# Analysis on the land use and cover change in Tianjin Binhai New Area based on the remote sensing

WANG Feng[1, 2], LIU Shu-ming[2], LU Wen-hu[2], DU Qiong-wei[2], JIANG Wei-nan[2], LI Jia-rui[2]

1. *College of Oceanography and Environmental Science, Xiamen University, Xiamen* 361005*, Fujian province, China;*

2. *National Marine Data and Information Service, Tianjin* 300171*, China*

**Abstract:** This paper carries out quantitative analysis on the land use/cover (LU/C) change of Tianjin Binhai New Area in recent 10 years through using land use transition matrix from the three-stage LU/C classification maps of 2000, 2005 and 2010 drafted by means of the National Land Classification System of China based on Landsat TM satellite remote sensing image and the Tianjin Binhai New Area 1:50 000 relief maps. On this basis, the impact of such driving factors as the economy and population on LU/C is further analyzed. The results show that the area of the building land in Binhai New Area has increased significantly over the ten years, and the greenland, wetland, and shoals of high ecological value have been dramatically transformed into the building land and unused land for the development and construction, and the change is more significant in the later five years.

**Keywords:** Binhai New Area; remote sensing; land use and cover change; driving factors

The land is the most fundamental material basis that mankind relies on to survive and develop. As the research of global change develops further, it is gradually realized that the land use/cover change caused by human activities will eventually affect the survival and development of mankind themselves in return.

The ways to classify land are diversified, including the classification by utilization ways, by functions, and by resources, and comprehensive classification. The classification by land cover/land use (LC/LU) adopted in this paper is a new way of land classification as the remote sensing technology appears. Land classification by means of remote sensing features fast speed, high precision and wide scope, and fully embodies the timeliness, objectivity and wide range of monitoring. It has become a main trend in the research of LU/C to use remote sensing technology to observe the land, uncover the rules of its space change and establish driving force model of regional land use change for analysis. The

Received on Jun. 8, 2014

Corresponding author: wangfengbest@hotmail.com

research content involves in a series of significant issues such as protection and utilization of land resources, protection and control of ecological environment, sustainable development of social economy [1] [2].

Tianjin Binhai New Area is located at the eastern coast of Tianjin, including the former three administrative districts Tanggu, Han'gu and Dagang, and some areas of Dongli District and Jinnan District. It has been included in the strategic layout of the national overall development in the program of the "11th Five Year Plan" [3], with establishing the resource-saving and environment-friendly city development mode and building eco-city as its strategic goals. Therefore, currently, many government organizations, research departments, social groups and researchers are more and more concerned with the land use/cover change of this area. Meng Weiqing et al. carried out quantitative analysis on the landscape indices of the coastal wetlands in recent 30 years by means of the landscape ecology, and the result showed that the coastal wetlands were tending to be fragmented and artificialized [4]. Xu Dayong et al. conducted image extraction, analysis and prediction on the vegetation coverage change in this area based on normalized deferential vegetation index (NDVI) and came to the conclusion that the vegetation coverage in this area obviously showed a downward trend, which threatened the ecological safety [5]. The above mentioned studies could not fully reflect the land change in Binhai New Area in recent years, especially after it was put into the program of the "11th Five Year Plan" and the strategy of "Ten Battles" was carried out as their study objects were relatively long time ago; besides, their study targets were relatively unitary, so the change of various surface features and the situation of mutual transformation were not fully reflected.

Based on the previous experience, this study has made a three-phase (2000, 2005 and 2010) land use/cover classification picture of Binhai New Area based on Landsat TM remote sensing image, and carried out corresponding statistics and conducted quantitative description on Binhai New Area LU/CC in recent years by applying land use transition matrix. On this basis, it further analyzed the influence of such anthropic factors as economy and population on LU/CC in this area and specifically described the change and mutual transformation of land types and land area in a more comprehensive way to provide a theoretical foundation for environmental protection and sustainable development in Binhai New Area.

## 1 Research method and data source

### 1.1 Classification system of land use

LU/CC classification system, a primary prerequisite for studying LU/CC, not only affects the expression of research result, but also decides the application field of the research data. Since 1970s, with the development of 3S and computer technologies, the classification system mainly for studying LU/CC has been rapidly developed. It focuses on the difference of land types for the investigation and research. Therefore, the size of scale, precision, decidability of remote sensing data, regional characteristics, practicability and systematicness should be considered in an all-round way [6].

In order to adapt it to the specific research purpose and degree, scholars in the world have built a lot of land classification systems from different perspectives; therefore, plenty of inconveniences are caused for summarizing, analyzing and sharing data due to the lack of uniform standard and bad compatibility. Until today, however, there is no “universal” land classification system that is extensively recognized around the world and fits all [7]. In view of this, this study comprehensively compares and analyzes the abovementioned classification system, develops a LU/CC two-grade classification system suitable for Tianjin Binhai New Area (Tab. 1) according to the land use and vegetation characteristics of this area based on the (tentative) National Standards of Land Classification, among which, Grade I includes the building land, moor, ocean, fresh waters, salt pan, vegetation and unused land.

**Tab. 1 Tianjin Binhai New Area LU/C Change Classification System**

| Grade I Classification | Grade II Classification |
|---|---|
| Building land | Urban-rural resident area, industrial, mine and factory land, land for traffic use, etc. |
| Moor | Area with accumulated water and mud, wetland, et al. |
| Ocean | |
| Fresh waters | Lake, river, reservoir |
| Shoal | Rocky beach, sand beach, mud bank |
| Salt pan | Salt pan, pit-pond, culture pond, etc. |
| Vegetation | Grassland, woodland, farmland, etc. |
| Unused land | Reclaimed land from sea, Gobi, saline-alkali soil, bare land |

### 1.2 Processing of remote sensing data

American Landsat sensor TM/ETM data are used in the study. Data of the three years 2000, 2005 and 2010 are selected and compared for the study.

Binhai New Area boundary vector graph is obtained by using Tianjin Binhai New Area 1:50 000 topographic map. Geometric precision correction is conducted on the image. Image enhancements such as histogram equalization, image fusion and thin cloud removal are applied to the images with relatively bad contrast. ENVI software is used to clip the original remote sensing image.

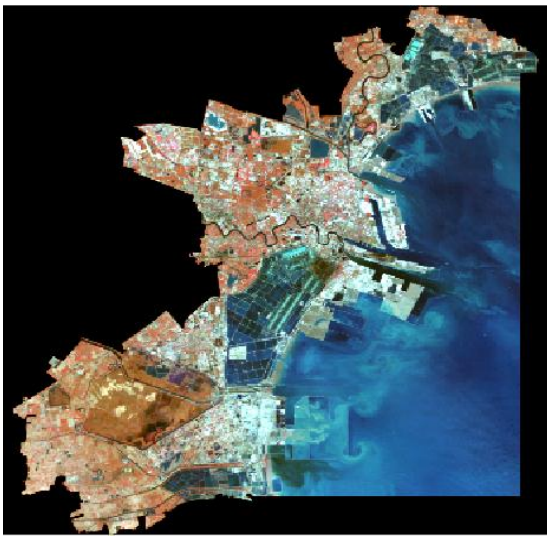

**Fig. 1 Clipped scope of Binhai New Area**

In terms of image classification, this study carries out automatic classification with computer by using the method combining supervised classification with texture-based object-oriented fuzzy classification. In order to protect the accuracy of extracting information of various surface features, field survey is conducted for the verification; besides, 1:50 000 topographic map and Google Earth image of corresponding period are used as the reference for artificial visual interpretation so that the data can be correct. Finally, the final classification image data of the years 2000, 2005 and 2010 are obtained (Fig. 2).

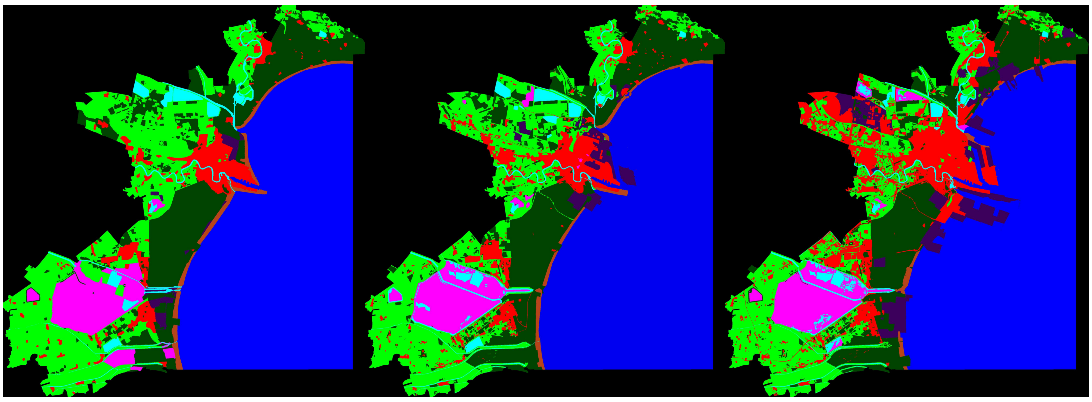

**Fig. 2 Land use classification data of Binhai New Area in 2000, 2005 and 2010 (from left to right)**

# 2 Statistical analysis of LU/C change

## 2.1 Analysis on overall quantity change and characteristics of Binhai New Area LU/C

### 2.1.1 Range of land use change

The LU/C change includes the change of area, space and quality of different types of lands. The change of area is firstly reflected in the total quantity of different types of land; through analyzing the change of the total quantity of various land use types, the change of land use structure and the overall trend of the change can be understood [8].

The result shown in Tab. 2 and Fig. 3 is obtained from statistical analysis on the land use classification data (Fig. 2) of Binhai New Area of the three phases, respectively, by using the abovementioned data.

The result shows that during the 10 years, the quantity change of land use types in Binhai New Area features sharp increase of building land and unused land, and sharp decrease of vegetation and ocean. The increases of building land and unused land are 335.113 km$^2$ and 202.417 m$^2$, respectively; while the decreases of vegetation and ocean area are as high as 238.859 km$^2$ and 139.542 km$^2$, respectively. With the implementation of multiple policies and the acceleration of developing process, the area change from 2005 to 2010 is obviously higher than that from 2000 to 2005.

**Tab. 2 LU/C area change of various types of Binhai New Area in recent 10 years (unit: km$^2$)**

| | 2000 | 2005 | 2010 | Change 2000-2010 | Annual change rate |
|---|---|---|---|---|---|
| Vegetation | 957.550 | 893.456 | 718.691 | -238.859 | -2.49% |
| Salt pan | 726.565 | 757.924 | 640.302 | -86.263 | -1.19% |
| Building land | 231.764 | 283.902 | 566.877 | 335.113 | 14.46% |
| Fresh waters | 113.926 | 125.436 | 108.591 | -5.335 | -0.47% |
| Moor | 235.541 | 206.242 | 211.453 | -24.088 | -1.02% |
| Unused land | 37.448 | 76.178 | 239.865 | 202.417 | 54.05% |
| Ocean | 1947.599 | 1925.247 | 1808.057 | -139.542 | -0.72% |
| Shoal | 69.848 | 52.813 | 27.590 | -42.258 | -6.05% |
| Total area | 4320.241 | 4321.198 | 4321.426 | | |

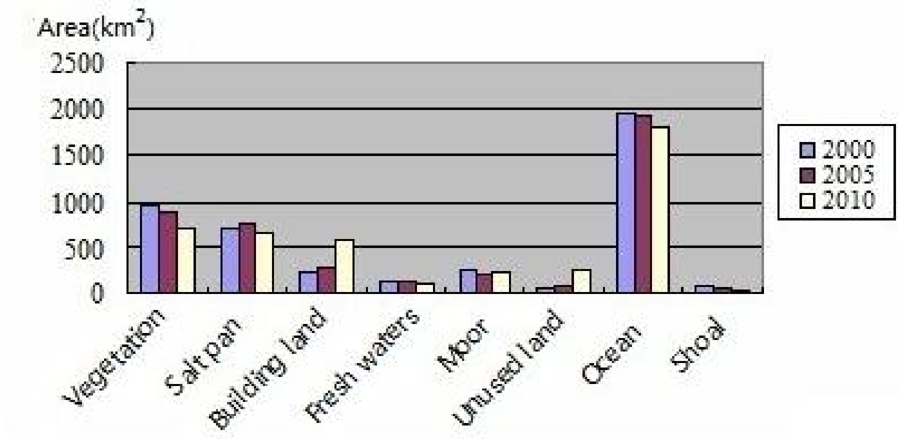


**Fig. 3 Statistics of area change of various types of LC/LC in the 10 years**

2.1.2 Dynamic degree of LU/CC

The dynamic degree of land use types refers to the quantity changes of certain type of land use within a given period of time in some research zone, which quantitatively describes the changing speed of land resource quantity and plays an active role in predicting the trend of land use change [9].

Its expression is as follows:

$$K = \frac{U_b - U_a}{U_a} \times \frac{1}{T} \times 100\%$$

where $U_a$ and $U_b$ are the quantity of certain types of lands at the beginning and at the end of the research period, respectively; T is the research duration; when T is assumed as one year, the dynamic degree of land use types, the value of K is the annual change rate of such land type in the research zone.

It can be known from Tab. 2 that the area of unused land and building land in Tianjin Binhai New Area has increased at a relatively high speed, with the annual change rate as high as 54.05% and 14.46%, respectively. The area of such land types as vegetation, salt pan, fresh waters, moor, ocean and shoal has also been reduced at different speeds, among which the relatively obvious annual change rates are -6.05% for the shoal and -2.49% for the vegetation. Besides, in spite of the relatively small change rate of ocean, but the final result should consider its change degree as its base number of area is relatively large.

The abovementioned two methods and results can relatively well reflect the quantity and change of LU/CC of Binhai New Area, but overlook the innate process of land use change. Therefore, other research methods are needed for further description.

### 2.2 Land use transition matrix

Under certain conditions, the mutual transformations between land use types have the characteristics of Markov Random Process; therefore, the model of Markov Transition Matrix can be used for further description. Markov chain comes from quantitative description of system state and state transition in the system analysis[10], which is a special random motion process characterized as "memoryless". It reflects a series of process for a semi-stable system to transit from the time $T_1$ to the time $T_2$; such transition requires that the state of $T_2$ is only related to that of $T_1$ [11].

Usually, the key for the application of Markov model to the land type transition lies in the determination of transition probability matrix. Transition matrix can show the dynamic change of types of certain LU/C from one year to another, namely, the ratio of certain type that remains unchanged, and the number transformed to other types and the ratio of transforming to other types [12].

**Tab. 3 Land use transition matrix model**

| | | $T_2$ | | | | $P_{i+}$ | Decrease |
|---|---|---|---|---|---|---|---|
| | | $A_1$ | $A_2$ | $\cdots$ | $A_n$ | | |
| $T_1$ | $A_1$ | $P_{11}$ | $P_{12}$ | $\cdots$ | $P_{1n}$ | $P_{1+}$ | $P_{1+}-P_{11}$ |
| | $A_2$ | $P_{21}$ | $P_{22}$ | $\cdots$ | $P_{2n}$ | $P_{2+}$ | $P_{2+}-P_{22}$ |
| | $\vdots$ | $\vdots$ | $\vdots$ | $\ddots$ | $\vdots$ | $\vdots$ | $\vdots$ |
| | $A_n$ | $P_{n1}$ | $P_{n2}$ | $\cdots$ | $P_{nn}$ | $P_{n+}$ | $P_{n+}-P_{nn}$ |
| $P_{+j}$ | | $P_{+1}$ | $P_{+2}$ | $\cdots$ | $P_{+n}$ | 1 | |
| Increase | | $P_{+1}-P_{11}$ | $P_{+2}-P_{22}$ | $\cdots$ | $P_{+n}-P_{nm}$ | | |

In Tab. 3, the items in the row stand for the land use type at the time $T_1$ and ones in the column stand for the type at the time $T_2$. $P_{ij}$ stands for the percentage of the area of land type j transformed from land type i during the period from $T_1$ to $T_2$; $P_{ii}$ stands for the percentage of area of land use type i that remains unchanged during the period from $T_1$ to

$T_2$. $P_{i+}$ stands for the percentage of land type i in the total area at the time of $T_1$. $P_{+j}$ stands for the percentage of land type j in the total area at the time $T_2$. $P_{i+} - P_{ii}$ is the percentage of area reduction of land type i during $T_1$ - $T_2$ period; $P_{+j} - P_{jj}$ is the percentage of area increase of land type j during $T_1$ - $T_2$ period[13].

**Tab. 4 Land type use change transition matrix (2000-2005)**

| | | 2000 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Greenland | Salt pan | Building land | Fresh waters | Moor | Unused land | Ocean | Shoal |
| 2005 | Greenland | 80.1219 | 9.1137 | 12.0071 | 10.6554 | 6.2471 | 9.8111 | 0.0016 | 0.4710 |
| | Salt pan | 8.9797 | 81.5518 | 7.1809 | 4.3108 | 11.6268 | 44.6141 | 0.0466 | 18.0237 |
| | Building land | 6.4986 | 3.1853 | 77.9166 | 1.0118 | 1.7802 | 23.9999 | 0.0384 | 4.0063 |
| | Fresh waters | 1.5100 | 1.3515 | 0.2644 | 71.1277 | 8.1790 | 0.0523 | 0.0020 | 0.2323 |
| | Moor | 1.9667 | 0.2888 | 0.2199 | 11.6211 | 72.1598 | 4.2617 | 0 | 0 |
| | Unused land | 0.7820 | 4.0762 | 2.1962 | 0.4274 | 0 | 16.1277 | 1.0123 | 11.0848 |
| | Ocean | 0 | 0.0893 | 0.0706 | 0.2394 | 0 | 0 | 98.4833 | 7.3854 |
| | Shoal | 0 | 0.3100 | 0.1316 | 0.5804 | 0 | 1.1332 | 0.4160 | 58.7965 |
| | Class Changes | 19.8781 | 18.4482 | 22.0834 | 28.8723 | 27.8402 | 83.8723 | 1.5167 | 41.2035 |
| | Image Difference | -6.6936 | 4.3161 | 22.4959 | 10.1033 | -12.4393 | 103.4248 | -1.1477 | -24.3887 |

**Tab. 5 Land type use change transition matrix (2005-2010)**

| | | 2005 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Greenland | Salt pan | Building land | Fresh waters | Moor | Unused land | Ocean | Shoal |
| 2010 | Greenland | 76.5995 | 2.1754 | 2.0552 | 1.8813 | 3.0570 | 4.1168 | 0.0006 | 0.0043 |
| | Salt pan | 2.5330 | 78.3102 | 1.3645 | 7.6295 | 0.0977 | 2.6128 | 0.1798 | 9.5457 |
| | Building land | 17.5097 | 8.8070 | 95.5719 | 1.4151 | 0.4866 | 69.6897 | 0.6708 | 6.7679 |
| | Fresh waters | 0.3006 | 0.4740 | 0.0369 | 71.1817 | 5.8558 | 0.0018 | 0.0330 | 0.3937 |
| | Moor | 0.1089 | 0.0007 | 0.0002 | 17.6014 | 90.5029 | 0 | 0.0250 | 2.3875 |
| | Unused land | 2.9286 | 9.8046 | 0.9478 | 0.1921 | 0 | 23.2264 | 5.1731 | 35.9239 |
| | Ocean | 0.0039 | 0.0006 | 0.0193 | 0.0927 | 0 | 0.3527 | 93.7328 | 5.6628 |
| | Shoal | 0.0008 | 0.4277 | 0.0042 | 0.0061 | 0 | 0 | 0.1849 | 39.3143 |
| | Class Changes | 23.4005 | 21.6898 | 4.4281 | 28.8182 | 9.4971 | 76.7737 | 6.2672 | 60.6857 |
| | Image Difference | -19.5605 | -15.5189 | 99.6736 | -13.4290 | 2.5269 | 214.875 | -6.0870 | -47.7591 |

The results can be concluded from the transition matrix.

During the two periods, shoal and unused land of relatively large ratio are transited and the transition degree of other land types is relatively small.

From 2000 to 2005, the transition ratios of the unused land area and shoal area are as high as 83.872 3% and 41.203 5%. Among them, the main ground features of unused land are salt pan and building land while the shoal of relatively large ratio is transformed to the unused land and salt pan.

It is more obvious from 2005 to 2010 that 35.923 9% of the total area of shoal was transformed to the unused land, with total transformation rate as high as 60.685 7%; 69.689 7% of unused land was transformed into the building land, with total transformation rate of 76.773 7%; besides, 17.509 7% of greenland was transformed into the building land.

The above results appropriately match the implementation of projects, such as regional construction, community demolition and relocation, and reclaiming lands from the sea in Binhai New Area, and coincide with the construction goal of prioritized projects in the "Ten Battle" strategy.

## 3 Discussion

The dynamic change of LU/C is a change of land use purpose and pattern under the action of various driving forces. There are a lot of driving factors affecting land use change, which can be generally divided into natural factors and anthropic factors. Natural factors refer to the tellurian physical factors exerting certain degree of influence on the land use management and pattern, mainly including climate, hydrology, terrain, soil, vegetation and natural disaster; anthropic factors include such aspects as society, economy, politics, culture, and technical progress, which are mutually connected, interacted and affected[14]. From a relatively short period of time, the change of the frequency and speed of natural elements is blunt and slow compared with the complex and rapid change of social and economic elements. The LU/C change of Binhai New Area in recent 10 years is mainly caused by human activities. Therefore, it is more important to analyze the anthropic driving factors of land use.

### 3.1 Economic factors

Economic factors, including economic structure and development level, industrial and transportation conditions, urban development and market condition, commerce and trade development, are the fundamental conditions deciding the development and utilization of land. The features of the changes of these economic factors directly affect the direction, structure, scale, layout and profit of the development and utilization [15].

In recent 10 years, Binhai New Area has kept continuous and rapid development since this area has deepened the reform, expanded opening-up, taken initiative to keep up with the international economy, improved investment conditions and worked hard to create a first-rate investment environment. In the 10 years, the gross output of the primary industry in Tianjin Binhai New Area has an average annual growth rate of 5.72%, the growth rate of 79.52% for the secondary industry and 76.79% for the tertiary industry. The total output value in Binhai New Area has increased from 57.174 billion Yuan in 2000 to 503.011 billion Yuan in 2010 [16] (Tab. 6).

**Tab. 6 Statistics of total output value of Binhai New Area (100 million Yuan)**

| Year | New Area subtotal | Primary industry | Secondary industry | Tertiary industry | Percentage in those of the whole city / % |
|---|---|---|---|---|---|
| 2000 | 571.74 | 5.20 | 383.45 | 183.09 | 33.6 |
| 2001 | 685.32 | 5.67 | 454.22 | 225.43 | 35.7 |
| 2002 | 862.45 | 6.09 | 576.06 | 280.30 | 40.1 |
| 2003 | 1046.30 | 7.30 | 697.66 | 341.34 | 40.6 |
| 2004 | 1323.26 | 7.91 | 878.85 | 436.50 | 42.5 |
| 2005 | 1633.93 | 7.15 | 1092.55 | 534.22 | 41.8 |
| 2006 | 1983.63 | 7.25 | 1354.40 | 621.98 | 44.4 |
| 2007 | 2414.26 | 6.78 | 1669.86 | 737.63 | 46.0 |
| 2008 | 3349.99 | 7.02 | 2304.37 | 1038.60 | 49.9 |
| 2009 | 3810.67 | 7.43 | 2569.87 | 1233.37 | 50.7 |
| 2010 | 5030.11 | 8.17 | 3432.81 | 1589.12 | 54.5 |
| Average annual growth rate / % | 77.98 | 5.72 | 79.52 | 76.79 | |

In Binhai New Area, the change of industrial structure has caused a re-distribution of land resources among industries, which consequently causes the change of land use structure. The ratio of primary industry tends to go down and the secondary and tertiary industries tend to go up. Driven by the mechanism of economic interests, land use is constantly transformed from agricultural land of low profit to non-agricultural land, showing an unbalanced situation. Meanwhile, with the development of social economy and the increase of total output value, human's ability to develop and use land has been improved, which provides a basic condition for the further and more extensive development and utilization, promoting the development of various wastelands and transformation of farmland and woodland of the middle or low production.

### 3.2 Factor of population

As a unique factor, population is the most important element in the anthropic factor for LU/C change, also one of most vigorous driving forces for the LU/C change. Firstly, the quantity of population directly affects the LU/C change; secondly, people try to meet their demands for the living environment by changing the type and structure of land use/cover to reinforce the intervention degree on the land, this natural complex. Therefore, in the study of LU/C change, the factor of population is often regarded as a comprehensive parameter reflecting the contribution of human activities to the change of land use/land cover [17].

In 2010, the permanent resident population in Binhai New Area accounts for 2.482 1 million, which is 1.293 1 million more than that 10 years ago, with the increasing rate of 108.75%, and the average annual growth rate is 7.64% [18]. Among the permanent resident population, the areas with relatively concentrated population include Tanggu with 850 974 persons, accounting for 34.28% of the total population of this area, Han'gu with 217 107, accounting for 8.75%; and Dagang with 523 144, occupying 21.08%.

If the land use in Binhai New Area is compared to an open system, population will be the organizers and participants in this systematic structure, and the consumers of the output product of this system as well. In other words, people accelerated the land development in Binhai New Area with growing utilization rate by adjusting and organizing the system structure of land use by means of production technology and activity patterns. Meanwhile, as participants, they also occupy the building land –land of certain area as a place for living. And finally, as consumers, people consume the product from land use system and increase pressure on the productivity of ecological system of land. Therefore, the growth of population leads to the growth of building land and causes higher production pressure on the farmland, woodland and greenland that are continuously diminishing [19].

### 3.3 Policy implementation and reclaiming land from sea

The guidance of government policy will play a key role in the change of land use featuring regional scale [20]. Since the program of the "11$^{th}$ Five Year Plan", Tianjin Binhai New Area has become another potential economic growth pole besides Shenzhen Special Economic Zone and Pudong New Area. Furthermore, the government has deployed the implementation of "Ten Battles" development strategy in 2009. However, over-emphasis on the economic development in making policies for the land use and development and overlook on the environmental construction to some degree have caused a low level of sustainable land use in Binhai New Area and the land use was not truly transformed from economy-dominated development pattern to sustainable development pattern[21]. Eventually, the area of such land types as vegetation, wetland and shoal favorable for maintaining ecological stability has sharply diminished and the area of the building land used for economic development dramatically increased. Developing towards this direction, it will definitely limit the sustainable development of the environment, economy and society in Binhai New Area in future.

The project of reclaiming land from the sea in Tianjin Binhai New Area is the largest project of land reclamation from sea in China, with a total plan area of more than 200 $km^2$, including subprojects such as Dongjiang port area, port industrial zone, port property zone and south port industrial zone. This project alleviated the shortage of land for industrial and residential use to some degree, met the demand of economic development and population growth on land reserves, and also increased the curve and length of the coastal line of the above mentioned areas [22]. However, the implementation of this project caused the area reduction and aggravated the fragmentation of natural land types such as shoal and wetland, which posed a severe challenge to the ecological environment of Binhai New Area.

## 4 Conclusions

There are a lot of methods to extract LU/C types from remote sensing image. This study chooses to use automatic classification with the computer by using the method combining supervised classification with texture-based object-oriented fuzzy classification, and then artificial visual interpretation is carried out to get classified images. Finally, the area, speed and location of land use/cover change of various types in Binhai New Area are known from the analysis by means of statistical calculation and land use transition matrix.

Economic development, population growth, policy implementation and land reclamation from sea have all exerted influence to some degree on the LU/C change in Binhai New Area. The area of building land has sharply increased and the land types of relatively higher ecological value such as greenland, wetland and shoal are dramatically diminished.

In future, correlation analysis between LU/C change and influential factors such as economy and population in the research zone can be carried out to give more clear interpretation and prediction by means of establishing mathematical model. Also, assessment can be conducted on the sustainable use of land for establishing a land sustainability assessment index system and scientific and rational assessment system fit for the research zone by combining the process of change.

## References

[1] Gong Wen, Zhou Jinsheng. Analysis on the Role of Remote Sensing Monitoring Technology in Land Use Supervision [J]. Natural Resource Economics of China, 2011, (5): 49 - 50.

[2] Liu Jun. Study on Land Use/Cover Change of Recession Belt of Three Gorges Reservoir Based on 3S Technology [D]. Chongqing: Chongqing Jiaotong University, 2010.

[3] Wu Jiali, Li Hongjun, Yuan Haozheng. Innovative Study of Overall Planning of Land Use in Tianjin

Binhai New Area [A]. City, 2011, (11): 52 - 55.

[4] Meng Weiqing, Li Hongyuan, Hao Cui, et al. Analysis of Remote Sensing Monitoring on Wetland Landscape Pattern of Tianjin Binhai New Area in Recent 30 Years [J]. Geo-Information Science, 2010, (3): 436 - 443.

[5] Xu Dayong, Zhang Tao, Sun Yichao, et al. Study of Vegetation Cover Degree Change and Prediction of Tianjin Binhai New Area Based on NDVI [J] Ecological Economics, 2010, (12): 45 - 50.

[6] Zhao Gengxing, Li Yuhuan, Xu Chunda. Study of Remote Sensing and GIS-Supported Dynamic Monitoring of Land Use – A case study Kenli County in Yellow River Delta [J]. Chinese Journal of Applied Ecology, 2000, 11(4): 573 - 576.

[7] Zhang Jinghua, Feng Zhiming, Jiang Luguang. Study Progress of Land Use/Land Cover Classification System [J]. Resources Science, 2011, 33 (6): 1 195 - 1 203.

[8] Zhu Huiyi, Li Xiubing, Analysis of Time-Space Change of Land Use in Bohai Rim [J], Journal of Geographical Sciences, 2001, 56 (3): 253-260.

[9] Wang Xiulan, Bao Yuhai. Discussion on Study Method of Dynamic Change of Land Use [J]. Progress in Geology, 1999, 18 (1): 81 - 87.

[10] Xu Lan, Zhao Yi. Prediction on Change of Land Use Pattern in Dongling District by Markov Process [J]. Chinese Journal of Apply Ecology, 1993, 4 (3): 272 - 277.

[11] Wang Siyuan, Liu Jiyuan. Land Use Pattern and Evolution of China in Recent 10 Years [J]. Journal of Geographical Sciences, 2002, 57 (5): 523 - 530.

[12] Chen Siqing, Liu Jiyuan, Zhuang Dafang, et al. Land Cover Change in Xilin River Valley based on Landsat TM/ETM data [J]. Journal of Geographical Sciences, 2003, 5 (1): 45 - 52.

[13] Liu Rui, Zhu Daolin. Discussion on Data Digging Method of Land Use Change Based on Transition Matrix [J]. Resources Sciences, 2010, (8): 1 544 - 1 550.

[14] Liang Changxiu. Beijing Land Use/Cover Change Study Based on RS and GIS [D]. Beijing: Beijing Forestry University, 2009.

[15] Wu Chuanjun, Guo Huancheng. Land Use of China [M]. Beijing: Science Press, 1994.

[16] Zong Guoying, Du Xiping. Statistical Book of Tianjin Binhai New Area 2011 [M]. Beijing: China Statistical Publishing House, 2011.

[17] Wang Xiulan, Analysis of Population Factor in Land Use/Land Cover Change [J]. Resources Science, 2000, 22 (3): 39 - 42.

[18] Tianjin Statistic Bureau. Report of Main Data of the Sixth Nationwide Census of Tianjin 2010, [EB/OL]． 2011-4-29．http://www.stats-tj.gov.cn/Article/tjgb/pcgb/201105/17511.html

[19] Qin Minzhou. Theory and Practice of Land Use and Sustained Development [M]. Xi’an, Xi’an Map Press, 1998.

[20] Liu Jiyuan, Zhang Zengxiang. Analysis of Space Pattern of Recent Land Use Change in China [J], Science in China: Edition D, 2002, 32 (12): 1 031 - 1 040.

[21] Cao Ying. Assessment of Sustainable Land Use and Study of Regional Development Countermeasures of Tianjin Binhai New Area [D]. Tianjin: Tianjin Normal University, 2013.

[22] Zhao Yingjie, Liu Xianbing, Liu Aizhen, et al. Discussion on the Rationality of Sea Use Manner in South Port Industrial Zone of Tianjin [J]. China Water Transport, 2011, (5): 49 - 52.

# 基于遥感的天津滨海新区土地利用/覆盖变化分析

王 丰[1,2]，刘书明[2]，卢文虎[2]，杜琼玮[2]，姜伟男[2]，李佳芮[2]

（1. 厦门大学海洋与地球学院，福建 厦门 361005；2. 国家海洋信息中心，天津 300171）

**摘 要**：采用全国土地分类系统，基于 Landsat 卫星 TM 遥感影像与天津滨海新区 1:50,000 地形图，进行相应数据处理，编制出 2000 年、2005 年、2010 年三期滨海新区土地利用/覆盖分类图，并运用土地利用转移矩阵对近 10 年来天津滨海新区土地利用/覆盖变化进行定量分析。在此基础上，进一步分析了经济、人口等驱动因子对土地利用/土地覆盖的影响。结果表明：十年间，滨海新区的建筑用地面积增加显著，而绿地、湿地、滩涂等高生态价值的土地向建筑用地、未利用地等开发建设用地大幅度转化，后五年变化尤为显著。

**关键词**：滨海新区；遥感；土地利用/覆盖变化(LUCC)；驱动因子