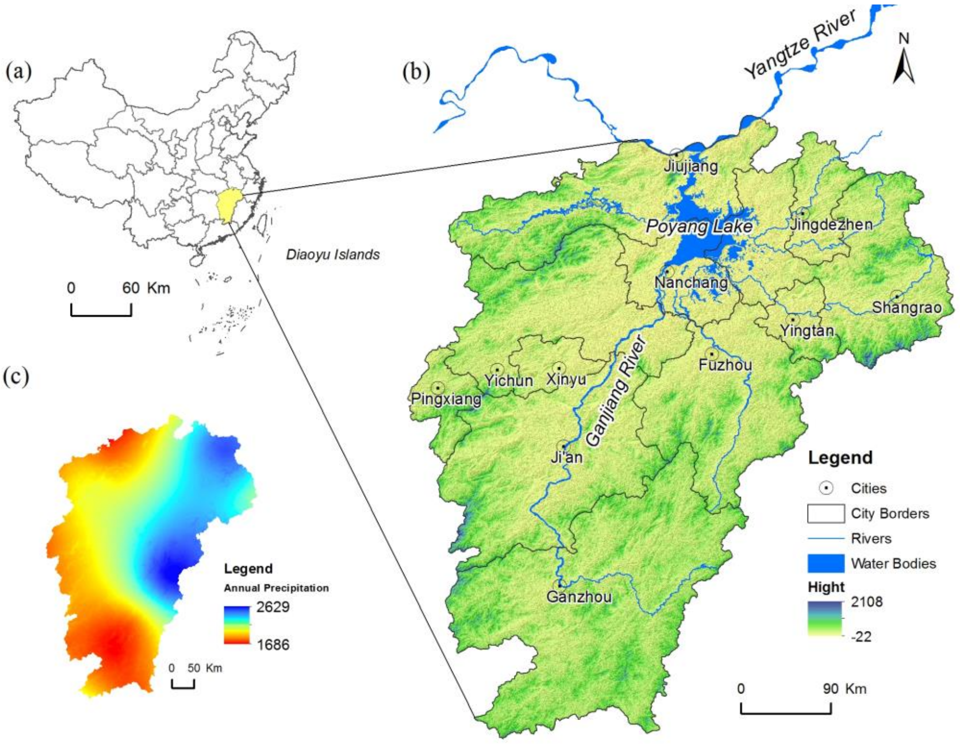


Figure 1: Study area.

Ganjiang River Basin is the biggest river running from north to south in Jiangxi Province and is one of the eight major tributaries of the Yangtze River. It originates in Shicheng County, rejoining Poyang Lake in Yongxiu County. The length of the main river is 823 km. The Ganjiang River Basin Province is divided into administrative divisions, including Ganzhou, Ji'an, Pingxiang, Xinyu, Yichun, Fuzhou, and Nanchang, and has a total of 7 District cities in 47 counties and cities (districts). Its land planning area is 80196 km2 and has a cultivated area of 1968.32 million acres. Ganjiang River Basin is located in a subtropical monsoon climate area, with four distinct seasons, a mild climate and abundant light. Rainfall is abundant, with an average annual rainfall of 1576.6 mm and a total water resource of 702.89 billion m3. Per capita water resources are approximately 3398 m3, and the average per acre water resource is 3571 m3. The spatial distribution of precipitation in the province is higher in the north than the south, higher in the west than the east and is higher in the mountains than on the plains[31].

Defined here as the municipal units in the Ganjiang River Basin, there are 7 cities for Ganzhou, Ji'an, Pingxiang, Xinyu, Yichun, Fuzhou and Nanchang. Despite abundant water resources, there are many problems such as ecological environment pollution and urban water pollution following the quick development of urbanization. Ecological recreation space is an important part of the urban environment. The urban green space and wetland resources of a city are the barriers of urban ecology, and display the extremely close relationship between water resources utilization and the ecological environment. Water resources are an indispensable basic factor in the ecological and natural environment. The relationship between urban ecological recreation space and water resources use needs further research.

2.2 Relationship between Urban Water Resources and Ecological Recreation Space

All cities worldwide are resource dependent, and cannot live without lakes, rivers, or another water source. A lack of water resources will seriously affect the natural ecosystem and the socioeconomic development of cities [32]. With fast paced life in the city, the relationship between mankind and nature may become estranged, and urban residents may strongly yearn for ecological recreation space. The urban ecological recreation space mainly consists of urban parks and green space, which is an important guarantee in realizing the sustainable development of cities. Rapid urbanization has caused many artificial buildings to replace natural surfaces, thus greatly changing the urban ecological environment [33]. Many rigid pavements will eventually lead to soil erosion and serious flooding. Urban ecological recreation spaces have ecological, recreational, entertainment and social culture functions, including biological diversity, an alleviated urban heat island effect, providing relaxing recreation places and relieving pressures on urban residents [34].

There is an intimate relationship between water resources utilization and the ecological environment. Water is the source of human survival, as it is an important foundation for social and economic development and is an indispensable basic factor for the natural environment. Ecological recreation space plays an important role in the urban ecological environment. The recreation space of a city can effectively conserve water, infiltrate water into the ground, form an atmosphere, provide a place for plants and soil, regulate the city’s ground water level, adjust the city’s microclimate, and gather the city’s rainwater. The ecological recreation space is the city’s green sponge, which has the purpose of conserving water sources, reducing surface runoff and preventing floods. Therefore, there is a close relationship between ecological recreation space and water use.

An ecological recreation space is a combination of urban green lands, urban parks, and urban wetlands. The ecological recreation space has a protective effect on water resources and vegetation. When the water infiltrates into an urban space, it has been purified because the urban green land has an infiltration function for water quality. Meanwhile, the recreation space prevents soil erosion, and at the same time increases biological diversity. An ecological wetland also protects river basins and lakes by preventing their pollution purifying the water quality. The rational use of water resources can balance the ecological recreation space. Finally, when water resources are used in the range of the water capacity, and will not cause the deterioration of the local ecological environment, they can enhance the satisfaction of urban residents and promote social and economic development in the region.

3. Materials and Methods

3.1 Freshwater Ecological Footprint

This paper divides the ecological footprint of water resources into two categories: a freshwater ecological footprint and a water pollution ecological footprint[35]. Four types of water for the freshwater ecological footprint include agricultural water, industrial water, living consumption water, and an ecological environment water supplement[36]. Living consumption water includes urban living consumption water and town living consumption water; Urban-rural living consumption water includes residential-use and public-use; agricultural water is for the irrigation of farmland and water used for forestry and the pastoral industry; the ecological environment water supplement is a function of maintaining the urban environment and some rivers, lakes, wetlands as well as the artificial recharge of water. Therefore, the freshwater ecological footprint calculation formula is:

$$EF_1 = \frac{W_1 + W_2 + W_3 + W_4}{P_{WC}} \tag{1}$$

From formula (1): EF1 is the freshwater ecological footprint (hm^2); W1 is the living consumption water; W^2 is the agricultural water; W3 is the industrial water; W4 is the ecological environment water supplement. PWC is global average production capacity of water resources (m^3/hm^2). From global statistics, the total amount of renewable water resources in the world is 46.70×104 billion EC, the world's land area is 1.49 billion km2, and the world's average water production capacity (global average production capacity) is 3140m^2/hm^2[37].

3.2 Water Pollution Ecological Footprint

The water pollution ecological footprint is the area of land needed to absorb water pollutants from a certain population. This paper cites the water pollution ecological footprint calculation method as based on the pollutant absorption known as “gray water” theory[38]. This paper cites the index of industrial wastewater and domestic sewage discharge (COD) to measure the ecological footprint of water pollution.

According to <Drinking Water Standards> (Ministry of Health, 2001) and <The Surface Water Quality Standard > (National standards of the People's Republic of China GB3838-2002), Industrial Wastewater Class IV is mainly suitable for general industrial water use areas and recreational water areas where the human body is not in direct contact with the water. The chemical oxygen demand (COD) is ≤30mg/Lin these locations; the centralized drinking surface water source protection zone two class III chemical oxygen demand (COD) is ≤20mg/L. The average density of COD in urban domestic sewage is usually 100-300 mg/L [39]; there are many pollutants in industrial wastewater, and the average value of COD is usually 400-500 mg/L. We take the intermediate values of 250 mg/L and 450 mg/L, which are calculated according to the ratio of domestic wastewater and industrial wastewater discharge: 6:4. The average COD density of urban wastewater in the Ganjiang River Basin is approximately 325 mg/L. We take the intermediate value of 250 mg/L and 450 mg/L, which is calculated according to the ratio of domestic wastewater and industrial wastewater discharge 6:4. The average COD concentration of urban wastewater in the Ganjiang River Basin is approximately 325 mg/L. According to 《Municipal wastewater treatment plant emission standards》(GB18918-2002), to achieve the first An emission standard(COD concentration of 50 mg/L), the second B emission standard(COD concentration of 100 mg/L), and the third C emission standard (COD concentration of 120 mg/L) in accordance with the secondary discharge standard (COD concentration of 100 mg/L), at least 2.81 times of class III water(COD ≤ 20 mg/L)should be supplemented.

$$EF_2 = \beta \times C_{\mathrm{W}} / P_{WC} \tag{2}$$

From formula (2): EF2 is water pollution ecological footprint; β is the waste water consumptive factor (this study uses 4); CW is the total wastewater discharge(m3); and PWC is the global average production capacity of water resources 3140 m3/hm2.

Therefore, for formula (3): EF is the sum of the freshwater ecological footprint and the water pollution ecological footprint.

$$EF = EF_1 + EF_2 \tag{3}$$

3.3 Water Resource Carrying Capacity

Water resource carrying capacity is the largest amount of supply for water resources supporting the sustainable development of regional resources, the environment and society (ecology, production and life) during historically rapid development[40]. According to previous studies, a water resources development and utilization rate of more than 30-40% of a country or region may cause the deterioration of the ecological environment, Therefore, we must deduct 60% of the water resource carrying capacity to maintain the ecological environment and biodiversity [41]. If ecological balance is maintained, the ecological environment will not deteriorate. Therefore, the water resource carrying capacity model is as follows:

$$EC = N \times \mathrm{ec}_{\mathrm{w}} = (1 - 60\%) \times \mathrm{a} \times \mathrm{r} \times Q / P_w \tag{4}$$

From formula (4): EC is the water resource carrying capacity(hm^2); N is Population number; ecw is the water resource carrying capacity per capita; a is the global equilibrium factor for water resources 1; Q is the total water resources(m^3); PW is the average production capacity of world water resources 3140m^3/hm^2.r is the regional production factor for water resources.

$$\mathbf{r} = \frac{\boldsymbol{\nu}}{\boldsymbol{\nu}_{\mathrm{w}}} \tag{5}$$

From formula (5): r is the worldwide urban water yield factor; v is the regional water yield per unit area; vw is the global water production per unit area; the global water yield factor is the national water production factor in the nationwide ratio of water regions within the country’s yield factor. China’s water production factor is the water ecological footprint of production factors within a specific year, or the regional water yield per unit area in a ratio of global water production per unit area.

According to national data, China’s land area is 960 million km^2, and its total annual water resources is 28412billion m^3[42]. The urban land area of the Gan River Basin is 14.517million km^2. The total amount of urban water resources in the Ganjiang River Basin is 1086.8 billion m^3(data from <Jiangxi Provincial Water Resources Bulletin>). In addition, China’s land area accounts for 6.44% of the world’s total land area, and its total water resources account for 6% of the world’s total water resources. From these figures, we infer that China’s water production factor worldwide is 0.932[43]. The calculated result of Ganjiang River Basin’s cities’ water resources in the national water yield factor is 2.53. When multiplying these two factors, the Ganjiang River Basin’s cities’ water resources have a global water production factor of 2.36.

3.4 Water Resources Ecological Profit and Loss

Measuring the sustainable use of water resources by the ecological footprint of water resources, namely, through the ecological deficit of water resources and the ecological surplus of water resources, is to compare the overall ecological footprint of water resources and the ecological carrying capacity of water resources[43]. Formula(6)is:

$$EB_{\omega} = \mathrm{ec}_{\omega} - \mathrm{ef}_{\omega} \tag{6}$$

From formula(6), EBw is the water resources ecological profit and loss; ecw is the per capita ecological capacity; efw is the per capita ecological footprint according to the water resources ecological profit and loss classification standard in Table 1.

Table 1: Water resources ecological profit and loss classification standard

Water resources ecological profit and loss	Numerical value	Status
EB_w	>0	Surplus state(Ecological sustainable)
EB_w	= 0	Critical state(Ecological balance)
EB_w	<0	Deficit state(Ecological unsustainability)

3.5 Water Resources Ecological Stress Index

Ecological stress is the ratio of per capita ecological footprint to the per capita ecological carrying capacity of a region. The index represents the degree of pressure on the regional ecological environment. It is calculated as follows:

$$ETI = \mathrm{ef}_{\mathrm{w}} / ec_{\mathrm{w}} \tag{7}$$

From formula (7), ETI is the ecological stress index for the study area. efw is the per capita ecological footprint; ecw is the per capita ecological capacity. The ecological pressure index was used to evaluate the regional ecological environment. We conclude that the change in China's ecological pressure index is in the range of 1.6-6.6[44]. To comprehensively assess the ecological environment in Ganjiang River Basin, we divide the ecological stress index standard of the study area to measure the ecological environment of the study area in Table 2.

Table 2: Ecological stress index classification standard

Pressure level	Numerical value	Degree of pressure
1	(0,2)	Very safe
2	(2,5)	Relatively safe
3	(5,8)	A little unsafe
4	(8,11)	Less safe
5	≥11	Unsafe

3.6 Regression Analysis of Urban Water Resources and the Ecological Environment in Ganjiang River Basin

A water resource ecological footprint effects ecological recreation spaces. It is influenced by many factors such as population, financial expenditure, municipal public facilities construction investments, per capita GDP and so on. To further explain the main factors the ecological footprint of water resources has in affecting ecological recreation spaces, this paper performed a preliminary screening of the ecological recreation space data including statistics and literature from the Jiangxi Statistical Yearbook, 2000-2016. Three indicators related to ecological recreation space were extracted and a static panel model was established. These include the green space coverage area, landscape green space area, and urban park green space area.

$$\begin{aligned}\mathrm{In}Y_{it} &= \beta_{0it} + \beta_{1it}\mathrm{In}X_{1it} + \beta_{2it}\mathrm{In}X_{2it} + \beta_{3it}\mathrm{In}X_{3it} \\ &+ \beta_{4it}\mathrm{In}X_{4it} + \beta_{5it}\mathrm{In}X_{5it} + \varepsilon_{it}\end{aligned} \tag{8}$$

From formula (8), InXit (i =1,2,…,5) is the selection of environmental factors or economic indicators, βit (i =1,2,…,5) are corresponding coefficients, εit is a random error term, i is the city and t is the year according to the construction of static panel model. In this paper, the ecological footprint of water resources is selected InX1it; population is InX2it; financial expenditure is InX3it; a municipal public facility is InX4it; GDP is InX5it; these are independent variables. Green space coverage area is InY1it; landscape green space area is InY2it; landscape green space area is InY3it; these are dependent variables. Through linear regression and index detection, we determined the utilization of water resources via ecological recreation space variable indicators. On this basis, we studied the quantitative relationship among indicators. Furthermore, we determined the regression equation and comparative analysis.

3.7 Research Outline

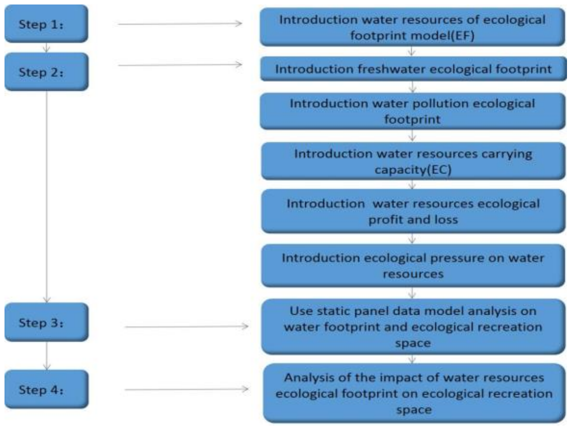


Figure 2: Research outline

This paper first introduces the model of the ecological footprint of water resources. Second, it performs a data analysis of various water resources in Ganjiang River Basin based on its freshwater ecological footprint, water pollution footprint, water resource carrying capacity, water resources ecological profit and loss, and its water resources ecological stress index. Third, this paper used a static panel model to analyze the inner association between water resources ecological footprint and ecological recreation space. Fourth, this paper analyzes the impact of a water resources ecological footprint on urban recreational space, then puts forward an optimization strategy for water resources utilization efficiency.

4. Results

4.1 Analyzing the Results of the Urban Water Resources Ecological Footprint and Ecological Carrying Capacity in Ganjiang River Basin

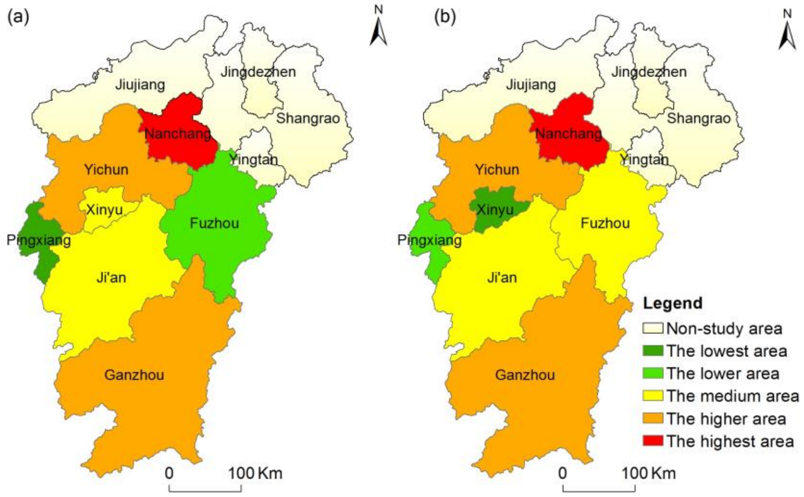
Table 3: Water ecological footprint and bearing capacity of water resources in the Ganjiang River
1×10^4 m^3/hm^2

Year	W1	W2	W3	W4	EF2	EF1	EF	EC
2003	12.52	36.82	12.37	0.78	35.92	62.50	98.43	375.34
2004	16.58	42.90	14.54	0.39	34.79	74.43	109.22	304.61
2005	5.55	43.83	14.38	0.44	33.21	64.21	97.42	472.94
2006	5.6	42.84	13.95	0.45	33.10	62.86	95.97	511.99
2007	6.32	52.60	17.03	0.73	34.83	76.70	111.54	349.02
2008	6.46	51.53	16.97	0.74	36.49	75.71	112.20	405.92
2009	7.28	59.54	17.00	1.97	39.96	85.81	125.78	324.95
2010	7.64	51.36	18.03	1.53	42.36	78.57	120.94	723.68
2011	7.99	58.02	18.84	0.68	48.54	85.54	134.09	287.91
2012	8.40	51.27	18.79	0.68	49.31	79.16	128.47	658.05
2013	8.71	57.55	19.66	0.70	49.88	86.63	136.52	411.75
2014	8.78	55.01	19.66	0.68	50.06	84.15	134.22	472.01
2015	8.96	50.06	19.74	0.70	50.45	79.47	129.92	562.29
2016	9.10	50.39	19.66	0.70	55.47	79.87	135.34	674.15

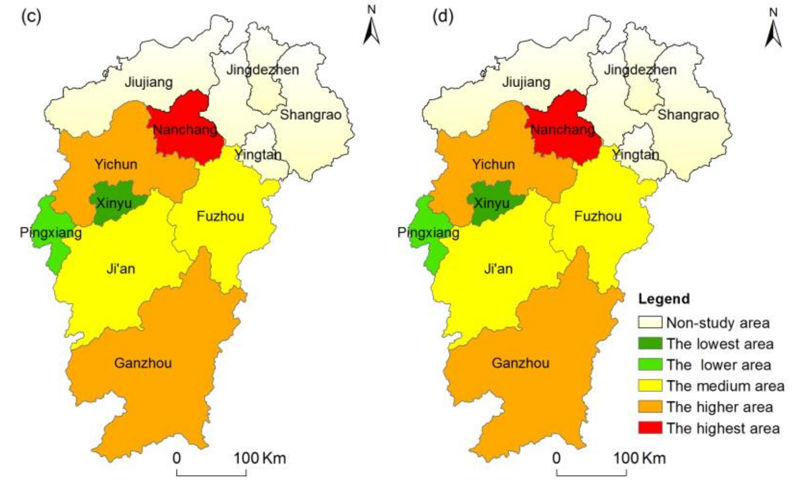
For the ecological water footprint of the urban water resources in the Ganjiang River Basin from 2003 to 2016, the ecological footprint and ecological carrying capacity of the water resources are calculated. The calculation results are shown in Table 3. The results are as follows: First, regarding the water resources profit and loss situation, the water resources ecological footprint is used within a reasonable range, and the water resource carrying capacity is more than enough. Second, in the freshwater ecological footprint, the ecological footprint of domestic water was used most from 2003 to 2004. In 2005, the amount of water used was the smallest, and in the later periods, it increased yearly and then plateaued. Third, in the industrial water footprint, water consumption continued to increase over time and became stable after 2013. Fourth, in the ecological environment water supplement, 2004 showed minimum water consumption and then a continuous increase, 2009-2010 showed the maximum consumption time, and after 2011, it decreased and became sustainably stable. Fifth, the water pollution ecological footprint continued to increase from 2009; from 2005 to 2016, the water pollution ecological footprint increased to 67%. Accounting for the entire footprint of water resources of 35.4%, the continuous growth of the water pollution ecological footprints is the main reason for the pollution of the ecological environment. The per capita water resources ecological footprint is within the per capita carrying capacity of water resources.

4.2 Spatial Analysis of Water Resources Ecological Footprint in Ganjiang River Basin in 2004-2016 years

The 2004-2016 spatial analysis of the water resources ecological footprint in Ganjiang River Basin concluded that: Excepting 2004, Ji’an had the least water consumption of all cities. Ganzhou had the highest consumption rate. In 2008, 2012, and 2016, Xinyu had the lowest water consumption rate, followed by Pingxiang city, Fuzhou city, Ji’an city, Ganzhou city, Yichun city, and Nanchang city. Nanchang consumed the most water during these years.



2004 *2008*



2012 *2016*

Figure 3: Water resources ecological footprint of spatial distribution map from 2004 -2016.

4.3 Analysis of Water Resources Ecological Pressure and Ecological Profit And Loss in Ganjiang River Basin

To scientifically assess the urban water resources situation in Ganjiang River Basin, the formulas of water resources ecological profit and loss, water resources ecological stress, the per capita ecological capacity, and the per capita ecological footprint were calculated. We conclude that from 2003 to 2016, the average water resources ecological stress is 0.822, and the ecological pressure is the security of the state. According to the profit and loss of water resources and water resources ecological stress, there is an urban water resources ecological surplus in the Ganjiang River Basin. Therefore, the current water resources utilization rate is within its carrying capacity and is ecologically sustainable.

Table 4: Water ecological ecological stress & ecological profits and losses in the Ganjiang River m^3/person

Year	EBw	ETI	ecw	efw
2003	--	--	--	--
2004	0. 336	0.69	0.696	0.362
2005	0.788	0.788	1.05	0.261
2006	0.856	0.856	1.11	0.254
2007	0.435	0.435	0.717	0.281
2008	0.59	0.433	0.81	0.281
2009	0.415	0.528	0.730	0.314
2010	1.496	0.242	1.804	0.307

2011	0.263	0.701	0.604	0.312
2012	1.065	0.310	1.388	0.322
2013	0.522	0.504	0.858	0.306
2014	0.712	0.397	1.042	0.330
2015	0.877	0.338	1.192	0.325

4.4 Correlation analysis of Urban Water Resources and Ecological Recreation Space in Ganjiang River Basin

To analyze the trend of urban water resources and ecological recreation space, this paper cites Stata software for static panel model analysis, and the results are as follows:

Table 5: Analysis the trend of water resources ecological footprint and ecological recreation space

	Green space coverage area		Landscape green space area		Urban park green space area	
	fixed effect	random effect	fixed effect	random effect	fixed effect	random effect
EF	0.3178**	0.2121	0.3268**	0.4076***	0.4106	0.4198*
	(0.1427)	(0.1475)	(0.1413)	(0.1512)	(0.2549)	(0.2198)
Population	-0.6234	-0.1729	-0.8540	-0.3546***	-2.1592	-0.3298*
	(0.9640)	(0.1111)	(0.9548)	(0.1251)	(1.7227)	(0.1770)
Financial	0.2934**	-0.3618***	0.2846**	-0.1876*	0.2835	-0.1695
Expenditure	(0.1174)	(0.00887)	(0.1163)	(0.0990)	(0.2098)	(0.1406)
Municipal	0.0746**	0.1747***	0.0717**	0.1294***	0.1284**	0.1918***
Public facility	(0.0348)	(0.0483)	(0.0345)	(0.0419)	(0.0623)	(0.0622)
GDP	0.0483	0.8605***	0.0827	0.6448***	0.1953	0.6841***
	(0.1453)	(0.01278)	(0.1440)	(0.1343)	(0.2597)	(0.1926)
Constant trem	7.5771	4.8353***	10.7617	4.2895***	26.5796	1.1391
	(14.3823)	(1.0428)	(14.2452)	(1.3203)	(25.7012)	(1.8131)
Constant trem	-3.05		36.49***		14.86**	

Note:***、**、* Represented respectively at the 1%, 5%, and 10% significance levels; Standard error of estimation coefficient in brackets.

First, for the impact of the water resources ecological footprint on the green space coverage area, the Hausman test value is negative, which indicates that the Hausman test is invalid. In this case, a fixed effects model analysis is generally selected. The results of the fixed effects model show that it has a statistically significant positive impact. Specifically, they show a 1% increase in the water resources ecological footprint, a green space coverage area increase of approximately 0.32%, and the result being significant at the 5% significance level.

Second, we evaluate the impact of the water resources ecological footprint on landscape green space area. The Hausman test value is 36.49 and rejects random effects at the 5% significance level of the null hypothesis, so we select the fixed effects model. The fixed effects model shows it has a statistically significant positive impact on the landscape green space area. Specifically, there is 1% increase in the water resources ecological footprint, landscape green space areas increase approximately 0.33%, and the result is significant at the 5% significance level.

Third, there are positive impacts of the water resources ecological footprint on urban park green space area. The Hausman test value is 14.86, and rejects random effects at the 5% significance level of the null hypothesis, so we select the fixed effects model. The fixed effects model shows that the impact of water resources ecological footprint on park green area is not significant.

Based on these above test results, the water resources ecological footprint has a positive impact on green space coverage area and landscape green space area. An increase in the use of water resources will increase the urban green space and green space coverage to ensure enough ecological recreation space. It will also increase the area of urban green space, and an effective and rational allocation of water resources gives ecological protections for urban green space. It also maintains the balance of urban groundwater. The increase of urban green space can also maintain the diversity of urban ecology, establish a human - animal - plant harmony in the urban ecosystem, and establish an urban-rural integration pattern of a green, eco-build water-saving city.

5. Conclusions and Suggestions

5.1 Save water for the Living and Ecological Environment, and Build a Water-Saving Eco-City

Our analysis shows that despite urban development, the water resources ecological footprint is within the scope of the water resource carrying capacity in Ganjiang river basin. Despite the abundant water resources in the basin, we still must pay attention to ecological water conservation. Specifically, the ecological footprint of water pollution has increased with the development of urbanization, which has worsened the urban ecological environment. Further, there need to be improvements in and an emphasis on the rational use of water resources, as well as paying attention to water conservation and ecological environment protection. In the future spatial layout of urban planning, water conservation is one of the main objectives of urban development. Whether this occurs through certain land use layouts, or the layout of municipal facilities, in the end, we must plan for a green water-saving city in advance [45].

5.2 Increasing Water Pollution Prevention Improves the Quality of Urban Ecological Recreation Space

The urban water pollution ecological footprint is increasing in Ganjiang river basin. This seriously damages the urban ecological environment and may endanger people's health[46]. First, we must improve the water pollution situation in the area, improve water quality, and improve the health of urban residents. The second is to build more ecological wetlands in the urban ecological environment, which effectively enhances the self-purification of polluted water, improves the urban ecological environment, and saves water [47]. Urban ecological recreation space is the urban ecological infrastructure based on the urban garden and green space. The patterns and functional levels of ecological recreation space are important factors reflecting the livability of the city [48]. Ecological recreation space is an important guarantee in achieving sustainable urban development. An increased use of water resources will increase the urban ecological recreation space. On the one hand, it provides people with the benefits of ecology, entertainment, recreation and so on. On the other hand, the urban ecological recreation space also protects the urban soil and water. At the same time, it also maintains ecological diversity and reduces the urban heat island effect.

5.3 Improving the Utilization Ratio of Water Resources and Paying Attention to Urban Rainwater Utilization

From the perspective of the water resources ecological footprint, the agricultural water and industrial water footprint have risen to more than half of the total ecological footprint. At present, agricultural water use in the Ganjiang River Basin accounts for 42% of total water use. Among them, agricultural irrigation water is the highest mode of usage. Improving agricultural irrigation technology and the water use efficiency of agriculture is necessary. At the same time, rainwater is a free water resource, and the natural rainwater microbial contamination concentration is low. As a city develops, the hard pavement of urban development increases. Rainwater runoff changes, precipitation quickly gathers and exceeds the carrying capacity of urban water resources, thus leading to urban shackles and even floods. Collecting and utilizing urban stormwater not only relieves the problem of urban water shortages but also repairs the urban ecological environment [49].

5.4 Optimize the Green Space Irrigation System and Coordinate Water Developments

In urban green space irrigation, the design of the water irrigation system is of paramount importance. For example, flooding irrigation consumes a large amount of water, while the fountain is a relatively economical alternative, but there is still much more room to save water. At the same time, there should be a focus on the configuration of plant species, as many aquatic plants and marsh plants have a significant effect on purifying urban sewage. The effective irrigation of ecological recreation space, wetlands and urban green space protects urban natural water bodies [50-51]. In urban construction, there should be a focus on a balance with the natural ecological environment. Urban planning should be aware of ecological environmental protections and prioritize urban ecological construction. At the same time, we should emphasize respect for nature and the harmony between Man and Nature [52].

Based on our analysis, urban water resources are highly correlated with ecological recreation space. Taking into account the current growth in water usage, in the future, the use of urban water resources in the Ganjiang River Basin will continue to rise. With increasing urban development, the water pollution ecological footprint should continue to deteriorate. Therefore, the prevention and control of water pollution and respect for natural ecological environments must increase. To achieve a balance between urban development and an ecological balance with the environment and consider the relationship between the demand for water resources and urban ecological recreation space, there must be further analysis of urban spatial planning issues. Improved water use efficiency is better for city development. Meanwhile, natural resource protections should be prioritized, so residents can live in harmony with nature.

References

[1] Hao Mengya, Ren Zhiyuan, Sun Yijie, et al. The Dynamic Analysis of Trade-Off and Synergy of Ecosystem Services in the Guanzhong Basin. Geographical Research, 2017, 36(3):592-602.
[2] Bing Zhao. Urban River Basin Governance And Thinking. Water Industry Market. No. 7 of 2011.
[3] Jianping Wang. Several Issues That Should be Paid Attention to in the Revision of Master Plan. Urban planning, 1995, 19(5):5-7.
[4] Jun Lu. The Evolution of Urban External Space And Regional Economy. Beijing: China City Press. 2001:27.
[5] Yesheng Long, Shenghai Yang. Study on ecological Urbanization Strategy in Poverty Alleviation and Development in Wuling Mountain Area .Ethnic forum.2013.2.
[6] Sun Yanzhi, Lu Chunxia, Xie gaodi, Li na, Hu xuqian. The Conjunciton between Urban Development and the Utilization of Water Resources in Beijing. Resources Science, 2015, 37(06): 1124-1132.
[7] Hong Tang, Fuqiang Xia, Degang Yang, Xuning Qiao. Scenario Warning for Urban Development and Water Resource Demand in the arid Oasis City of Urumqi. Resources Science, 2014, 36(06): 1168-1174.
[8] Leqin Zhang. Forecast of Water Resources Demand in the Evolution Of Urbanization in Anhui Province. Urban Problems, 2016(05):43-49.
[9] Li Hua. The Pattern and Optimization of Urban Ecological Recreation Space in Shanghai. Economic Geography, 2014, 34(1):174-180.]
[10] Arnberger A, Eder R. The Influence of Green Space on Community Attachment of Urban and Suburban Residents. Urban Forestry & Urban Greening, 2012, 11(1):41-49.
[11] Research on Ecological Tourism Space Construction and Development Strategy in Zhengzhou. Chen Jiaping. Areal Research and Development, 2013, 32(4):94-97.
[12] Spartz J T, Shaw B R, Place meaning Surrounding An Urban Natural Area: A Qualitative Inquiry. Journal of Environmental Psychology, 2011, 31(4):344-352.
[13] Wenzhong Zhang. The Core Framework of the Livable City Construction. Geographical Research, 2016, 35(02):205-213.
[14] Bing Li, Xun Li. Green and Ecological Urban Development Status and Trends. Urban Development Studies.2016, 23(10):91-98.
[15] Linnan Huang. Weixin Zhang. Cuiling Jiang. Xiaoqiu Fan. Water resources ecological footprint calculation method. Journal of Ecology,, 2008(03):1279-1286.
[16] Zhiming Feng, Yanzhao Yang, Huimin Yan, Tao Pan, Peng Li. Research on Resource and Rnvironment Carrying Capacity in the Past 100 years: From Theory to Practice. Resources Science, 2017, 39(03):379-395.
[17] Wei Guo, Qiting Zuo, Junxia Ma. Spatial and Temporal Change Analysis of Harmony Development among Population-Water Resources-Economics in Henan, China. Resources Science, 2015, 37(11): 2251-2260.
[18] Cheng C, Tong S Y, Peng H Y, et al. Ecological Carrying Capacity of Water Resources in the Central Yunnan Urban Agglomeration Area. Resources Science, 2016, 38(8):1561-1571].
[19] Fuyuan Wang, Kaiyong Wang. Assessing the Effect of Eco-City Practices on Urban Sustainability Using an Extended Ecological Footprint Model: A case study in Xi'an, China. Sustainability 2017, 9, 1591.

[20] Yu Ding,Jian Peng. Impacts of Urbanization of Mountainous Areas on Resources and Environment: Based on ecological footprint model. Sustainablility 2018, 10,765.

[21] Yuze Zhang, Junlin Zhang, Jianlan Ren. Moderate scale of Shandong Peninsula Urban Agglomeration--Analysis Based on Water Resources Perspective. Urban Problems.2017, 10.45-52.

[22] Liu Zigang, Zheng Yu. Evaluation of water ecological carrying capacity based on ecological footprint theory: A case study of huzhou. Resources Science.Vol.33, No.6 JUN.2011.

[23] Guan D J, Su Y, Zuo T A, et al. Dynamic Change Evaluation of Water Ecological Capacity in Bijie City of Guizhou Province. Journal of Chongqing Jiaotong University (Natural Science),2015.

[24] Yung-Jaan Lee, Chuan-Ming Tung, Piin-Rong Lee and Shih-Chien Lin. Personal water footprint in Taiwan: A case study of Yunlin County. Sustainability 2016, 8, 1112.

[25] Harris J M, Kennedy S. Carrying Capacity in Agriculture: Global and regional issues. Ecological Economics, 1999, 29(3):443-461.

[26] Jian Yin, Huixiao Wang, and Yan Cai. Water Foorprint Calculation on the Basis of Input-Output Analysis and a Biproportional Algorithm: A case study for the Yellow River Basin, China. Water 2016,363.

[27] Rijsberman M A, Ven F H M V D. Different Approaches to Assessment of Design and Management of Sustainable Urban Water Systems. Environmental Impact Assessment Review, 2000, 20(3):333-345.

[28] F Pellicer-Mart ńez, Martinez-Paz J M. The Water Footprint as an Indicator of Environmental Sustainability in Water Use at the River Basin Level. Science of the Total Environment, 2016, 571: 561–574.

[29] Jianzheng Wang. Application of ecological footprint Analysis in urban planning .Zhejiang University.2007.

[30] Peifeng Yang, Yunan Cai. The Reaearch on Urban Green Space System Planning and Constuctible Mode Form the Angle of Ecological Question View: Case Study Of Taiyuan City. Urban Development Studies, 2016, 23(09):62-67.

[31] Jiangxi Water Conservancy Planning and Design Institute. Report on the revision of the Comprehensive Planning of the Ganjiang River Basin in Jiangxi Province. 2011.10.

[32] Manzhu Bao. Talking about the Influence of Urban Landscape Construction on Urban Water Resources and Water Quality. Chinese park, vol.7, 2005(3).

[33] Wu Fei, Li Shuhua, Liu jiaomei. The effects of greening, None-greening square and lawn on temperature, Humidity and Human Comfort. Acta Ecological Sinica, 2007, 27(7):2964-2971.

[34] Kun Sun, Linsheng Zhong, Aiping Zhang, Guoping Zhang. Comparative Analysis of Ecological Value of Urban Recreation and Leisure Space - A case study of Changshu. Geographic research, 2016, 35(02): 256-270.

[35] Lazaric, Longhi, Thomas. Gatekeepers of Knowledge Versus Platforms of Knowledge: From Potential to Realized Absorptive Capacity. Regional Studies,2008(42):837-852.

[36] Federico Munari, Maurizio Sobrero & Alessandro Malipiero, Absorptive Capacity and Localized Spillovers: Focal Firms as Technological Gatekeepers in Industrial Districts. Industrial and Corporate Change, 2011(2):429-462.

[37] Su Yongxian, Huang Guangqing, Chen Xiuzhi, et al. Research Progress in the Eco-Environmental Effects of Urban Green Space. Acta Ecologica Sinica, 2011, 31(23):7287-7300.

[38] Qingwen Min, Wenjun Jiao, Shengkui Cheng. Pollution footprint: A Type of Ecological Footprint Based on Ecosystem Services. Resource science, 2011, 33(2):195-200.

[39] Shuli Hua. Urban Sewage Treatment plant COD Concentration Variation Study. Agricultural Resources And Environment. Beijing Agriculture, 2011(10):139-140.

[40] Storper M, Venables A J. Buzz: Face-to-Face Contact and the Urban Economy. Journal of Economic Geography, 2004(4):351-370.

[41] Wenguo Wang ,Mingxiong He, Ke Pan, et al. Spatial and temporal Analysis of Water Resources Footprint and Ecological Carrying Capacity in Sichuan Province. Journal of Natural Resources, 2011, 26(9):1555-1565.

[42] Storper M, Venables A J. Buzz: Face-To-Face Contact and The Urban Economy. Journal of Economic Geography, 2004(4):351-370.

[43] Qiang Yu, Jinlong Wang, Yanan Wang .The Development Path of Urbanization in Hebei Province Based on Water Resources Footprint Analysis. Economic Geography.2014 (11):69-73.

[44] Xu Fuliu, Zhao Shanshan, Du Tingting etc. Quantitative Assessment for Economic Development Stress Status and Trends Of Eco-Environment. China Population, Resources and Environment. 2004(14):30-36.

[45] Cai ran, Yin Wenyue, Zhang Sijing Improving urban water use efficiency and planning and building water-saving cities -- a summary of the 8th International Symposium on urban water

development in China. Urban development research, 2013, 20 (11): I0001-I0003

[46] Wei Cao. Safety pattern of Water Resources Environment in the Process of Urbanization. Huazhong Architecture, 2007(02):88-90+94.

[47] Haixia Wang, Guangyou Sun, Huili Gong, Shaopeng Yu. The Wetland Construction Strategy under The Sustainable Development Strategy of Beijing. Journal of Arid Land Resources and Environment, 2006(01):27-32.

[48] Li Hua. Evaluation and Optionization Conunter Measures for Service Functions of Urban Ecological Recreation Space. Planning research, 2015, 39(08):63-69.

[49] Weiping Xu, Xunlian Si, Kuo Li. Discussion on Future Research Direction of Rainwater Resources Utilization and Compensation Mechanism in Water-Deficit Cities. Journal of Arid Land Resources and Environment, 2011, 25(04):90-93.

[50] Riming Hao, Wei Xu. The Role of Urban Wetland in Urban Green Space Ecosystem Construction and Its Protection Suggestions. Jiangsu Forestry Science and Technology, 2005(06):46-49+56.

[51] Fangqing Chen, Jean Marie Hartman. The Ecological Restoration and Management of Degraded Wetland Ecosystem --A case study of Hackensack Meadowlands in America. Journal of natural resources. 2004(02):217-223.

[52] Xuesong Cui, Haiming Li. Study on the Construction of Ecological City in China. Economic Review, 2007(04):34-36.