Changes of Wetland in Xiamen City Based on Remote Sensing and GIS

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Keywords: Wetland; decision tree classify method; Dynamic changes

Abstract. Wetland is a valuable natural resource, with irreplaceable ecological functions. With the development of industrialization, urbanization and population growth, wetland area is decreasing. And ecological functions gradually weakened. Based on TM remote sensing image from 2000 to 2011, this paper built decision tree model of wetland classification to extract wetland by classify. The paper has an research on the dynamic change of wetland of Xiamen city. The results show a growing trend between 2000 and2011, wetland area of Xiamen city increased 583.16 hm^2. About 448.93 hm^2 area is changed from wetland to non-wetland, which 440.73 hm^2 area of waters into non-wetland. About 583.16 hm^2 area is changed from non-wetland to wetland. The total area of natural wetlands is increasing 239.39 hm^2; including 477.15 hm^2 non-wetland turn into natural wetlands and 237.76 hm^2 natural wetlands turn into artificial wetlands. This shows that human activities lead to a large of natural wetlands of the study area had transformed into wetlands. According to the wetland area and the average annual rate of change, it is easily seen that tidal wetlands, mangroves, farms and salt wetland are large impacted by human activities or other factors.

Introduction

The traditional method is needed a lot of manpower and time to investigate the wetland resources. So it is inefficiency and also has a destruction to wetland. With the development of remote sensing, remote sensing is used in wetland resources investigation, which can solve the problems. Now years of satellite images is used to study dynamic changes of wetland, integrated geographic information technology research and protected the wetland [1].

There are many wetland classification methods. For example, combine supervised classification and unsupervised classification [2]. Using tasseled cap transformation and decision tree classification extract wetland. [3]. Based on remote sensing images and geographical information technology (GIS) identify the wetland [4]. Xie et al. [5] extract mariculture area based on object-oriented classification. Based on the image spectral characteristics of MODIS, Liu et al.[6] extract the wetland using the logistic regression model in Great Khingan.

The wetland has specific textual features, which spectral characteristics has both of soil and water. So considering the wetland specific features should prove the precise of the extract wetland. Based on remote sensing, the paper has an research on the dynamic change of wetland in Xiamen city using decision tree model.

Data and methods

Study area

Xiamen city is load on the southeast of China (117° 53′-118°25′E； 24 °23′-24° 55′N), across the sea with Taiwan Strait.

Data

Remote sensing image is TM Landsat 7, including Mar.25 in 2000, Sep. 2 in 2006 and Feb.4 in 2011. Geographical coordinates is WGS84.

Method

Refer to “wetland protection” and wetland classification in China. The wetland classifications and specification in table 1. The interpretation key is the key in remote sensing image.

The wetland is extracted using the decision tree model (Fig.1). TM2,TM3,TM4,TM5 is means the band of the remote sensing image.

The precision evaluation index is Kappa coefficient and overall accuracy based on confusion matrix.

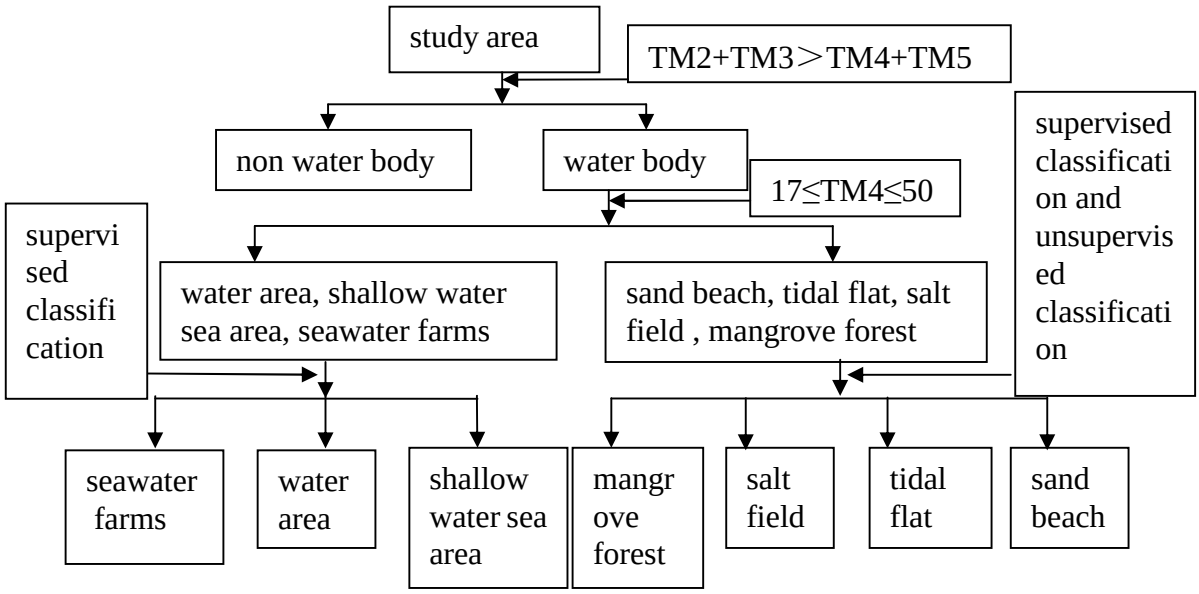

Fig.1Decision tree model of extracting of wetland in Xiamen city

Table 1 Wetland classification and specification

Type	Classifications	interpretation key	Specifications
Natural wet land	water area		River , estuary areas, lake, pool.
	shallow water sea area		water depth is less than 6 m area, and vegetation coverage was less than 30% in low tide.
	tidal flat		Intertidal mudflats and coastal marshes
	sand beach		The sea sand, the sand island, sand dunes and mound swamp
	mangrove forest		The intertidal marsh, mainly for the mangrove plant community
Constructed wetland	salt field		Coastal wetland evaporation to make salt from seawater
	seawater farms		The seaside aquaculture farms and tidal flats farms

Results

Based decision tree model, the wetland is extracted using remote sensing image in Xiamen city in 2000, 2006 and 2011 (Fig.2). The overall accuracy precision is 82.63%, 81.21% and 79.98%, and the Kappa coefficient is 0.84, 0.81 and 0.78. The extracted wetland based on decision tree model is showed reliably.

The dynamic change of wetland in Xiamen city

Based on the ArcGIS 10.2, the area of the wetland classifications is showed in table 2 from 2000 to 2011 (Tab.2). And the changes of classifications is showed in table 3 and 4 from 2000 to 2011 (Tab.3 and 4). From 2000 to 2006, the area of wetland is increased 312.3 hm^2, including 332.61 hm^2 natural wetland increased and 20.31 hm^2 constructed wetland decreased. The change rate is 16.667% per year. Water area is increased 1588.8 hm^2, which is the most. Shallow water sea area is increased 154.53 hm^2. Mangrove forest is increased 11.2 hm^2. Sand beach is decreased 27.91 hm^2. Tidal flat is decreased 1084.95 hm^2. In the constructed wetland, salt field is increased 178.38 hm^2, and seawater farms is increased 158.07 hm^2.

From 2006 to 2011, the area of wetland is increased 270.86hm^2, including 93.22 hm^2 natural wetland and 664.08 hm^2 constructed wetland. The change rate is 20% per year. Water area is decreased 447.8 hm^2. Shallow water sea area is increased 478.62 hm^2. Sand beach is decreased 10.67 hm^2. Tidal flat is decreased 137.47 hm^2. Mangrove forest is increased 24.01 hm^2.In the constructed wetland, salt field is increased 177.84hm^2, and seawater farms is increased 541.92 hm^2, which is the most.

The change between wetland and land

From 2000 to 2011, area of land changed from wetland is 448.93 hm^2, including water area 440.73(the most of all classfication) (Tab. 3 and 4). That means the increased land due to natural wetland decreased. Area pf wetland changed from land is 583.16 hm^2, including the construted wetland increased 106.01 hm^2. the total constructed wetland is increased 342.77 hm^2. From 2000 to 2011, the nutural wetland is increased 239.39 hm^2, including 477.15 hm^2 changed from land and 237.76 hm^2changed to constructed wetland. That means parts of natural wetland changed to constructed wetland because of human activities.

Table 2 the wetland area in Xiamen city from 2000 to 2011 (unit: hm^2)

	Natural wet land					Constructed wetland		
	water area	shallow water sea area	sand beach	tidal flat	mangrove forest	salt field	seawater farms	total area
2000	30061	4859.01	102.36	8206.74	6.10	539.64	6312.15	50087.0
2006	61349.8	4704.48	74.45	7121.79	17.3	361.26	6470.22	50399.3
2011	31202	5183.10	63.78	6984.32	41.4	183.42	7012.14	50670.16

The change among the wetland classfication

From2000 to 2006, the tidal flat is increased 1084.95 $hm^2$and the salt field is increased 178.38 hm^2. The seawater farms and mangrove forest are decreased (Tab. 3). From2006 to 2011, The seawater farms and mangrove forest are increased about 541.92 hm^2 and 24.1 hm^2. (Tab. 4). The seawater farm is increased most. Tidal flat and salt field are decreased. So the seawater farm is mostly changed from water area from 2000 to 2006. Also part of the seawater farm is changed to tidal flat and salt field, which is the reason of salt field increased. Tidal flat area is increased 70% o from f the natural wetland and 30% from seawater farm. The mangrove forest is decreased 11.2 hm^2, which is changed to land. Of course, some other wetland classification is changed to mangrove forest, but it is a small amount. So mangrove forest show sharply decreased. From 2006 to 2011, 239.74 hm^2area of water area is changed to seawater farms. And 371.22 hm^2 areas of seawater farms are changed to tidal flat. So the total seawater farms is decreased totally. And the tidal flat is increased. The mangrove forest is increased from tidal flat and a small amount of seawater farms.

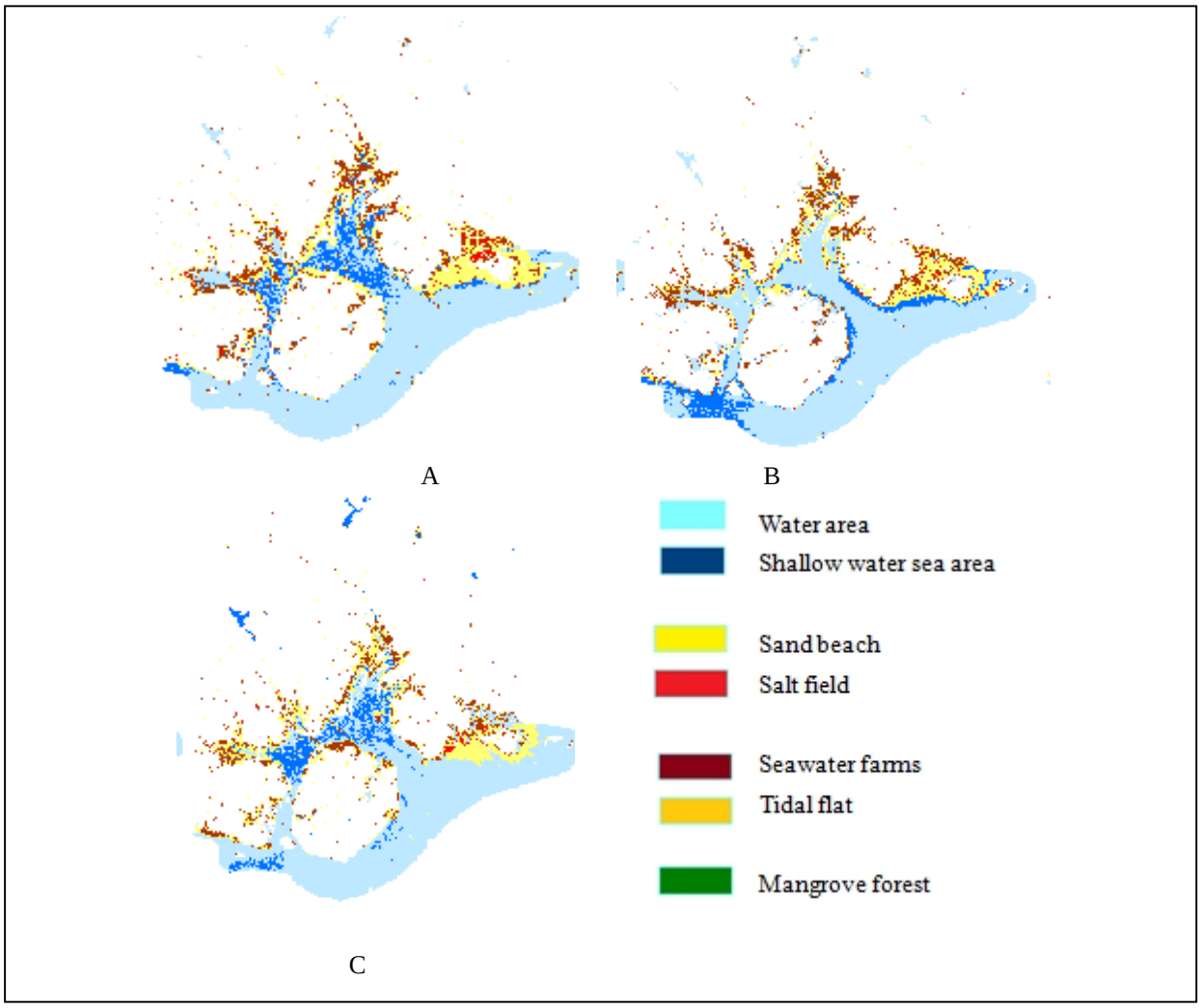

Fig.2 Spatial distribution of wetland in Xiamen city in 2000(A), 2006(B) and 2011(C).

Table 3 wetland classsfication transition matrix from 2000 to 2006 (unit: hm^2)

	water area	shallow water sea area	sand beach	salt field	seawater farms	tidal flat	mangrove forest	land	total
water area	0	15.87	0	155.23	792.92	181.64	2.38	440.73	1588.8
shallow water sea area	43.62	0	0	0	73.5	37.41	0	0	-154.53
sand beach	0	27.91	0	0	0	0	0	0	-27.91
salt field	39.21	0	0	0	94.76	44.41	0	0	-178.38
seawater farms	8.06	72.11	0	21.31	0	56.59	0	0	158.07
tidal flat	661.33	116.6	0	0	307.02	0	0	0	-1084.95
mangrove forest	0	0.7	0	0	1.1	1.2	0	8.2	11.2

Table 4 wetland classsfication transition matrix from 2006 to 2011(unit: hm^2)

	water area	shallow water sea area	sand beach	salt field	seawater farms	tidal flat	mangrove forest	land	total
water area	0	33.55	0	0	239.74	73.51	0	101	-447.8
shallow water sea area	333.47	0	8.46	0	94.57	42.12	0	0	478.62
sand beach	0	3.2	0	0	0	3.37	0	4.1	-10.67
salt field	90	3.4	0	0	7.76	76.68	0	0	-177.84
seawater farms	5.8	38.8	0	4.1	0	371.22	0	122	541.92
tidal flat	0	104.01	0	0.7	21.51	0	10.34	0.91	-137.47
mangrove forest	0	3.27	0	0	0.85	19.98	0	0	24.1

Conclusions

From 2000 to 2010, the area of wetland is increased 583.16 hm^2, which show increasing trend. Part of natural wetland is destroyed or changed to others. The area is decreasing. Constructed wetland is decreasing, especially the mangrove forest increased rapidly. The tidal flat and mangrove forest in natural wetland, seawater farms and salt field in constructed wetland is greatly influenced by human activities or other factors. The wetland area is increasing due to the understanding the wetland ecology functions, protection and recovering to wetland. The wetland changed to land is 448.93, when wetland changed from land is 583.16. And the natural wetland is increased 239.39, including 477.15 changed from land and 237.76 changed to constructed wetland. That means the human activities lead to the sharply changed of natural wetland.

Acknowledgements

This work was financially supported by National Natural Science Foundation of China (41501448, 41501447) Xiamen University of Technology Foundation for high-level talents (YKJ13025R). And the help of all the reviews and editors is gratefully acknowledged. We thank all the authors and editors for the research assistance.

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