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THE STUDY OF WETLAND CHANGE IN DIANBAI DISTRICT OF MAOMING CITY

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ABSTRACT

Due to the development of the economy, wetlands are usually occupied and destroyed by human beings, which makes wetland resources more and more tense. In order to further understand the changes of wetland resources in Dianbai District, Maoming City, Guangdong Province in recent years, this study using ENVI5.3, Arc GIS 10.1 software as a study tools and combined with the land use type map of Dianbai District in 2010 and 2020 to create a wetland distribution map, meanwhile, to calculated a Land Use Transfer Matrix (LUTM) for analysis the wetland changes in this area. This study concluded that, firstly, In terms of temporal and spatial changes, the wetlands in Dianbai are mainly concentrated in the southwest, northeast, south and southeast, and the changes in the middle and east are the least. Secondly, compared with 2010, the wetland area in Dianbai has increasing slightly in 2020, the reason of wetland loss may be due to man-made encroachment and global warming. Thirdly, the area of the estuary has increased a little bit and has been successfully protected. Final, the main purpose of this study is to draw people's attention to wetlands, restore and protect wetland ecosystems, as well as urging developing sustainable strategy by government.

KEYWORDS: *Wetland; Land Use Transfer Matrix (LUTM); Geographical Information System (GIS); Remote Sensing (RS); Dianbai Area*

INTRODUCTION

On December 24, 2021, the 32nd Session of the Standing Committee of the 13th National People's Congress of the People's Republic of China adopted the Wetland Protection Law of the People's Republic of China, which will come into force on June 1,2022(National People's Congress, 2021).It shows that the protection of wetlands has become a trend in China, and thinking about how to implement effectively and deeply in the future. The concept of wetland narrowly refers to the transition zone between land and water, and generally refers to all large areas of water bodies on earth except the ocean (more than 6 m deep). Nevertheless, the meaning of wetlands is generally considered in a broad definition, that is, wetlands include swamps, peat lands, wet meadows, lakes, rivers, flood detention areas, estuaries and deltas, beaches, reservoirs, ponds, paddy fields, and sea areas with water depth of 6 meters at low tide.

In terms of broad definition, wetland covers only 6% of the earth's surface, but provides living environment for 20% of the known species, mean while together with forests and oceans which is called the three major ecosystems in the world, that has irreplaceable ecological function such as climate regulation, maintain biodiversity, coastal protection, purify water quality and flood storage, etc., Also, it is an important part of the global carbon cycle (Tan et al., 2022). Thus, it enjoys the reputation of "the kidney of the earth".

Wetland ecosystem belongs to the water ecosystem, which is also a transition area between an aquatic ecosystem and land. Its biological community is composed of an aquatic and terrestrial species. Besides, its material circulation, energy flow and species migration and evolution are relatively active, and it has high ecological diversity, species diversity and biological productivity. Therefore, the research and attention of the wetland ecosystem have a great meaning of environmental protection.

The United States, the United Kingdom, Australia and other developed countries have long understood the importance of wetlands to the environment. In the 1970s, they began to formulate laws and regulations on wetland protection, and have formed relatively perfect laws and regulations on wetland protection, and created targeted systems according to the actual situation of each region (Yao, 2019). Thus, from this background of perspective the "3S (GIS, RS, GPS)" technology has been introduced in the monitoring and research of the wetland environment since the 1980s (Wang et al., 2021; Chen and Wang, 2022)

The wetland research started late in China. Since the 1990s, the Institute of Geography of the Chinese Academy of Sciences has compiled the swamp map, the Northeast RS interpretation database and the swamp Annals of China (Yao, 2019). China has a large range of east, west and south, and a vast territory, not only is the total wetland area large, but also in each region. According to statistics, China's wetland area accounts for 10% of the world's wetlands, ranking first in Asia and fourth in the world. In China, wetlands are distributed from the cold temperate zone to the tropics, from coastal areas to inland areas, and from plain areas to plateau mountains. There are often a variety of wetland types in one region, and one wetland type is often distributed in multiple areas.

Although there are many wetland resources and rich species in China, due to the large population and the weak awareness of wetland protection, meanwhile by developing of economy, the wetlands in China have varying attenuation, degraded or even disappeared in terms of quantity and type. As one of the three major ecosystems, the atrophy and extinction of wetlands have weakened the natural regulation capacity of various regions in China, and causing the ecological environment is gradually unbalanced.

In recent decades, with the great population explosion, developing economic and the advancement of urbanization, in order to meet the needs of human development, many wetlands have been occupied, transformed and even become extinct, increasingly affecting the healthy development of human beings themselves. Thus, human beings are obliged to pay more and more attention to wetlands issues. Based on above opinion, this study will discuss and study the wetland's change status in Maoming Dianbai District through RS imagery and technology, so as to realize the wetland's change status and influence in this area, and then put forward general suggestions on the countermeasures of wetland change.

STUDY AREA.

Dianbai District is located in the west of Guangdong Province, east of western Guangdong region, and southeast of Maoming City (shown as Figure 1). Between the east longitude 110°54 '~111°29', and the north latitude 21°22 '~21°59'. It is about 50 kilometers wide from east to west, about 55 kilometers long from north to south, with a land area of 2128 square kilometers, 40 meters iso-depth sea area of about 4300 square kilometers (including 20 meters iso-depth sea area of 1132 square kilometers, and 10 meters iso-depth sea area of 480 square kilometers, or 48,000 hectares).

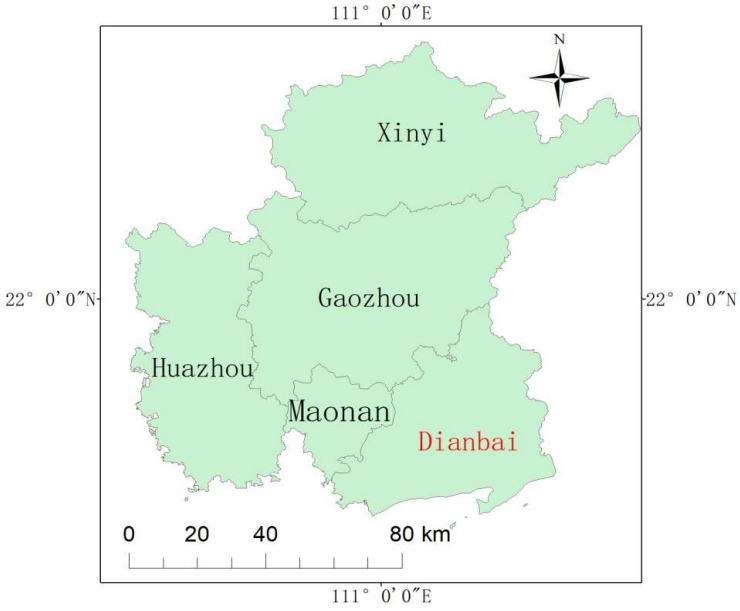


Figure 1: The Administrative District Map of Maoming City.

Dianbai is located in a low latitude area south of the Tropic of Cancer, which belongs to a tropical monsoon climate. The year climate is warm, abundant light, abundant rainfall, water and heat in the same season, less frost and no snow, like spring. The terrain of Dianbai District slopes from northeast to southwest, north and northeast high, low in the south and southwest, and the south around the South China Sea, the harbor roundabout. Mountain areas, plain and coastal terraces each account for one third, that is, the north is the middle and low mountains, the middle is along the river plain and low hills, the southwest is the loess hills, the south is the coastal terraces. There are many rivers in Dianbai District, the main rivers are Shalang River, Rudong River, Longzhu River, Madian River, Daqiao River, Magang River, Danchang River, Zhaitou River and so on. Among them, Shalang River is located in the north of the territory, which is the largest river in Dianbai District, also the mother river of Dianbai.

In 2020, the total area of wetlands in Maoming city is 69,263.2 hectares, and the eastern and northern wetlands are scattered, with the southern, southeast, western and central wetlands, among which the southern and southeast are the most dense, while the Dianbai wetlands covered the majority of the southern and southeast wetlands.

From 2010 to 2020, the economic development trend of Dianbai has been under good circumstances. According to the county report of “Economic Development Index” in the coordinated development index of "One Nuclear Area, One Belt and One Region" in 2020 shows that, Dianbai has ranked among the top 10 districts with strong economic strength around eastern Guangdong, western Guangdong and northern Guangdong, ranking seventh among the 29 districts. Among the single indicators, Dianbai ranked second among the 74 counties (cities) and districts around eastern Guangdong and northern Guangdong with a total GDP of 66.376 billion yuan, and the local general public budget revenue ranked first, being the only district with more than 2 billion yuan.

However, according to the statistical data the average protection rate of Maoming wetland is only about 16.81%. In the economic development of nearly ten years, the area reduction of Dianbai wetland is not only affected by natural factors such as climate change, but also mainly caused by human factors, including reclamation, wetland pollution, artificial digging and drainage, etc.

METHODS AND DATA

Framework of Process

In this paper, the RS images of Land sat are used to classify the Dianbai wetland distribution map by a serial of RS technology processing. Unsupervised classification method is used to classify the images, and the distribution map of Dianbai wetland is obtained. Then, the images obtained by the Chinese Academy of Sciences (CAS) are preprocessed, the raster images is subset, and then the images of different years after fusion are intersected to make a Land Use Transfer Matrix (LUTM), which is analyzed and summarized according to the result maps. The whole processing framework is shown as Figure 2.

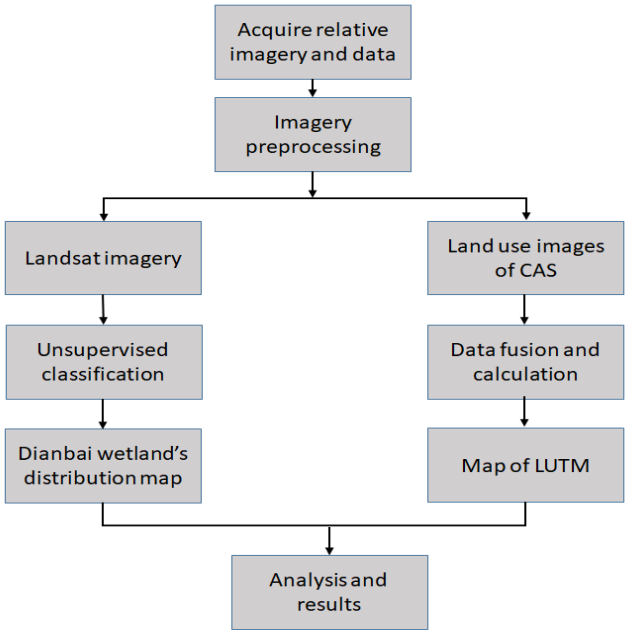


Figure 2: The Processing Framework of this Study.

Images Processing

The data used in this study are the Land sat images in 2010 and 2020 which retrieved by the website of Geospatial Data Cloud (GDC), then making radiation calibration, atmospheric calibration and other preprocessing. Incorporating with other data acquired from the Data Center of Resource and Environmental Science (DCRES), China Academy of Sciences (CAS), which the land use RS detection data and images of Guangdong Province in 2010 and 2020 are used. This two RS data are respectively cut to obtain the land use RS detection data and images of Dianbai District, Maoming City, Guangdong Province in 2010 and 2020.

Method of LUTM

This study uses static analysis and dynamic analysis respectively, static analysis is using unsupervised classification method, obtaining the wetland distribution map in 2010 and 2020, then using ArcGIS10.1 software to process the land use status image in 2010 and 2020, and then calculate and process the area transfer matrix of land use change between 2010 and 2020, then the images for dynamic comparative analysis.

The Land Use Transfer Matrix (LUTM) is a two-dimensional matrix based on the changing relationship of the current situation of land coverage in the same region. The analysis of the resulting transfer matrix enables two time phases and different land classes, which describe the types of land use that change in different years, as well as the location and area of change (Liu and Wang, 2022). It can not only reflect the above static fixed area and fixed time area data of each class, but also reflect the richer area transfer of each class in the initial stage and the transfer of each class area at the end stage. In terms of the area, reflect the regional land use change. The area change is first reflected in the total change of different land use types. By analyzing the total change of land use types, the total change trend of land use change and the change of land use structure can be understood.

Table 1 is the display data of the LUTM, where column T1 represents the initial phase and row T2 represents the next phase. A1 to An indicates n different land cover types. Suppose column Pn=Pi (initial phase land type), and row Pn=Pj (next phase land type). Pij represents the area of the initial phase Pi to the next phase Pj.

Table 1: Land Use Transfer Matrix (LUTM)

T1	T2			
	A1	A2	...	An
A1	P11	P12	...	P1n
A1	P21	P22	...	P2n
...	...	...	...	...
An	Pn1	Pn2	...	Pnn

In this study, the RS images of 2010 and 2020 were extracted using ENVI software. Firstly, the images were classified by SVM classification, visually interpreted, and the classification results were acquired for the distribution map of Dianbai wetlands in 2010 and 2020. Then, through the LUTM analysis to obtain relevant data, at first will cut the Dianbai land use type map, import into Arc GIS software, then loading the attribute table, and let the land use classification type connected to the layer. The purpose is combining land classification type "value" to the layer, to get the specific Dianbai land use type map.

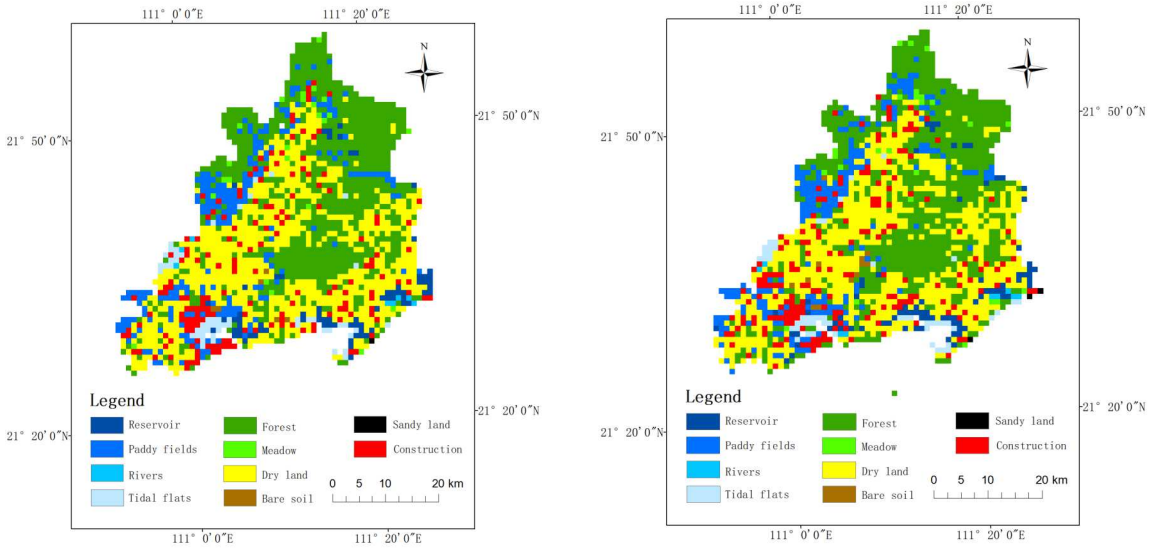
In order to reflect on the changing land use in different years, the new land use type map should be further processed. The process must convert the raster data into vector data and then analyze it. To make the subsequent image processing and analysis more convenient, the vectorized images are fused (fuse the ground classes with the same attributes). Then, the "intersection" operation of the two fused images is analyzed to obtain the more concentrated changing area of the wetland in the Dianbai area, and then the area of each class in the "intersection" image is calculated.

Finally, conducting the calculation of the transfer matrix, the attribute table of the "intersection" image is transformed into an Excel file, then transformed into a data perspective table according to the requirements of the LUTM, that is, the Dianbai LUTM is obtained, and then the change of the Dianbai wetland can be studied.

RESULTS AND ANALYSIS

Analysis of Wetland Distribution

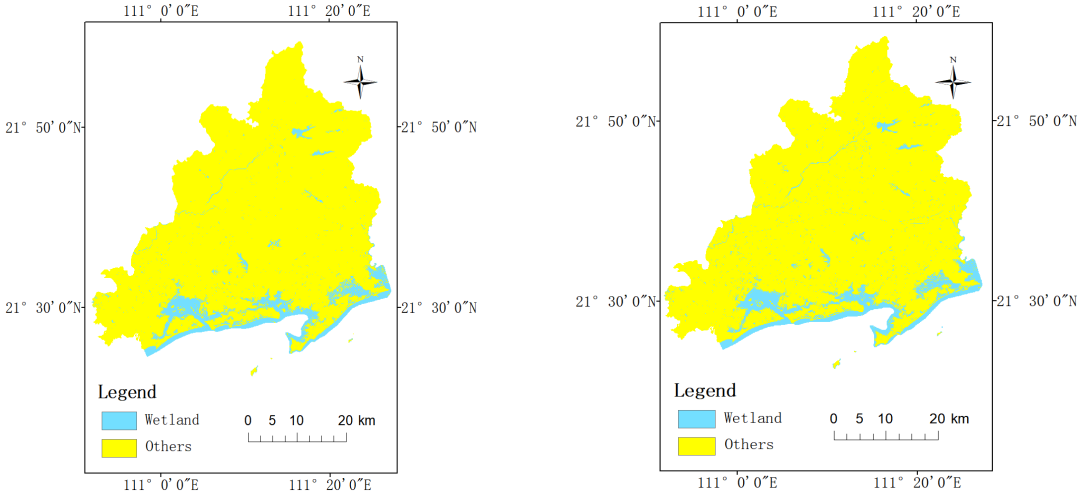
In 2010, the land use in Dianbai District can be divided into 10 kinds, among which four kinds belong to wetlands, namely, reservoirs, paddy fields, rivers and tidal flats (shown as Figure 3). By wetlands, reservoir pits and ponds in the southern coastal areas, and paddy fields in the southwest, northwest and north areas; rivers and canals in the southeast and northwest; tidal flats are more scattered in the white area, and some are more concentrated in the river estuary and coastal areas.



(a) 2010 (b) 2020

Figure 3: Land Use Status of 2010 and 2020 in Dianbai District.

As the whole, the wetlands distribution in 2010 was relatively scattered inner the Dianbai area (show as Figure 4c), except for the coastal areas in the south. While compared to 2020, the wetlands in both years were concentrated in the area of north and south (show as Figure 4). In 2020, the layout of wetlands in Dianbai has not changed significantly (show as Figure 4d), but it can still be seen that wetlands have a trend of expanding and mass development. However, the tidal flat at the estuary has a more obvious degradation phenomenon, the area has shrunk.



(c) 2010 (d) 2020

Figure 4: The Distribution Map of Dianbai Wetlands in 2010 and 2020.

In addition, in terms of Dianbai wetland change area, there are different degrees of wetland loss, wetland increase and wetland remain the same, including the main wetland loss and increase area is the north and southwest region, wetland remains the same area is mainly in the northwest, the estuary, and coastal areas (shown as Figure 5). Overall, from the change map of the wetland in 2010-2020, the temporal and spatial changes situation of land use, can be seen that the places of wetland changes in the Dianbai are mainly concentrated in the southwest, northeast, south and southeast, and the central and east have the least changes.

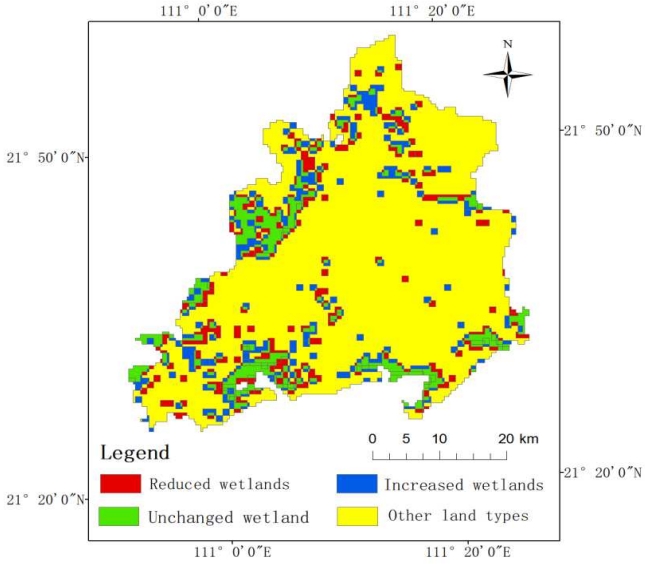


Figure 5: The Map of Wetland Change Situation in Dianbai from 2010 to 2020.

Analysis of LUTM

After the above classification and calculation, the LUTM table is obtained in this study (shown as Table 2).Then calculating the land use change situation, in contrast to the year 2010 period, the net increase in construction land in 2020 is 22.83 km ^{2}; The net reduction in dry land is 20.45 km ^{2}; The net increase area of bare soil is 6.01 km ^{2}; The net increase in sandy land is 0.89 km ^{2}; The net increase in meadow area is 0.52 km ^{2}; The net reduction area of forest is 26.86 km ^{2}; The wetlands areas (including rivers, reservoirs, paddy fields, and tidal flats) is 9.09 km ^{2} net increasing in which only the tidal flats area is reduced.

In addition, the study found that the detail changing situation of land use, specifically on the four types of wetland changing status such as the rivers changes to dry land is covering 2.06 km ^{2}; reservoir changes to dry land are mainly covering 15.10 km ^{2}, paddy fields changes to forest, dry land as well as construction land, covering area are 42.82 km ^{2},32.44 km ^{2}and 21.97 km ^{2}respectively; and tidal flats change to dry land and construction land that covering 6.44 km ^{2} and 4.83 km ^{2}respectively (excluding the mutual transformation between the four types of wetlands). Totally, the paddy fields are increasing from 2010 to 2020. However, except for the paddy fields the wetland transformed from other lands is very small.

Table 2: The Dianbai Land Use Transfer Matrix (LUTM)

	Year 2020									
Year 2010	**Meadow**	**Dry land**	**Rivers**	**Construction**	**Forest**	**Bare soil**	**Sandy land**	**Reservoir**	**Paddy fields**	**Tidal flats**
Meadow	3.43	4.26		1.19	8.82	0.60		0.18	4.24	1.18
Dry land	3.43	440.75	1.40	90.69		6.30	0.29	17.75	27.74	4.10
Rivers	1.01	2.06	1.81	0.42	0.29			1.00		1.00
Construction	0.89	69.07	0.18	37.34	21.23	0.70	0.59	7.22	27.56	3.09
Forest	12.01		0.89	24.89	521.88	0.41	0.42	10.84	50.33	4.11
Bare soil		1.88		0.12	1.06	1.54		0.54	0.87	
Sandy land					0.4 1		0.18			
Reservoir	0.18	15.10	3.00	7.25	8.94			27.99	2.05	4.92
Paddy fields	3.34	32.44	0.59	21.97	42.82	2.46		4.18	94.74	3.59
Tidal flats	0.12	6.44	1.01	4.83	3.46			5.40	2.81	24.26

Aggregate Analysis

From Table 2, compared to 2010, the wetland area in Dianbai District was increasing in 2020, by 9.09 km^2. In terms of area, the wetlands area in Dianbai did not decrease, instead increased, indicating that there is more attention and protection to the wetlands in Dianbai. However, from the perspective of the main transfer direction of wetland, most of the wetland in Dianbai has been transformed into construction land and dry land, so it is speculated that the main reason probably for the loss of wetland in Dianbai is affected by human factors and climate.

For instance, in response to the call of the government policy, Dianbai earnestly implements the eleventh five-year plan for the national economic and social development of Dianbai County (2006-2010), hence their industry, agriculture, commerce, rural areas and towns have achieved gratifying development, enhancing the development of Dianbai, and making develop more rapidly in the following decade. Thus, after 2010, the growth of population and Dianbai accelerated the industrialization and urbanization process, the first, second and third industries joint development, actively promoted urban construction and rural revitalization. Therefore, as we can see based on this development factor, the main sources of urban land increase are rural settlements, reservoirs, ponds, paddy fields and tidal flats.

However, the process of urbanization requires land occupations, including reservoirs, ponds, paddy fields and tidal flats. Activities such as agriculture, road construction, and urbanization often cause indirect damage to the wetland system. Hydrological changes associated with these activities affect water supply and drainage patterns across the surface and groundwater divisions, reducing the size and distribution of ecosystems dependent on these water sources (Baker et al., 2007).

In the objective background of global warming in the past hundred years (Zhou, 2021). With the economic development of the Dianbai causing environmental pollution is serious, in the lack of purposeful human protection measures, the part of the Dianbai itself is very "weak" so that the small wetland gradually aridity and become dry land. Under the dual pressure of human-made activities and climate change, the strict degradation and disappearance of wetlands in Dianbai from 2010 to 2020 made the already scarce wetland resources more tensely, the original ecosystem was destroyed, and the quality of wetlands declined rapidly (Ge et al., 2019).

In addition, Dianbai coastal area has a superior geographical location, due to being near Bohe port and many other ports, however by frequent human activities that serious damage to the tidal flats. According to the comprehensive strategic positioning of Guangdong's marine economy, the new pattern of marine comprehensive development of "three zones, three circles, three belts" and " one Peninsula in the six Bay Area", Dianbai has become a key development area of the Marine economy in western Guangdong, and is committed to implementing the construction of a beautiful Bay area (Maoming Municipal People's Government, 2017). However, in the construction process, it is inevitable to reverse the impact on tidal flats. Meanwhile, the construction of Dianbai coastal scenic spots and some improper behaviors of tourists will also destroy the coastal tidal flats. Therefore, as shown from Figure 3, the tidal flats at the estuary of the Dianbai are degraded.

Nevertheless, recently the construction of Dianbai's Beautiful Bay Area also created a very successful case. Until 2019, Dianbai had the largest contiguous artificial mangrove planting demonstration base in the country, the rare 2,600 hectares, forming a unique "sea forest" landscape. The mangrove nature reserve area is about 2,000 hectares, and the wetland park is about 420 hectares. Mangrove is growing in the tropical and subtropical coast intertidal zone, by mangrove plants as the main body of evergreen trees or shrubs of wetland woody plant community, in the purification of seawater,

wind waves, solid carbon storage, maintaining biodiversity plays an important role, hence acquired "coast guard" "ocean green lung" reputation, is also an important habitat for growth and breeding places to rare and endangered waterfowl, fish, shrimp, crab, and shellfish. The attention and protection of mangroves is worth learning from the whole country and even the whole world.

In short, the Dianbai's wetland in the north and southwest, their loss and increase reasons need further investigation, but the northwest and the estuary, coastal areas of wetland development condition is good. Analyze the reasons, due to the southwest has large paddy field distribution, and Dianbai climate belongs to subtropical climate which suitable for rice growth, the number of paddy fields is related to the food security, so the stability of the southwest paddy fields has made great contribution for wetland protection. However, the estuary and coastal areas except for a small part of wetland degradation, most of the wetland is well protected.

As we know, wetlands provide a variety of resources for human production and life, and have various ecological benefits such as flood control, climate regulation and habitat functions. However, with the development of society and economy, the acceleration of urbanization process, human activities (urbanization, deforestation, agricultural reclamation, etc.) as external stress factors, and combined with natural driving factors by relatively small space area, accelerated the wetland landscape area reduction, landscape fragmentation, ecological degradation factors (Leiet al., 2010). Thus, for the attention and protection of wetlands, different places should take reasonable and effective measures according to the current local problems and the causes of wetland degradation, to restore and optimize the protection of wetlands in an orderly manner.

At present, the construction of ecological civilization has become a national policy. Facing the severe situation of tighter resource constraints, serious environmental pollution and ecosystem degradation, in order to ensure the sustainable development of wetland ecology (Ge et al., 2019), this study makes the following suggestions:(1)Respect the natural selection results of the local ecological structure, should not recklessly transform the original ecological structure; (2) Should be correctly committed to constructing an environment-friendly society with economy, society and environment win-win condition. Attach importance to the development of human and land relationship;(3) The government shall take compulsory measures, such as cracking down the artificial occupation on rivers for landfill, excessive renovation and transforming wetlands into construction land, then strengthening the protection of Dianbai wetlands, and further to formulate an effective wetland management mechanism;(4) Residents should actively respond to the "double-carbon" policy, firmly believe that green mountains and clear waters are gold and silver mountains, protecting the environment and wetlands, as well as start implementing from themselves.

CONCLUSION

This study, incorporating RS and GIS technology, investigated the wetlands situation in the Dianbai area. After implementing image classification, land area calculation and land use transfer matrix, the wetland changes in this area between 2010 and 2020 were compared, and the following results were obtained:

- In terms of temporal and spatial changes, the wetlands in Dianbai District are mainly concentrated in the southwest, northeast, south and southeast, and the changes in the middle and east are the least.

- Compared with 2010, the wetland area of Dianbai District shows a little bit increase in 2020. It is further found that the mangrove wetland area at the estuary has been successfully protected, and also can enhance the protection of wetland.
- For the reduction of wetlands, the main reasons are the promotion of urbanization, economic development, human occupation and destruction of wetland resources in Dianbai District. Coupled with global warming, some wetlands with poor quality have degenerated into dry lands.
- It is suggested that targeted measures must be taken immediately to continuously strengthen the attention and protection of wetlands, restore the lost wetland resources, and establish a good relationship between people and land as well as developing sustainable strategy.

Overall, the conclusion of this survey can be used as a basis for improving public awareness of wetland protection, and as a reference for other researchers to investigate and study wetlands. The reason is relative to Beijing, Shanghai, Guangzhou and other economically developed areas, Dianbai economy is relatively backward, people's ecological consciousness is not strong, but also due to the development being relatively backward, natural ecological resources protection is relatively good, but develop rapidly in recent years, causing the environmental cost of natural ecological resources such as wetlands. In this regard, we should fully protect the existing natural ecological resources, restore the natural ecological resources which were destroyed before, and should still establish clear waters and green mountains while obtaining economic development.

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