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Early Warning of Resource and Environmental Carrying Capacity in Guangxi Coastal Region under the Background of New Urbanization

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Abstract:

Taken Guangxi coastal region as a case study, a set of early warning and evaluating indicator system that appropriated for resource and environmentbearing capacity of coastal area was established. By applying the decoupling elastic model, the relationship between urbanization level and depletion index was incorporated in the evaluation process of early-warning. The veto evaluation based on the departmental red line control was also added as improvement approach. Finally, the comprehensive early warning model that incorporated the basis evaluation, specific evaluation, process evaluation, veto evaluation and integrated evaluation was established. The research results indicated that resource and environment carrying capacity of Guangxi coastal regions were in poor condition with most of the region were overloaded except the Tieshangang district. The level of urbanization has increased, as well as the degree of resource and environmental depletion. The decoupling relationship between resource and environmental depletion and urbanization was expansion connection and the type of urbanization was extensive. Half of the study area was extremely severe warning level and three districts were the severe warning level. The major reasons were the tight per capita utilization of land resources, seriously seasonal and planned water pollution and unreasonable overdevelopment and exploiting of coastalzone resources. The extensive exploitation of urbanization was a secondary reason. The development of urbanization in Guangxi coastal region was expected to follow a new path of intensive, green, distinctive and intelligent urbanization.

Keywords*:Decoupling elastic model, Depletion index, Veto evaluation, Red line control.*

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I. INTRODUCTION

The coastal region has superior natural and socio-economic conditionsbecause it is the window of reform and opening up, and it is also the region with the fastest urbanization and the highest level of development [1,2]. The coastal zone of Guangxi is a transition zone of Beibu Gulf with abundant natural resources, unique geographical advantages and prominent strategic positions. However, with the population explosion, the expansion of business and the construction of coastal chemical industry projects, the resources and environment of the coastal area is facing unprecedented pressure [3]. A series of issues have appeared, including the shortage of land resources, the pollution of marine water and the intensive development of shoreline resources have emerged [4]. Therefore, it is in urgent need of proposing a practical and feasible new urbanization development path for the coastal zone under the constraints of resources and environment conditions.

With the widespread focus on the ecological environment and sustainable development, the researches with regard to resource and environmental carrying capacity have been promoted from qualitatively to quantitatively [5, 6]. In order to facilitate the comprehensive comparison and measurement, key parameter calibration and threshold definition, standardized evaluation and comprehensive measurement have become to the new hotspots and obstacles [7-9]. Previous studies generally paid particular attention to the coupled relation between urbanization level andcurrent resource and environment, which relied too much on coupling degree index andcoupling harmonious degree model [10-12]. In consequence, the innovations of theoretical model and quantitative method have become the bottleneck of this research filed. It is a fresh idea to incorporate the relationship between urbanization process and current resource and environmentcondition into earlywarning model [13, 14]. And exploring the quantitative relation of urbanization level and resource and environmental depletion index by applying decoupling theory is yet to be discussed.

Thanks to the insufficient investigation onresource and environment carrying capacity in coastal areas, we took the coastal region of Guangxi as a case study to investigate the resource and environment carrying capacity, which was the basis to carry out the early warningevaluation. First, a set of early warning and evaluation system that appropriate for resource and environment carrying capacity of coastal area has been established. Second, the concept of resource and environmental depletion rate and the depletion index were redefined. In addition, by applying the decoupling model, the relationship between urbanization level and depletion index was incorporated in the evaluation process, as well as the one vote veto method. Finally, the comprehensive early warning model that integrated the basis evaluation, specific evaluation, process evaluation, veto evaluation and integrated evaluation was established. The results were expected to improve the accuracy of early warning and demonstrate the decoupling elastic of carrying capacity.

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II. MATERIALS ANDMETHODOLOGY

2.1ResearchArea

The coastal region of Guangxi is situated in the southwestern tip of China, between107°28′-109°46′ E and 20°54′-22°07′ N. It starts from the Yingluo Port at the junction of Guangdong and Guangxi in the east, the Beilun River at the junction of China and Vietnam in the west, the Beibu Gulf in the south and the inland of Guangxi in the north. The study area is composed of eight county administrative areas including Fangcheng District, Dongxing City, Gangkou District, Qinnan District, Tieshangang District, Yinhai District, Haicheng District and Hepu County and the sea areas under their jurisdiction(Fig 1).

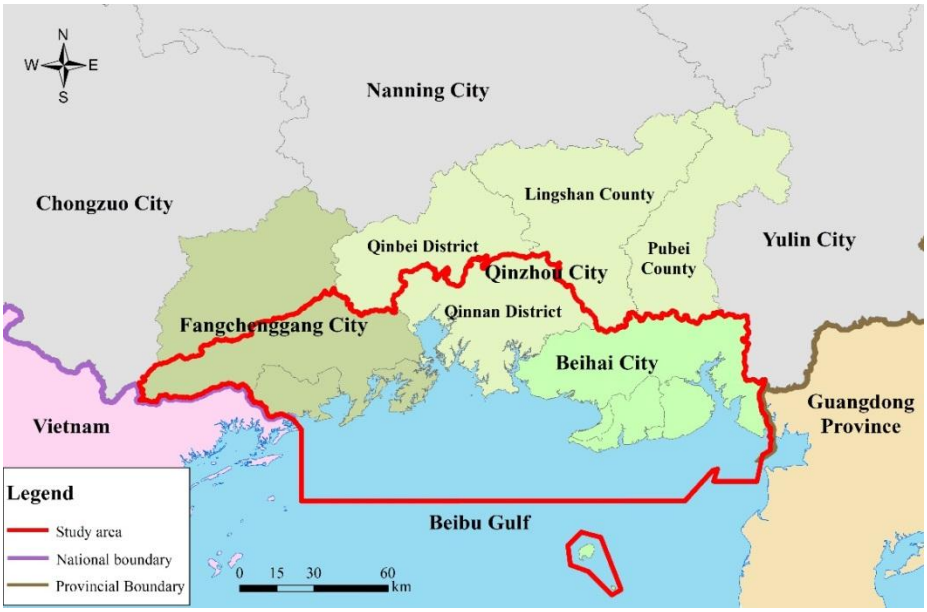

Fig1: Location map of the study area

South subtropical oceanic monsoon climate prevails in the study area, which has the characteristics of high temperature and plenty of rain, distinct dry and wet seasons, short summer and long winter and the prevailing monsoon. There is sufficient sunshine, abundant rain and long frost-free period. The mean annual air temperature is 23°C, and the mean annual precipitation is 1941.2 mm. The summer precipitation accounts for more than 75% of annual precipitation. In winter, the northeast wind prevails, while south wind or southwest wind prevails in summer.

2.2Data Source

2.2.1 Remote Sensing Data

The Landsat5/8 TM/OLI satellite data of 2010 and 2015 with the 30-m spatial resolutionwere obtained from Geospatial Data Cloud (http://www.gscloud.cn). This platform also provided the digital elevation model product with the spatial resolution of 30-m.The land use and land cover data of 2010 and 2015 were obtained from the Resource and Environment Data Cloud Platform (http://www.resdc.cn/).

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2.2.2 Statistical Dataset

The statistical yearbook of Guangxi and every city of 2010 and 2015 offered the data like urban population, Gross Domestic Product (GDP), Non-agricultural output value, per capita disposable income and so on. Water resource data were obtained from water conservancy yearbook and water resources bulletin. Daily PM 2.5 concentration data were downloaded from weather post platform (http://www.tianqihoubao.com/). The quality of seawater was obtained from Guangxi marine environment quality bulletin.

2.3Methods

2.3.1 Early-warning IndicatorSystem of Resource and EnvironmentCarrying Capacity

The early-warning indicator system was established based on the principles of scientificity, hierarchy, representativeness, differentiation and operability, based on the background of new urbanization and the characteristics of Guangxi coastal region. The structure of the index system was constituted by four layers, i.e. the target layer, system layer, element layer and indicator layer. The early warning model contained four parts correspondingly. First, the basic evaluation system included three elements and six indexes. Second, the specialized evaluation system only contained one element and one index. Third, the process evaluation system had resource environment and urbanization two elements and eight indexes. Veto evaluation system had one element and three index (TABLEI).

TABLEI. Early-warning indicator system of resource and environment carrying capacity of Guangxi coastal region

Target Layer	System Layer	Element Layer	Indices Layer
Early warning of resource and environmental carrying capacity in Guangxi coastal region	Basic evaluation system	Resource	Available land area per capita
			Water consumption per capita
			Intensity ofshoreline development
			Intensity of ocean development
		Ecology	Resource and environmental depletion index
		Environment	Water qualification rate in marine functional areas
	Special evaluation system	Urbanized area	Exceeded days of PM2.5
	Process evaluation system	Resource and Environment	Resource and environmental depletion index
		Urbanization	Proportion of city population
			GDP per capita
			Proportion value of non-agricultural production
			Disposable income of urban residents per capita

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			Proportion of education expenditure
			Participation rate of new rural cooperative medical system
			Proportion of urban land
	Veto evaluation	Water resource	Total water consumption
			Water utilization efficiency
			Water qualification rate of water function zone

2.3.2Resource and Environmental Depletion Index

Resource and environmental depletion rate (*H*) was proposed to represent the ratio of the actual value of an element index of resource and environment carrying capacity to critical threshold of critical overload.

If the number of indicators with critical overload or overload in basic evaluation and special evaluation was *n*, and the critical overload interval is (*a*, *b*), the resource and environmental depletion rate was defined as below:

H_i = effective value/standard value(a) -1 (1)

Where, the H_i is the resource and environmental depletion rate under the condition that the indicator is negative and the effective value is greater than standard value. While the indicator is positive and the effective value is less than standard value, the resource and environmental depletion rate was defined as:

H_i = 1 - effective value/standard value (b) (2)

The resource and environmental depletion index (*E*) was refined, which referred to the sum of regional resource and environmental depletion rates (Eq.3).

$$E = \sum_{i=1}^{n} H_i \quad (3)$$

Where, H_i is the resource and environmental depletion rate of the *i*-th indicator that constitutes the critical overload or overload.

2.3.3Decoupling Model

The decoupling model was established based on the resource and environmental depletion index.

$$\theta = \frac{\Delta E}{\Delta U} = \frac{(E_t - E_0)/E_0}{(U_t - U_0)/U_0} \quad (4)$$

Where, θ is the decoupling index, $\Delta U$is the variation rate of urbanization level,ΔE is the variation rate of resource and environmental depletion index,U_0, $U_t$are the urbanization level of beginning year and end year.E_0, $E_t$are the resource and environmental depletion index of beginning year and end year.

The decoupling status was divided into eight types on the basis of urbanization level, depletion index and decoupling index and the criterion was defined (TABLEII).

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TABLEII. Criterion of decoupling status and urbanization

DECOUPLING TYPE	ΔE	ΔU	θ	MEANING	TYPE OF URBANIZATION
Strong decoupling	-	+	(-∞, 0]	The level of urbanization has increased and the pressure on resources and environment has decreased	Economical urbanization
Weak decoupling	+	+	[0, 0.8]	The level of urbanization has increased as well as the pressure on resources and the environment, and the growth rate of the former is larger than the latter	Economical urbanization
Expansion connection	+	+	[0.8, 1.2]	The level of urbanization has increased as well as the pressure on resource and the environment, and the growth rate of the two is basically the same	Extensive urbanization
Expansion negative decoupling	+	+	[1.2, +∞)	The level of urbanization has increased as well as the pressure on resource and the environment, and the growth rate of the former is less than the latter	Extensive urbanization
Strong negative decoupling	+	-	(-∞, 0]	The level of urbanization has decreased, and the pressure on resources and the environment has increased	Extensive urbanization
Weak negative decoupling	-	-	[0, 0.8]	The level of urbanization has decreased as well as the pressure on resources and environment, and the former has decreased more than the latter	Extensive urbanization
Recession connection	-	-	[0.8, 1.2]	The level of urbanization has decreased as well as the pressure on resource and environment with the same rate	Extensive urbanization
Recession decoupling	-	-	[1.2, +∞)	The level of urbanization has decreased as well as the pressure on resources and the environment, and the former has decreased less than the latter	Economical urbanization

The decoupling status was applied to reflect the relation of urbanization condition and the

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resource and environment depletion index. Strong decoupling, weak decoupling and recession decoupling was categorized as economical urbanization, while the strong negative decoupling, weak negative decoupling, expansion connection, expansion negative decoupling, recession connection was categorized as extensive urbanization.

III. DATA ANALYSIS

3.1Basic Evaluation

In the basic evaluation section of early warning evaluation system, the county-level administrative districts were taken as evaluation objects. The evaluation was based on the unique natural environmental foundation of the coastal zone in consideration of the natural features such as resources, ecology and environment. The basic evaluation result of early-warning in 2015 for each district was figured out by integrating the carrying capacity of six index including per capita available land area, per capita water resource, intensity ofshoreline development, intensity of ocean development, resource and environmental depletion index, water qualification rate in marine functional areas (TABLEIII).

TABLEIII. Early-warning basic evaluation results of resource and environment carrying capacity of Guangxi coastal region

	Overload Indicator	Critical Overload Index	Basic Evaluation Results
Fangcheng District	Per capita available land area	Intensity ofshoreline development and water qualification rate in marine functional areas	Overload
Dongxing City	Per capita available land area and intensity of ocean development	Intensity ofshoreline development	Overload
Gangkou District	Water qualification rate in marine functional areas	Per capita available land area and intensity ofshoreline development	Overload
Qinnan District	Water qualification rate in marine functional areas	Per capita available land area and intensity ofshoreline development	Overload
Hepu County	Water qualification rate in marine functional areas	Per capita available land area and intensity ofshoreline development	Overload
Haicheng District	Per capita available land area	Water qualification rate in marine functional areas and intensity ofshoreline development	Overload
Yinhai District	Water qualification rate in marine functional	Per capita available land area	Overload

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	areas		
Tieshangang District	None	Per capita available land area and intensity ofshoreline development	Critical overload
Coastal area	Water qualification rate in marine functional areas	Per capita available land area and intensity ofshoreline development	Overload

In a word, the overall basic evaluation result of the Guangxi coastal region was overload. There was no non-overloaded district as seven of the eight districts were overload with only one critical overload district.

3.2Special Evaluation

Generally, the urbanized area refers to the urban district under the municipal administrative district. So the Guangxi coastal region, the urbanized areas include Fangcheng District, Gangkou District, Qinnan District, Haicheng District, Yinhai District and Tieshangang District. The municipal PM 2.5 was applied to represent the urbanized area in term of the character of air mobility.

TABLEIV. PM 2.5 concentration of Guangxi coastal cities in 2015

	Fangcheng District	**Qinzhou**	**Beihai**
Exceeded days of PM2.5 (days)	19	31	15
Annual average concentration (μg/m³)	30.16	35.22	29.50
Carrying capacity	Non-overloaded	Non-overloaded	Non-overloaded

Thegeneralconditionof PM2.5 in Guangxi coastal cities was good. The exceeded days of PM2.5 of Qinzhou were more than the two other districts, as well as the annual average concentration. The carrying capacity of the three districts were non-overloaded in terms of the exceeded days of PM2.5 were less than 60 days. As a result, the urbanized areas under the jurisdiction, namely Fangcheng District, Gangkou District, Qinnan District, Haicheng District, Yinhai District and Tieshangang District were also non-overloaded. In consequence, the special evaluation results of the six districts in Guangxi coastal region were all non-overloaded (Table IV).

3.3Process Evaluation

The process evaluation in the early warning evaluation system of resource and environmentbearing capacity breaks the stereotypical perception.As it incorporated the relation of resource and environment depletion and urbanization level, which not only reflects the variation tendency of resource and environmental depletion but also takes over and quantifies the results of basic evaluations and special evaluations primely, as well as elastically demonstrates the early warning results of resource and environmental carrying capacity.

3.3.1Resource and Environmental Depletion

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TABLEV. Resource and environmental depletion index of Guangxi coastal region

Indicators	Per Capita Available Land Area		Intensity Of Shoreline Development		Water Qualification Rate In Marine Functional Areas		Intensity Of Ocean Development		Resource And Environmental Depletion Index Resource	
Years	2010	2015	2010	2015	2010	2015	2010	2015	2010	2015
Coastal region	0.5284	0.5313	0.2794	0.3860	0.2198	0.2767	0.0000	0.0000	1.0275	1.1940
Fangcheng District	0.6503	0.6288	0.0000	0.1303	0.3521	0.1044	0.0000	0.0000	1.0024	0.8635
Dongxing City	0.6253	0.6960	0.6191	0.4624	0.0047	0.0000	0.0000	0.6723	1.2491	1.8307
Gangkou District	0.4715	0.5628	0.2004	0.3212	0.1842	0.2770	0.0665	0.0000	0.9226	1.1610
Qinnan District	0.3593	0.3169	0.4328	0.5644	0.3259	0.5579	0.0000	0.0000	1.1180	1.4391
Hepu County	0.5468	0.4819	0.4031	0.3938	0.3737	0.2799	0.0000	0.0000	1.3236	1.1556
Haicheng District	0.8974	0.9215	0.0256	0.1501	0.0000	0.0654	0.2352	0.0000	1.1581	1.1370
Yinhai District	0.1441	0.3235	0.0000	0.0000	0.0000	0.4804	0.0000	0.0000	0.2352	0.8763
Tieshangang District	0.3614	0.4600	0.1106	0.3334	0.2490	0.0000	0.0000	0.0000	0.7210	0.7934

The resource and environmental depletion in Guangxi coastal region was intensified from 2010 to 2015 (TABLEV). In 2010, the maximum depletion appeared in Hepu County, while the minimum depletion was in Yinhai District. However, the maximum depletion appeared in Dongxing City, and the minimum depletion was in Tieshangang District in 2015. Moreover, the maximum variation of resource and environmental depletion index from 2010 to 2015 was occurred in Yinhai District and Dongxing City, both of which displayed aggravated trend. The minimum variation was in Haicheng District, with the resource and environmental depletion turned to be better than previous. Nevertheless, it is insufficient to diagnose the variation tendency of resource and environmental carrying capacity only depending on the depletion index. In this study, the urbanization level was combined to establish the elasticargument in the further analysis.

3.3.2Urbanization Level

The average urbanization levels of Guangxi coastal region in 2010 and 2015 were 0.0575

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and 0.0675 respectively. The urbanization level has increased 17.27%, which indicated the urbanization levels of Guangxi coastal region have improved in recent five years. The urbanization level of the eight counties in Guangxi coastal region all presented increasing tendency with varying degree, of which the Haicheng District increase the most. As sorted from large to small in 2010, the rank of the urbanization level of the eight counties was Gangkou District > Haicheng District > Yinhai District > Tieshangang District > Dongxing City > Hepu County > Fangcheng District > Qinnan District. The rank of the urbanization level in 2015 was Haicheng District > Gangkou District > Yinhai District > Dongxing City > Tieshangang District > Qinnan District > Fangcheng District > Hepu County.

3.3.3Decoupling

In order to determine the type of urbanizationin terms of the bearing capacity of resource and environment at this stage, whether the variation tendency ofresource and environment carrying capacity was compatible with the development state of urbanization was analyzed under the background of new type urbanization. Then, the warning level was determined.

Overall, the relation of resource and environment depletion index and the development state of urbanization in Guangxi coastal area was expansion connection. That is, the urbanization level and the pressure on resource and environment have promoted at the same time with the similar growth rate. This kind of urbanization development model was extensive and was the most common model in our country. There were three decoupling types in Guangxi coastal region, namely strong decoupling, weak decoupling andexpansion negative decoupling (TABLEVI).

TABLE VI. Decoupling analysis results of Guangxi coastal region

	ΔE	**ΔU**	**θ**	**DECOUPLING TYPE**	**TYPES OF URBANIZATION**
Coastal Region	0.1620	0.1622	0.9990	Expansion connection	Extensive urbanization
Fangcheng District	-0.1386	0.1183	-1.1713	Strong decoupling	Economical urbanization
Dongxing City	0.4656	0.1974	2.3591	Expansion negative decoupling	Extensive urbanization
Gangkou District	0.2583	0.1744	1.4815	Expansion negative decoupling	Extensive urbanization
Qinnan District	0.2873	0.1806	1.5912	Expansion negative decoupling	Extensive urbanization
Hepu County	-0.1269	0.0764	-1.662	Strong decoupling	Economical urbanization
Haicheng District	-0.0182	0.2593	-0.0703	Strong decoupling	Economical urbanization

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Yinhai District	2.7249	0.2121	12.8502	Expansion negative decoupling	Extensive urbanization
Tieshangang District	0.1004	0.1530	0.6560	Weak decoupling	Economical urbanization

The decoupling type of Fangcheng District, Hepu County and Haicheng District were strong decoupling, which demonstrated that the levelsof urbanization of the three regions were increasing while the stress on resource and the environment was decreasing and the level of urbanization has embarked on a green development path. The decoupling type of Dongxing City, Gangkou District, Qinnan District and Yinhai District were expansion negative decoupling. The results revealed that with the improvement of the urbanization level of these districts, their respective resource and environmental pressures were also increasing, and the pressure increased faster than the development speed of urbanization. As a result, the Resources and environment have become constraints on urbanization development, and the type of urbanization presented as extensive in these districts. Only the result of Tieshangang District was the weak decoupling type. This meant that the improvement of urbanization level in this district was accompanied by the increase in the stresses on resource and the environment. However, urbanization level has increased more than the pressure of increased resource and environment, namely the urbanization type was economical.

In summary, the results of process evaluation in the early-warning assessment system of resource and environmentbearing capacity of Guangxi coastal region were as follows: Fangcheng District, Hepu County, Haicheng District, and Tieshangang District belonged to the economical urbanization type, while Dongxing City, Gangkou District, Qinnan District and Yinhai District werecategorized as extensive urbanization.

3.4Veto Evaluation

The veto evaluation in the early warning assessment system of resource and environment carrying capacity was assisted by the total controlperspective and the ‘one-vote veto’ idea was implemented. The control red lines of water, arable land, ecology and urban space which were closely linked to human life and social development were taken as indicators. And the evaluation results had a decisive effect on the determination of the warning level. With regard to the Guangxi coastal region, the red lines of prime farmland preservation and marine ecosystem conservation were not officially delineated until 2017. Therefore, only the water resource protection red line was selected as the indicator for the veto evaluation in the early warning assessment system of resource and environmental carrying capacity. Guangxi has established three red line control indicators including total water consumption, water utilizationefficiency (declining rate of water consumption per 10,000-yuan ofvalue-added by industry, effective use coefficient of cropland irrigation water), and water qualification rate in water function zone (TABLEVII).

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TABLEVII. Three red line control indicators of water resources in Guangxi coastal cities

	BEIHAI	FANGCHENGGANG	QINZHOU
Total water consumption (100 million m^3)	11.12	6.59	14.99
Veto evaluation results	Not veto	Not veto	Not veto
Declining rate of water consumption per 10,000-yuan of value-added by industry(%)	49	40	56
Effective utilization coefficient of farmland irrigation water	0.473	0.469	0.468
Veto evaluation results	Not veto	Not veto	Not veto
Water qualification rate of water function zone (%)	100	100	92.3
Veto evaluation results	Not veto	Not veto	Not veto

Due to the red line control indicators were based on the total control, the water resource utilization of the municipal administrative district was used to reflect the water utilization of the county administrative district. As a result, the veto evaluation results of early warning assessment system of resource and environment carrying capacity in Guangxi coastal region were all not veto in the eight counties.

3.5 Early Warning Results

As the final step of early warning, the integrated evaluation synthesized the results of the above basic evaluation, specific evaluation, process evaluation and veto evaluation. The early warning level of resource and environmentbearing capacity of Guangxi coastal region was determined on account of integrated evaluation results.

Forthe whole coastal region, as the results of basic evaluation, specific evaluation, process evaluation and veto evaluation were overload, not overloaded, extensive and not veto respectively, the final early warning results of the study area was extremely severe warning (TABLEVIII).

TABLEVIII. The integrated evaluation results in the early warning evaluation system for resource and environment carrying capacity of the Guangxi coastal region

	Basic Evaluation	Specific Evaluation	Process Evaluation	Veto Evaluation	Warning Level
Coastal region	Overload	Not overloaded	Extensive	Not veto	Extremely severe
Fangcheng District	Overload	Not overloaded	Economical	Not veto	Severe
Dongxing City	Overload	Not overloaded	Extensive	Not veto	Extremely severe

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Gangkou District	Overload	Not overloaded	Extensive	Not veto	Extremely severe
Qinnan District	Overload	Not overloaded	Extensive	Not veto	Extremely severe
Hepu County	Overload	Not overloaded	Economical	Not veto	Severe
Haicheng District	Overload	Not overloaded	Economical	Not veto	Severe
Yinhai District	Overload	Not overloaded	Extensive	Not veto	Extremely severe
Tieshangang District	Critical overload	Not overloaded	Economical	Not veto	Light

There were three types of warning levels appeared in the Guangxi coastal region, i.e., light warning, severe warning and extremely severe warning. Tieshangang District was the only one region shown as the light warning. Three districts including Fangcheng District, Hepu County and Haicheng District were the severe warning level. Half of the study area was extremely severe warning level.

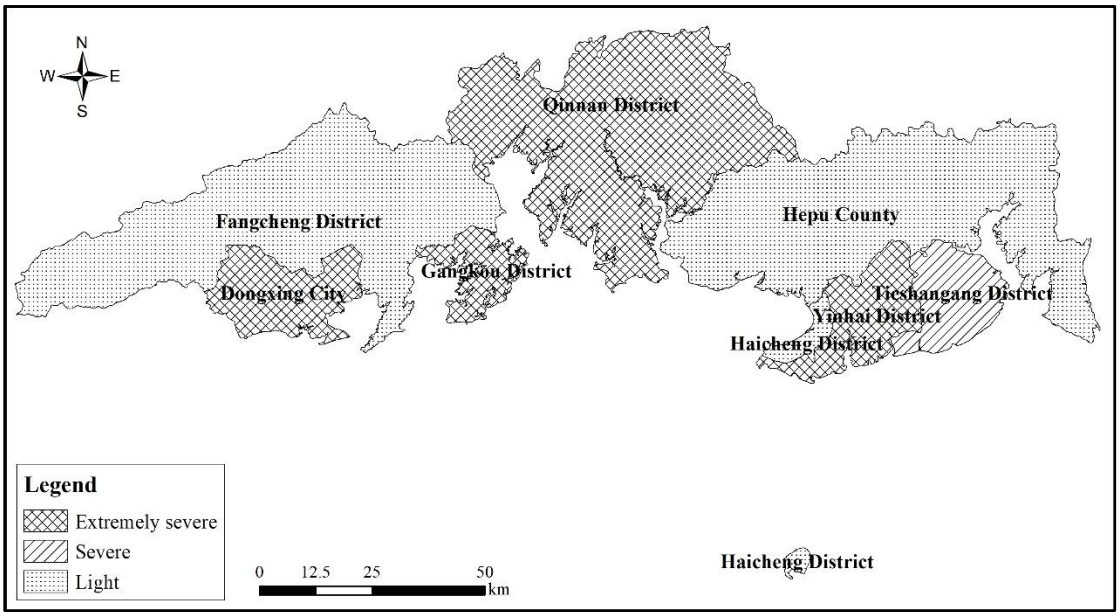

Fig 2: Early warning level of Guangxi coastal region

Generally, the early warning results indicated that the resource and environment carrying capacity for Guangxi coastal region was not optimistic with all eight administrative regions presented different levels of early warning (Fig 2).

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IV. CONCLUSION

Taken Guangxi coastal region as a case study, the early warning model and a set of evaluation indicator system that appropriate for assessing resource and environment carrying capacity of coastal area was established. By applying the comprehensive model, the basic evaluation, special evaluation, process evaluation, veto evaluation and integrated evaluation of resource and environmentbearing capacity of Guangxi coastal region was performed and the early warning results was obtained. The primary conclusions were as follows:

(1) What made the research different was that the relation of urbanization level and resources and environment, and 'one-vote veto' idea was integrated into the evaluation. The revised process evaluation and appended veto evaluation was applied to improve the early warning model. In addition, the concept of resource and environmental depletion rate was proposed and the resource and environmental depletion index was redefined to construct the evaluation indicator system and carry out the early warning evaluation.

(2) The resource and environmentbearing capacity of Guangxi coastal region was not optimistic. The basic evaluation result indicated that there was no non-overloaded district as seven of the eight districts were overload with only one critical overload district. Resource indicators such as per capita available land area and intensity of ocean development, and water qualification rate in marine functional areas that exceeded the standard threshold were the direct causes of overload in most areas of Guangxi coastal region. In terms of the number of overload indicators, the carrying capacity of Dongxing City was the worst with two indicators were overloaded, namely, per capita available land area and intensity of ocean development. The carrying capacity of Dongxing City was the best with no indicators were overloaded.

(3) The utilization of water resources of Guangxi coastal region was under the control of three red lines and the air quality in urbanized areas was good as well. The results of special evaluation have shown that only few days of PM2.5 exceeding the standard. This indicated the good air quality and comfortable living environment of the study area. The exceeded days of PM2.5 of Qinzhou were the most, as well as the annual average concentration. The veto evaluation results revealed that the water resources have not exceeded the red line in terms of total water consumption, water utilization efficiency or water qualification ratein functional zone and the water resource utilization was within a reasonable range.

(4) The process evaluation results presented that the relation of resource and environment depletion index and the urbanization condition of Guangxi coastal area was expansion connection. The urbanization level and the pressure on resource and environment have promoted at the same time with the similar growth rate. This kind of urbanization development model was extensive and was not sustainable.

(5) As the integrated evaluation results demonstrated, the early warning results of the study area was extremely severe warning. Half of the study area was extremely severe warning level. Three districts including Fangcheng District, Hepu County and Haicheng District were the severe warning level. Tieshangang District was the only one region shown as the light warning. The results indicated that the resource and environment carrying capacity in Guangxi coastal

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region was not coordinated with social and economic development. The future development of most regions is unsustainable. It is necessary to diagnose the problems of social and economic development based on the variations of carrying capacity, and regulate the binding and restrictive policies to realize the objective of sustainable development.

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