Dynamics Analysis and Prediction on the Land Use of Typical Karst Wetland Watershed in Southeast Yunnan, China

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Abstract: In order to understand the situation of land use in Karst and the corresponding trend of variation in the future 30 years, based on the geographic information system (GIS), the dynamic variation of land use in Karst wetland has been analyzed by using the Landsat pictures in the year of 1990, 1995, 2000, 2005, 2010 and 2015. The spatial distribution of land use in 2025, 2035 and in 2045 has been simulated and analyzed. Meanwhile, the change in wetland has been further evaluated by combining with the social and economic data of the local statistical yearbook (2005-2013). The results show that the area of agricultural land, construction land and garden area increased by 3.42%, 0.71% and 0.02% respectively, but the area of unused land, wetland and forest land decreased by 2.36%, 1.21% and 0.58% respectively. What's more, the sub-scenario predictions showed that the major land-use types still are the farmland, forest land and wetland in the study area in the future, and the transfer way land use types is different under the various scenarios. For example, in scenario I, wetlands and agricultural land are the main sources of land circulation and mainly became the land for township residents; In scenario II, the increase in construction land and unused land occupies part of the agricultural land and forest land; under scenario III, Convertion of farmland from construction land, woodland and wetlands are the main land-use patterns in the future. However, although the wetland area has increased, it is still necessary to strengthen and apply the land use environmental management strategy to achieve the best balance between the development of tourism and the ecological protection of environmental resources due to the activity from human activities.

Introduction

Wetlands are considered to be one of the world's most valuable natural resources, and it supports human well-being and the development society and economic [1], which is essential to sustain the environmental quality in ecosystems, protect the habitat of animal and plant and to meet the human needs [2]. Under the effects of the natural and human factors, wetlands are facing with severe

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pressure on the demand for natural resources and the accumulation of environmental stress [3]. As an indicator of the interaction between the human and nature, land use reveals the change mechanism of human activities to the nature, and it is the key factor to analyze the driving mechanism of land use change. Therefore, it is necessary for monitoring the dynamic changes in land use to protect the environment or to ensure the sustainable development of resources [4]. The remote sensing images can be used to verify the variation of land use with time [5], and remote sensing technology is widely recognized as a tool to monitor the use of land use trends appropriately and accurately [6]. Furthermore, the type of land use can be studied by the using the remote sensing images in a short period of time, and corresponding higher accuracy can be achieved more easily.

In recent years, the land use prediction models have been built by many researchers and some urban geospatial statistical models, such as logistic regression [7], cellular automata (CA) [8], Markov chains [9-10], etc. The Markov model not only predicts the complex urban environment, but also predicts the future prospects of ecologically fragile areas [11]. A. G Bozkaya et al use a Markov chain-based, stochastic Markov model and cellular automata Markov model to predict the land use and cover in the protected area on the northwest coast of Turkey. The results showed that CA Markov yielded reliable information better than St. Markov model [12]. Petit et al studied a land-cover change on the basis of a temporal series of three multispectral SPOT images in the region of Lusitu of the Southern Province of Zambia, and the rates of change of Markov-based model was given [13]. Wu et al investigated the land use change dynamics by the combined use of satellite remote sensing, geographic information systems (GIS). The results indicated that there had been a notable and uneven urban growth and a major loss of cropland loss between 1986 and 2001 [14]. Although there were a large number of studies based on the Markov model, there are significant differences in the different research areas and there are few studies on the karst wetland.

The typical karst landforms in the southeastern Yunnan are representative in the karst landforms, and are the typical ecological sensitive region, which has a high value of research and protection. In this study, the changes in land use types from the year of 1990 to 2015 of the Puzhehei wetland basin has been investigated, and CA-Markov has been used to predict trends of land use change in the next 30 years. Firstly, the land use change in the 25 years (1990-2015) of the study area was captured by using remote sensing images, especially analyzed wetland area changes quantitatively. Furthermore, the reasons of land use change have been analyzed and the land use changes of the study area in the next 30 years have been predicted of different scenarios. On the basis, the changes of wetland area was further analyzed quantitatively, which provides the basis for understanding the development trend of future Puzhehei wetland and has important practical significance in the area of ecological protection and resource allocation.

Materials and Methods
Study area

The study area of Puzhehei river basin is located in the southeastern part of Yunnan Province, northwest of Wenshan autonomous Prefecture. It is away from the capital of Kunming 364 km, covers an area of about 33.17×103 km^2, longitude 103 ° 55 '~ 104 ° 13' N, latitude 24 24 ° 05 '~ 24° 12 'E, as shown in Figure.1. Additionally, it is located in the Pearl River source, and the upstream of Yangtze River and Red River, which is a typical karst area of the lake. The climate of the basin is the low latitude monsoon climate with the average annual temperature of 16.4°C and the average rainfall of 1206.8 mm. There are 54 lakes, 312 solitary peaks, 83 caves, 15 rivers and a underground gullies with the length of 120 km distribute in the region, and the total area of the waters is 26.7 km^2. As the three largest lakes in the study area, Puzhehei lake, Luoshui cave lake

and Xianren cave lake connect each other with the zonal distribution. Because the kinds of landforms, such as karst maintains group, lakes group, karst caves group, and wetland etc are exhibited in the region, coupled with the improper economic activities conducted by human, the study area become the typical ecologically sensitive areas.
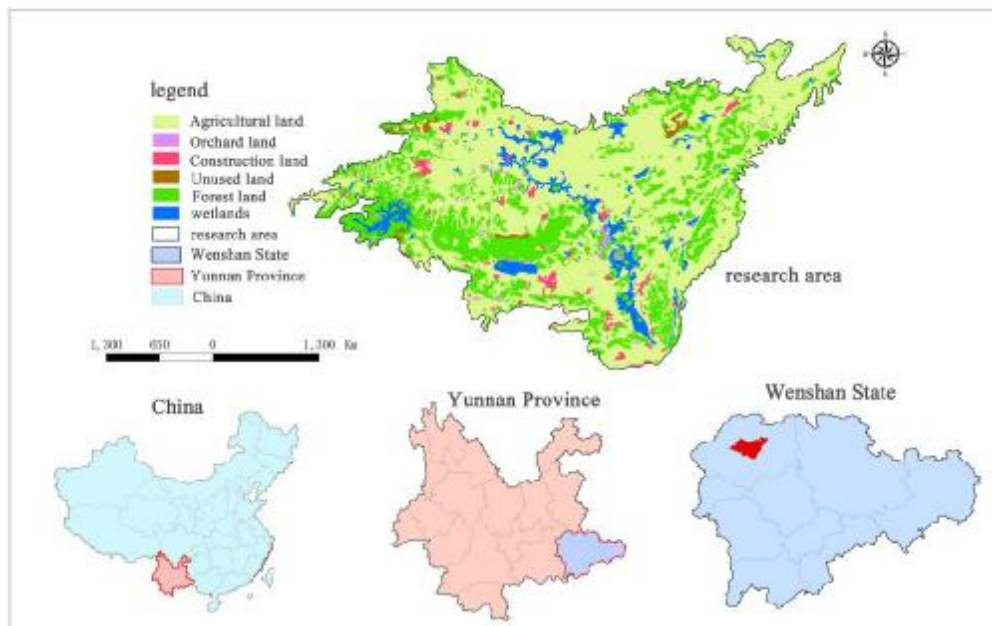

Fig 1. Location map of the study area

Methodology

Data acquisition and processing

The high quality Landsat pictures were obtained by Landsat TM in the year of 1990, 1995, 2000, 2005, 2010 and by ETM in 2015. The Landsat pictures have the characteristics of the cloud cover of less 5%, the spatial resolution of 30m and the unified projection coordinate information of WGS-1984-UTM-Zone-49N. Then, the Landsat pictures were manipulated by the ERDAS software from the several aspects of radiation location, atmospheric correction, geometric correction, image stitching and cutting. What's more, according to the characteristics of land resources and the difference landscape change and the characteristics of image data, the land use in Puzhehei basin can coded by the six types of construction land, woodland, farmland, wetland, unused land and garden land. This process is finished on the ArcGIS10.2 software by combining investigation of the ground control points and the terrain data, the spectral features and the texture features of the ground objects. Furthermore, in order to ensure the accuracy of the interpretation of land use types in the study area, the high spatial resolution sensing image were sampled by the ground GPS and the accuracy of each issue image were also be calculated, as shown in Tab.1. Meanwhile, other auxiliary data including GDP, total agricultural output value, rainfall, the number of tourists, the total output value of tourism, the area of land and the total population, etc has been obtained by the local government.

Table 1. The classification precision of land use of puzhehei basin

Time	1990	1995	2000	2005	2010	2015
Image	TM	TM	ETM	TM	TM	OLI
kappa coefficient	0.78	0.82	0.85	0.82	0.84	0.87

CA-Markov prediction model

Cellular automata (CA) is a dynamic system with the ability to simulate spatial and temporal evolution in which the time, space and state are discrete. Because of the advantages of powerful and complex computational functions, highly dynamic characteristics and spatial concepts [15], it has been used to simulate the growth process of city [16]. As a spatial probability model based on the grid, Markov model can be used as a tool to predict the trend of land use change [17-18]. However, the Markov model does ignore the spatial knowledge distribution within each category, and the transition probability is not constant among different landscape types. Compared with the Markov model, the CA-Markov model has been widely used to simulate the spatial and temporal variation since the ability to simulate and analyze the spatial distribution quantitatively. Thus, the CA-Markov model can simulate the change process of land use pattern more reasonably. The IDRISI softwares were used to process the data and the specific process is as follows:

(1) Dividing the cell size and building the filter

The cell size of 30 m × 30 m and the cellular filter with the grid cell of 5 × 5 m are selected.Because the cell size of 30 m × 30 m selected during the simulation can simulate the land use change in the study area better, according to itsarea and the land use type.

(2) Choosing the run time of the model and cell iteration times

Based on land use data for 1995, 2005 and 2015, the transferring matrices of land use type were calculated from 1995 to 2005 and 2005 to 2015.Setting the Landsat pictures in 2015 as the initial value and the number of CA cycles as 10, the types of land use change in the 20252035 and 2045 can be simulated by combining land use transition probability theory between the years of 1995-2005 and 2005-2015.

Results and analysis

Dynamic change of land use

Table.2 gives the area change and coverage of land use of Puzhehei basin in 1990-2015. As can be seen from the Tab.2 that the area of construction land and farmland in Puzhehei wetland area have been increased, but the area of the unused land has been decreased and the area of woodland and garden fluctuated irregularly in the years of 1990-2015. During this period, the area of construction land increased from 549.05 ha to 784.77 ha, which means that construction land area increased by 0.71% due to development city in the past 25 years. The increase in construction land is mainly distributed in the southwest of the study area where the population is concentrated in towns and wetland parks. However, because there are a wetland park in southern of the area,the Luoshui cave landscapes and the area of building land developed linearly, the density of the construction land in the eastern border of the study area having been decresed. Over the past 25 years, the area of unused land has been decreased from 1,024.34 ha to 243.12 ha, especially, the unused land decreased fastest at the rate of 55.33% during the period of 2000 to 2005, reaching 55.33%.

Table 2. The area change and coverage of land use of Puzhehei basin in 1990-2015

	Land use type	Construction land	Forest land	Agricultural land	Wetland	Unused land	Orchard land	Total
1990	Area （ha）	549.05	9369.64	19670	2319.14	1024.34	236.69	33168.9
	Coverage （%）	1.66	28.25	59.3	6.99	3.09	0.71	100
1995	Area（ha）	621.82	9343.73	19818.3	2241.09	898.55	245.39	33168.9
	Coverage （%）	1.87	28.17	59.73	6.76	2.71	0.74	100
2000	Area（ha）	674.25	9180.54	20045.4	2190.14	838.81	239.7	33168.9
	Coverage （%）	2.03	27.68	60.43	6.6	2.53	0.72	100
2005	Area（ha）	706.77	9423.89	20695.6	1573.34	530.71	238.56	33168.9
	Coverage (%)	2.13	28.41	62.4	4.74	1.6	0.72	100
2010	Area (ha)	756.37	9165.24	20777.8	1848.94	376.1	244.45	33168.9
	Coverage (%)	2.28	27.63	62.64	5.57	1.13	0.74	100
2015	Area (ha)	784.77	9177.4	20804	1916.2	243.12	243.1	33168.9
	Coverage (%)	2.37	27.67	62.72	5.78	0.73	0.73	100

The transfer process of the land use type in the years of 1990-2000, 2000-2010 and 2010-2015 has been studied. The percentage of transfer matrix of each landscape area in Puzhehei basin (1990-2015) is shown in Tab.3

Table 3. The percentage of transfer matrix of each landscape area in Puzhehei basin (1990-2015) (%)

Time	Land scape Type	1	2	3	4	5	6
1990-2000	1	1.84	0.02	0.00	0.02	0.00	0.00
	2	0.01	22.04	9.49	0.12	0.66	0.02
	3	0.28	5.19	52.27	2.62	0.49	0.13
	4	0.04	0.15	2.94	4.85	0.07	0.02
	5	0.08	1.19	0.42	0.09	1.98	0.00
	6	0.00	0.07	0.08	0.02	0.00	0.62
2000-2010	1	2.03	0.00	0.00	0.00	0.00	0.00
	2	0.02	24.74	2.12	0.12	0.66	0.02
	3	0.23	1.19	56.85	1.54	0.49	0.13
	4	0.01	0.15	3.17	3.18	0.07	0.02
	5	0.00	1.48	0.42	0.64	0.00	0.00
	6	0.00	0.07	0.08	0.09	0.00	0.57
2010-2015	1	2.27	0.01	0.00	0.01	0.00	0.00
	2	0.00	26.91	0.72	0.00	0.00	0.00
	3	0.08	0.71	60.95	0.90	0.00	0.00
	4	0.00	0.04	0.61	4.86	0.02	0.00
	5	0.02	0.00	0.40	0.00	0.71	0.00
	6	0.00	0.00	0.00	0.01	0.00	0.73

Note：1、Construction land, 2、Forest land, 3、Agricultural land, 4、Wetland, 5、Unused land,

Although some measures have been taken to protect and manage the Puzhehei Wetland Park,

the development of tourism in the study area made the wetland area reduced by 1.21%. Additionally, the increase in some human factors, such as the local housing construction, land reclamation and deforestation, made the ecological environment of the study area further damaged. Correspondingly, the area of the woodland fell by 0.78% during 2005-2010, but the area of farmland and garden were increased by 3.42% and 0.02%, respectively.

6、Orchard land

As illustrated in Tab.3, the transfer process of the land use type among the agricultural, forest lands, wetland and unused land is obvious and out of the area are greater than the transfer into the area. In the out of the land to the agricultural land and forest land, wetland and unused land accounted for a certain percentage of the early transfer, the proportion of late transfer out of the smaller, the proportion of the overall transfer out of the orchard lands. Transfer to land to agricultural lands, forest land and wetland, unused land and construction land into the proportion of smaller. During the period of 1990-2000, the forest land and wetland was mainly transformed to the area of agricultural. The increase in construction land was caused by the decreasing of the farmland and the unused land was used for planting trees. In addition, the conversion between agricultural and wetland was the most intense in 2000-2010, 3.17% wetlands were converted into agricultural and1.54% agricultural were converted into wetlands. However, the conversion between agricultural and wetland was not obvious in 2010-2015. Only 3.17% wetlands were converted into agricultural and 0.90% agricultural was converted into wetlands. Meanwhile, 0.72% forest lands were converted into agricultural and 0.71% agricultural was converted into forest lands. Hence, the conversion between agricultural and forest lands was obvious.

Model validation

In order to test the accuracy of the CA-Markov model for the prediction of land use change, the simulation accuracy of the land use types of Puzhehei basin in 2010 and 2015 has been tested by simulating the cellular and initial cellular. The results show that the prediction accuracy in 2010 and 2015 is more than 80%, and the CA-Markov model can simulate the trend of land use types better, as indicated in Tab.4.

Table 4. The contrast of land use simulation accuracy of Puzhehei basin　　　　(%)

Land use type	2010			2015		
	Simulated cells	Actual cell	Relative error	Simulated cells	Actual cell	Relative error
Construction land	6400	8400	0.24	6777	8710	0.22
Forest land	79154	101833	0.22	86499	101968	0.15
Agricultural land	209409	230855	0.09	210629	231156	0.09
Wetland	13644	20533	0.34	17455	21289	0.18
Unused land	1267	4189	0.7	1433	2710	0.47
Orchard land	1178	2723	0.57	1100	2700	0.59
Total	311052	368533	0.16	323893	368533	0.12

Table.4 shows that the relative error of cellular simulation in 2010 and 2015were 0.16 and 0.12, respectively. The relative error of forest lands and agricultural are below 0.20 and that of the wetland and construction land are below 0.30. Unfortunately, the relative error of the forest lands and the unused land is large, which is owing to the proportion of the total area of the forest lands and unused land is small and the slight change of the area has a significant influence on the results. The forecast map and the present map of Puzhehei basin land use in 2010 and 2015 have been

counted to verify the accuracy of the location. Correspondingly, the Kappa coefficients of 0.84 and 0.86 can be got. The Kappa coefficients more than 0.75, which means both the forecast maps and the present maps exhibit the high accuracy and the accuracy of predictive value and the simulation results have a good reliability.

Different scenario scenario forecast result

Different scenarios design

According to the results of CA-Markov model scenario design at home and abroad, the current situation of the research area is divided into the following three scenarios: Scenario 1 is the economic development scenario: According to the "Guidelines for the Development of Overall Planning for the Development of Characteristic Towns in Yunnan Province" and " Yunnan Province Leading Group Office of the Leading Group on the development of township planning notice submitted "to speed up Puzhe black karst water town development, to further enrich and improve the Pudeheiliuchi environmental protection content, combined with water and other characteristics to take into account the platform Facilities, low hill gentle slope land for construction land, to meet the needs of key projects.Scenario 2 is a trend development scenario: According to the spatial variation of land use under the natural evolution of the CA-Markov model, the transition matrix and suitability map set from 2005 to 2015 are imported into the model and the data of 2025, 2035 and 2045 Land use change.Scenario 3: Ecological Protection Scenario: According to the Regulations on the Protection of Putianshan Scenic Spot, the General Plan of Yunnan Qubei Puluhei National Wetland Park, the Overall Land Use Planning of Qiu Bei County (2010-2020), the Qiu Bei County The people's government actively responds to the concept of strengthening the protection of cultivated land and promoting the scientific development of urbanization, and carries out vegetation restoration in the wetland conservation area to realize the project of returning farmland to forests, returning farmland to forest, afforestation and wetland restoration.

Prediction of Spatial Distribution of Land Use in Different Scenarios

According to different scenarios, the trend of land use in Puzhehei watershed in 2025, 2035 and 2045 was simulated. The growth patterns of land use varied under different scenarios. The simulation results are as follows (as shown in Figure 2):
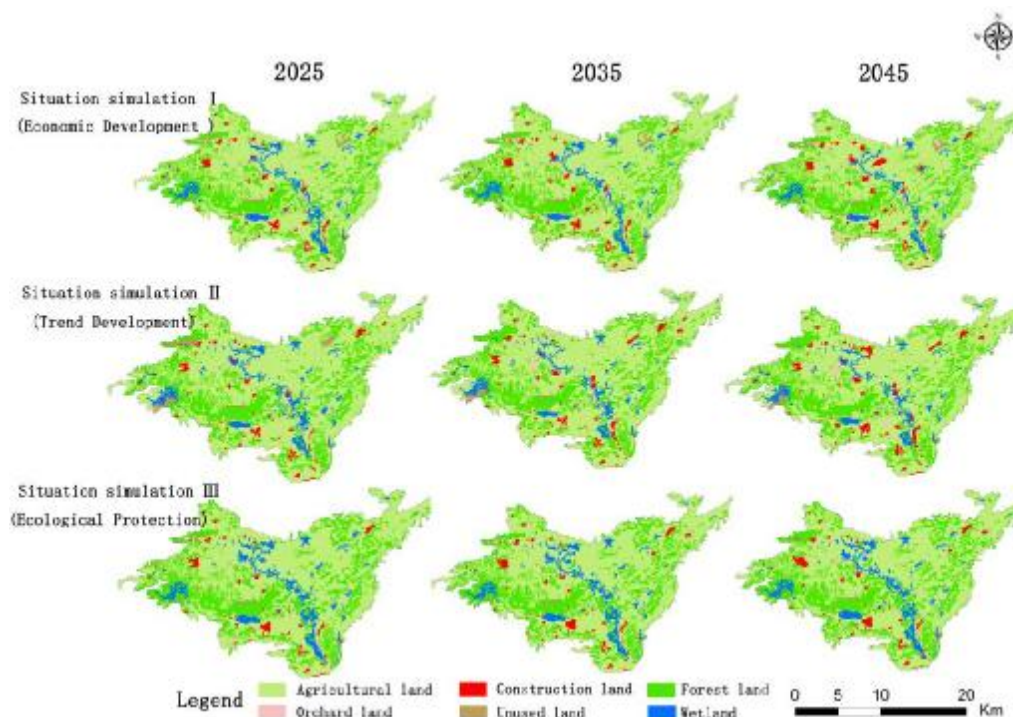
Fig 2. The dynamic change of land use predict of Puzhehei basin in 2025-2045

(1) Economic Development Scenario Ⅰ. Under scenario Ⅰ, the trend of land use types in Puzhehei River Basin by 2045 is significant. The construction area and garden area are increasing, and the increase of construction land is 3.18%. The increase of construction land area mainly covers the lakes and other important traffic routes; the area of wetland, farmland and forestland is decreasing, and the area of wetland is reduced to 1502.94 ha, and mainly concentrated in the black village of Puzhehei, which is making great efforts to develop the tourism industry. This shows that in the scenario I, the future wetland and agricultural land will mainly flow to the land for tourism development, which is also the main source of increase of construction land.

(2) Trend Development Scenario II. Under scenario II, the land use pattern of Puzhehei River Basin changed significantly from 2025 to 2045. By 2045, the increase of construction land mainly expands on the basis of the existing construction land, with the growth rate of 3.81%. The change of construction land mainly concentrates around the scenic area of the water hole and around the scenic area of national wetland park. The decrease of the forest land area mainly concentrates in the basin Around the Hongqi Reservoir in the west. In the meantime, wetland occupies a lower share of 3.98% to 3.82% in the downstream and upstream of wetland parks. By 2045, the wasteland around the Hongqi Reservoir will become a forest land, while the forest land near the Yajiayakou Village in Yangjiayakou will become a wasteland, with the area of unused land declining. This shows that in scenario Ⅱ, the increase of construction land and unutilized land occupies part of agricultural land and forest land, while the increase of wetland is mainly affected by policy factors. For example, from the beginning of 2015, Wetland Park and other watershed ecological corridors and ecologically fragile areas.

(3) Ecological Protection Scenario Ⅲ. Under the ecological protection scenario, farmland, forest land and wetland will remain the major land-use types in the future in 2015-2045. The area of construction land, forest land and wetland will increase during the period, with the growth rates of 0.42% and 1.85%, respectively. 0.49%. The area of agricultural land and unused land decreased, and the rate of reduction of agricultural land area reached 2.62%. The area of unused land and garden land did not change much, and the conversion of agricultural land to agricultural land was

the most obvious. It can be seen that under scenario III, agricultural land is converted to construction land, and forest land and wetland are the major land-use types in the future.

Table 5. The area change of land use predict of Puzhehei basin in 2015-2045

Land use	Economic Development			Trend Development			Ecological Protection		
	2025	2035	2045	2025	2035	2045	2025	2035	2045
	Area (ha)	Area (ha)	Area (ha)	Area (ha)	Area (ha)	Area (ha)	Area (ha)	Area (ha)	Area (ha)
Construction land	764.69	825.82	1056.21	1077.86	1695.09	2341.62	684.11	776.92	826.08
Forest land	9242.88	9238.29	9186.61	7608.72	7529.43	7630.04	9442.46	9717.74	10056.12
Agricultural land	20909.70	21024.91	20793.90	22196.69	21897.59	21219.93	20728.85	20340.61	19858.90
Wetland	1758.00	1593.33	1502.94	1439.01	1321.20	1268.54	2007.36	2077.09	2170.13
Unused land	243.12	198.43	154.22	169.64	145.18	124.04	152.21	101.70	100.39
Orchard land	250.51	243.42	386.12	676.98	580.41	584.73	153.91	154.84	157.28

Conclusion and discussion

Conclusion

The Puzhehei River Basin is very representative of the Karst landform in the southeast Yunnan, and is a typical ecologically sensitive area. Human activities have a great influence on the land-use change in the basin.

(1) The dynamic changes of land use indicate that the area of land for construction and farmland in Puzhehei River Basin increased continuously from 1990 to 2015, the area of wetland and unused land continued to decrease, and the area of forest land and garden fluctuated. Among them, farmland, wetland, The most intense use of land area conversion, significant conversion of forest land and garden area, the conversion of construction land area is not significant.

(2) Among the three scenarios, farmland, woodland and wetland are still the major types of land use in the study area in the future. Under scenario I, wetlands and agricultural land are the main sources of land circulation and mainly flow to the land for township residents; under scenario II, the increase in construction land and unused land occupies some of the agricultural land Land and forest land; under scenario III, agricultural land is converted into construction land, and forest land and wetland are the main land use types in the future.

Discussion

The change in the area of wetland

The change in the area of wetland of the study area in the year 1977-2014 is given in Fig.3. The red in the Fig.3 labels the increased lake wetland and the total area is 218.16 ha. The blue in the Fig3 labels the decreased lake wetland and the total area is 334.24 ha. Especially, the decrease in area of wetland is obvious and the decreased area is 745.8 ha. In addition, the water cover of this area in 1990 is the most, while that is the lowest in 2005. As the basin settles from the northeast to the southwest of the middle of the basin, the reduced water body over the past 38 years is a sign of a decrease in wetland water depth.

Based on the field investigation, the ground control points were set up, and the land use status of the Puzhehei lake wetland was investigated. The land use status chart is shown in Fig4. The survey results show that the total area of the puddle lake wetland is 1104.5 ha in April 2014,

among which the submerged macrophytes are the largest, with an area of 618.36 ha, accounting for 56.01% of the total wetland area, followed by fish ponds with an area of 142.78 ha, Accounting for 12.93% of the total wetland area; water plant and bare land area of 130.8 ha, 110.49 ha, accounting for 11.85% of the total wetland area and 10.01%.
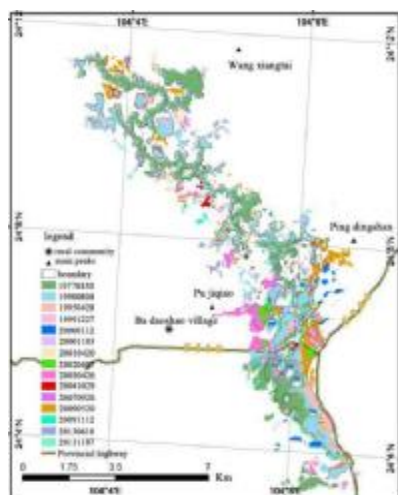

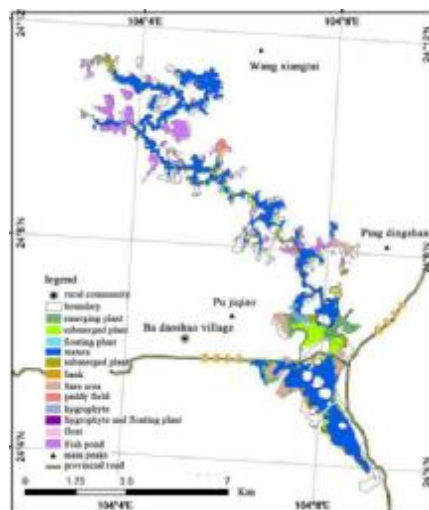Fig 3. Theoretical boundary distribution   Fig 4. Distribution map of Lake Wetland

Changes in wetland area are affected by human or natural factors, including the development of tourism and agriculture, which can lead to the release of large quantities of household waste, solid waste, fertilizers, sludge and pesticides into wetlands, resulting in considerable loss of wetland area [18-19], this phenomenon will lead to other problems, such as water depth, water quality deterioration and lead to destruction of natural ecosystems [17]. in 2009, the national wetland park was built in the lower reaches of the river basin, and the wetland area increased obviously. At the same time, the relevant management policies were set up to reduce sediment, solid waste into the wetlands and the implementation of returning farmland to forests, returning pond to Lake, returning farmland and other measures. From 2005 to 2010, the wetland area increased obviously, and the concentration of TN and TP in the water quality increased, and the wetland was faced with the risk of increasing the pollutant from the surrounding farmland, increasing the use of chemical fertilizer and increasing the water consumption. Accordingly, the proper use of agricultural fertilizers and modified cultivation and irrigation patterns will be one of the strongly recommended strategies, and it is strongly recommended to reduce the area of farmland around the wetlands. Another strategy to overcome the effects of pollutants and sediments on wetlands is the implementation of sustainable lakeside and forestry programs in research areas [18], which is important for protecting wetland area degradation and wetland water pollution.

The impact of social and economic development on wetlands

Wetland systems are inherent dynamic systems that can be produced, modified and destroyed through a series of natural processes, but the direct and indirect consequences of human activities are the main drivers of wetland change and loss. Under the common influence of natural factors and human factors, the area of wetland in Puzhehei River Basin changed greatly from 1990 to 2015. The natural factors influencing the change of wetland area in the study area are mainly climate change, and the rainfall is one of the main potential factors influencing the change of the wetland area of the black lake in combination with the previous study [19] and the climate data of the study area. In addition, the human factor is also a potential cause of changes in the wetland area of the Puhu Lake,

and the extensive expansion of towns and agriculture has promoted wetland water resources for irrigation and drainage, and reservoirs, embankments and swamp dams and floodplains Is a common phenomenon that causes wetland hydrological changes [20-21], where land expansion is closely related to socioeconomic variables such as gross domestic product (GDP), agricultural aggregate output value and population level and urbanization level.

Considering the composition of natural factors and human factors, seven indexes of average annual rainfall, GDP, cultivated area, total agricultural output value, total population, Number of tourists and Total output value of tourism were selected. The results of the analysis are shown in Table 6. From a long time series, the area change of the Puzhehei wetland is negatively correlated with the increase of GPD and the total agricultural output value, which is positively correlated with the increase of the total population, Changes, the number of tourism population and tourism output value is weak, and the local average rainfall is basically irrelevant. This shows that the change of the wetland area in the study area is mainly caused by the human factors. The increase of the total agricultural output value is directly related to the decrease of the wetland area, and the increase of the total output value of the tourism area is indirect to the decrease of the wetland area Impact.

Table 6. Analysis of related factors of Lake area degradation

related analysis		Wetland area(ha)	Annual rainfall (mm)	GDP (Billion)	cultivated area (mu)	Total agricultural output value (Billion)	Total population (number)	Number of tourists (number)	Total output value of tourism (Billion)
Wetland area(ha)	Pearson Correlation	1	.050	-0.833**	.332	-0.835**	.835**	-0.641	-0.595
	Sig. (2-tailed)		.885	.001	.319	.001	.001	0.17	0.213
Annual rainfall (mm)	Pearson Correlation	.050	1	.252	.432	.260	.260	-0.773	-0.637
	Sig. (2-tailed)	.885		.455	.184	.439	.439	0.071	0.174
GDP (Billion)	Pearson Correlation	-0.833**	.252	1	.689	.998**	.998**	.983**	.889*
	Sig. (2-tailed)	.001	.455		.019	.000	.000	0	0.018
cultivated area (mu)	Pearson Correlation	.332	.432	.689	1	.694	.694	0.754	.850*
	Sig. (2-tailed)	.319	.184	.019		.018	.018	0.083	0.032
Total agricultural output value (Billion)	Pearson Correlation	-0.835**	.260	.998**	.694	1	.793	.988**	.929**
	Sig. (2-tailed)	.001	.439	.000	.018		.004	0	0.007
Total population (number)	Pearson Correlation	.447	.528	.787*	.957**	.793	1	.921**	.862*
	Sig. (2-tailed)	.168	.095	.004	.000	.004		0.009	0.027
Number of tourists (number)	Pearson Correlation	-0.641	-0.773	.983**	0.754	.988**	.921**	1	.935**
	Sig. (2-tailed)	0.17	0.071	0	0.083	0	0.009		0.006
Total output value of tourism (Billion)	Pearson Correlation	-0.595	-0.637	.889*	.850*	.929**	.862*	.935**	1
	Sig. (2-tailed)	0.213	0.174	0.018	0.032	0.007	0.027	0.006	

**.The correlation was significantly correlated at 0.01 level; *.The correlation was significantly correlated at 0.05 level

In recent decades, the development of wetland landscapes in the Puzhehei River Basin has become a significant feature of local development and has also increased the potential for negative, harmful and irreversible impacts on the spatial distribution and sustainability of wetland ecosystems.

The Tourist population in the study area reached 200.2 million in 2013, while the number of tourists in 2008 was 90.02 million, and the number of tourists increased by about 55.03% from 2008 to 2013. This growth trend raises increasing demands for land and water use. Although local government officials and agencies have developed a number of strategies to control wetland area reductions and their negative impacts, the agricultural land area is expected to reach 21 219.93 ha by 2045, based on the Puzhehei River Basin land use forecast, two times in 1990.Therefore, the strengthening of the harmonious development of the region and the protection of wetland ecology should be one of the main objectives of the future development of the Puzhehei River Basin.

Suggestion

Based on the analysis of land use dynamics and forecasting results in the next 30 years, it is suggested that strict measures should be taken to put the land use protection in the karst wetland basin in the first place in view of the special geomorphological features and the difficulty coefficient of landscape restoration in the study area.Proceed from several aspects:(1)Strictly regulate the housing system.For the increase in construction land mainly concentrated in the vicinity of wetland parks and townships, and the occupation of wetland and farmland area of the phenomenon, the local government should strictly implement the relevant housing regulations, residents can turn to the southwest direction of housing construction, both to enjoy the karst wetland landscape, But also to protect the wetland landscape;(2)Establish the awareness of ecological and environmental protection. The local ecological construction should be put in the first place,In the tourism development, and guide people to establish the concept of "protecting the ecological landscape is far greater than the value of over-exploitation of the tourism industry" to ensure the economic development while focusing on ecological construction and restoration ;(3)Implement the principle of priority governance.For areas with more severe land use change (such as the Hongqi Reservoir and the tourist attractions around the study area), it is necessary to increase the protection of human nature and give full play to the role of nature reserves and ensure the stable development of ecological functions.

Acknowledgements

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