

# ANALYSIS OF THE EXPANSION OF THE BUILT-UP AREA OF DALIAN CITY

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**ABSTRACT:** With the astounding development and gradual improvement of remote sensing technology, as an advanced science technology, it is used to provide multi-temporal, large scope real-time information for land-use dynamic change, and also is one of the best efficient methods for studying the earth resources and environment. Remote sensing image has its characteristics of ample information and reflecting the objective realities. The paper uses multi-temporal TM images in 1986, 1996 and 2000, and relevant statistic data to analyze land-use changes of Dalian City in Liaoning Province of China over ten years by means of the correlation analysis method. The results have shown that two methods could conformably reflect the present land-use change. Urbanization is closely correlative to natural factors and economic development. Especially in recent 20 years, under the influence of the reform and open-up policy, Dalian, as a specific coast city, is becoming an international metropolis.

**KEY WORDS:** land-use change; remote sensing; driving force; Dalian City

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City is a typical dynamic spatial complicated system. Its development is affected by many factors such as nature, society, economy, culture and politics, etc. (HE *et al.*, 2002). Particularly in the end of 1978, the policy of opening-up to the outside world made China concentrate on the economic development and go on reforming, which speeded up economic development. However, economic activities had given rise to the population conglomeration in the urban area, and this phenomenon made population, land, construction and infrastructure rapidly increase. In the case, urban area has to be expanded toward suburbs with a wide margin. For the time being, with the dramatic development of economy and fast growth of population, China is facing a process of large-scale and speedy urbanization. We chose Dalian, a coastal city in Liaoning Province of China, as a study area, and selected three-temporal TM images (1986, 1996 and 2000), coordinating with the statistic data of society and economy, to conduct systematic analysis of driving factors affecting urban land-use change (CHEN, 1999).

## 1 GENERAL SITUATION OF STUDY AREA

Dalian City is located in the utmost south end of the Liaodong Peninsula. Its east links with the Yellow Sea; its west is adjacent to the Bohai Sea; its south faces the Shandong Peninsula (ZHAO, 1996). It is a head of the economic circle around the Bohai Sea, and the central belt of the door of Beijing, Tianjin and the Northeast Asia, called "Northeast Window". Dalian is also a city of the important port, industry, commerce and tourism in China, and is a quite important door opening to the outside of Liaoning Province, and even the whole northeast of China. The transportation to the outside world mainly relies on the air and the sea. Dalian is a key international trade port of Northeast China, known for seaport in freight second to Shanghai. Dalian is also an economic hub of the great region cross the provinces, and its open-up region has extended to other inland provinces, which form a new layout of open-up to the world. The economic and social development of the whole city have made historicly un-

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precedented achievements and Dalian has become one of the most open-up, vigorous, rapid and powerful cities in China. It is a pioneer of the opening up to the outside of the Liaoning Province as well as the Northeast China (WANG, 1998).

## 2 DATA SOURCES AND ACQUIRING METHOD

### 2.1 Data Sources

The data used in the study are mainly remote sensing data and statistical data. With the development of remote sensing technique, it provides a new data source and new approach for the exploration of the earth for geographic research. It offers the dynamic information to monitor the global change and creates an advanced condition to study the resource and environmental changes. Its image contains plenty of information, which would reflect the reality. The statistical data feature the standard, systematic and time-continuous structure. This research is to use the related statistical data combined with the remote sensing data to analyze the dynamic changes of the built-up area and conduct a drive-force analysis, which can directly reflect the change status of the Dalian City.

### 2.2 Acquiring Methods of Data

A standard pseudo-color combination should normally use TM4, TM3 and TM2 bands since they could reflect object's information better. A series of image processing should be completed before man-machine mutually interpreting, in order to identify the object clearly. Afterwards, three-temporal images should be strictly rectified so that exact dynamic information can be extracted (Fig. 1).

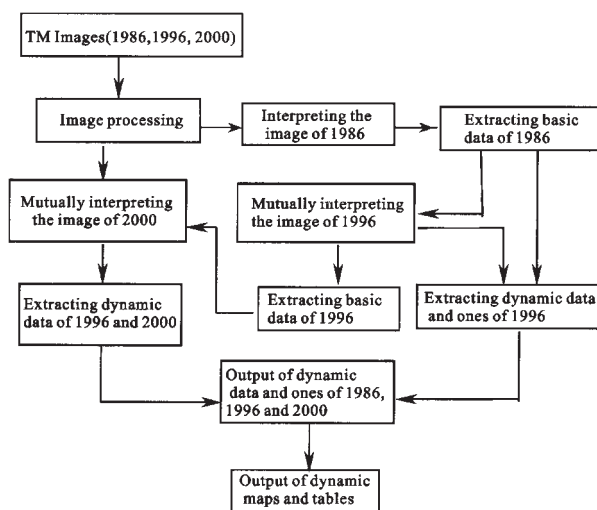


Fig. 1 Flow chart of image processing

## 3 LAND USE/COVERAGE CHANGES

### 3.1 The Change of Quantity

The three-temporal land-use maps can be produced by interpreting the TM images in the 1980s, 1990s and 2000 respectively (Table 1), in which the urban area amounted to 111.35km<sup>2</sup> in the 1980s and 215.59km<sup>2</sup> in the 1990s, increased by 93.61%, doubled within 10 years. While it had reached 265.69km<sup>2</sup> in 2000, upped to 23.24% within 4 years. The greenland had grown up 51.97% from 1986 to 1996 and 133.85% from 1986 to 2000, but the land in suburbs has relatively decreased.

### 3.2 The Change of Land Type

In fact the expansion and changes of urban land in the built-up area attribute to the change of land type.

Table 1 The change of land-use in quantity (km<sup>2</sup>)

Code	Type	1986	1996	2000	1986 - 1996	1996 - 2000	1986 - 2000
21	Forestry	10.09	3.29	5.98	-6.79	+2.69	-4.10
24	Green land	5.85	8.89	13.68	+3.04	+4.79	+7.82
42	Water field	0.58	0.63	0.82	+0.05	+0.19	+0.24
51	Urban area	111.35	215.59	265.69	+104.24	+40.10	+154.34
53	Farm	1.72	1.86	3.70	+0.14	+1.84	+1.97
123	Arable land	63.01	3.72	7.33	-59.29	+3.61	-55.68
999	Sea	5.70	0.03	0.09	-5.67	+0.06	-5.61

After interpreting and processing of the above images, the change data of land type can be obtained (Table 2). Urban expansion is primarily due to the occupation of the suburban land and the project of filling sea. Mean-

while, the municipal government has also paid much attention to the landscape engineering, thus the green land area has increased by 4.14km<sup>2</sup> in 1996 and 7.64 km<sup>2</sup> in 2000.

Table 2 Land type change (km<sup>2</sup>)

	Urban area		Arable land		Green land		Sea
	1986 - 1996	1996 - 2000	1986 - 1996	1996 - 2000	1986 - 1996	1996 - 2000	
Forestry	5.50	11.40	0.40	0.00	0.90	2.27	0.00
Green land	1.11	2.36	0.00	0.00	—	—	0.00
Water field	0.04	0.18	0.00	0.00	0.00	0.00	0.00
Urban area	—	—	0.00	0.11	0.14	2.95	0.18
Arable land	56.54	35.41	—	0.00	3.10	1.97	0.00
Sea	5.67	5.59	0.00	0.00	0.00	0.45	—

## 4 ANALYSIS OF DRIVING FORCES FOR THE BUILT-UP AREA CHANGE

### 4.1 Correlation Analysis

The correlation analysis results, which were produced by applying SPSS statistic software to analysing the built area, total population, nonagricultural population, infrastructure investment, Gross Domestic Products (GDP), the primary industry, the secondary industry and the tertiary industry, have shown that the built-up area of Dalian City has a good positive correlation with the tertiary industry, total population, nonagricultural population, fix asset investment and GDP (correlation coefficients are respectively: 0.923, 0.913, 0.889, 0.866 and 0.835). However, the primary industry and the secondary industry have negative correlations with the expansion of built-up area. There is, therefore, a bigger driving action against the expansion of the built-up area by the former ones, in particular the tertiary industry, is a key driving force.

### 4.2 The Analysis of the Change Factors

City is a center of mankind's activities and residence, and is a substance reflection of politics, economy, technology and culture for a country or a region (ZHANG, 2000). But the development of the cities in certain region and their formation of scale distribution would be influenced by many synthetical factors such as history, geographic place, transportation condition, natural resources, economic development level and policy, etc. In this case, the index of reflecting city is complicated, this paper concentrates on the following aspects to conduct the analysis of the development of the city.

#### 4.2.1 Economic status

The economic reform of city's gradual deepness promotes the rapid development of both society and economy, and makes the process of urbanization go into a new stage of sustainable and steady development (XU, 2002). The great change took place in the economy of

Dalian City, whose GDP and per capita GDP have grown rapidly, and changed from 13.243 billion yuan (US\$1.6 billion) in 1988 to 64.922 billion yuan (US\$7.82 billion) in 1998.

#### 4.2.2 Industry structure

The industrial structure has changed a lot during the past ten years. After the economic reform, the primary industry occupying less proportion in the whole industry has gradually decreased in small fluctuation, but the secondary industry staying in high ratio has greatly declined. The tertiary industry has obviously risen (XU, 2002), surpassed the secondary industry by 1995 and been remained continuously rising tendency (Fig. 2).

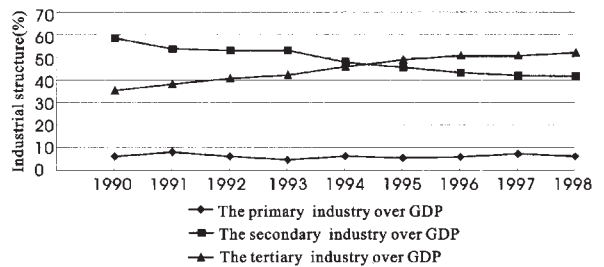


Fig. 2 Change of industrial structure in Dalian City

#### 4.2.3 Population growth

With the step-by-step opening-up of labor market, foreign temporary resident population come in and increase the proportion of urban population, which force urban area to expand towards its suburbs. In addition, all kinds of development zone's exploration as well as counties surrounding big cities as parts of these cities make urban area expanding towards a wide margin. So the change of population would directly reflect the land-use change of a city (Fig. 3).

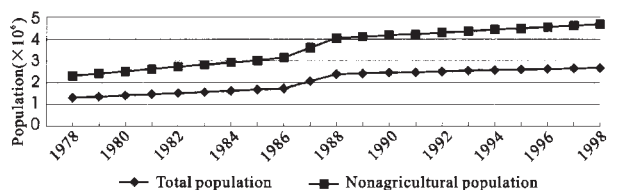


Fig. 3 Change of population in Dalian City

Economic development and population growth bring necessarily about great changes of land use. According to the statistic data, the area of Dalian proper has increased by 2.5 times from 90km<sup>2</sup> in 1986 to 234km<sup>2</sup> in 1998. Because of terrain and water limitation, the port development was restricted in those days. So the planning of Dalian City has changed traditional strategies, carved a new road from centralizing expansion to separating development. Especially with the economy and technology development zone going smoothly, the municipality promptly adjusted ideas and decided to develop a new area, in this way, Dalian has become a dual-structure city—one old and one new area (HU *et al.*, 2000) (Fig. 4).

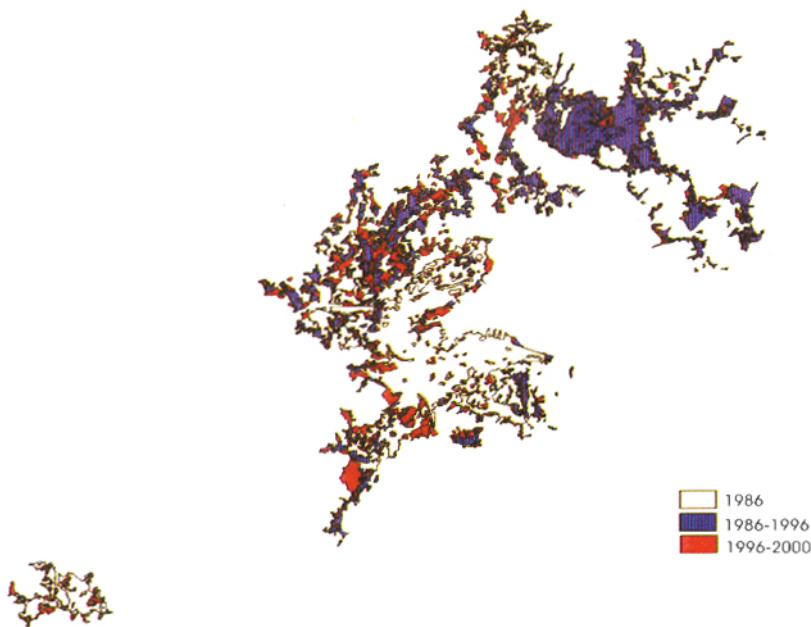


Fig. 4 Built-up area expansion from 1986 to 2000

In one word, reforming and opening-up brings a vital force to the coastal cities. Dalian, as the first opening-up coastal city of Northeast China in 1984, through many years' ever-increasing development and construction, has experienced a great change and owned a modern harbor and aviation facilities, and successively built various development zones (HU *et al.*, 2000). Many modern communication facilities were available. The hardware has drawn many foreign investors, which further speeds up the economic development of the coastal regions. Obviously, the betterment of modern traffic transportation and popularization of communication technology are varying the urban layout. These advancement has shorten the distance of economic contact, lowered abstracting of conglomeration of big city to industries and residents and stimulated

#### 4. 2. 4 Policy—control valve of expansion

In general, a modern city is controlled by policy, law and planning. Before reform and opening-up, due to the restriction of financial system, population transfer, household register policy and housing, urban expansion held up, which limits the development of a city. After reform and opening up, through the transformation of economic system and adjustment of administration, the development of a city is greatly speeded up (YANG, 1997). At present, Dalian is marching towards a goal of healthy production, comfortable living, economic smooth in its city and countryside and the international exchange of culture, economy and science and technology (ZHENG and LI, 1992).

enterprises and population living in urban center to move outwards, which forced the development of Dalian City (HU *et al.*, 2000).

## 5 CONCLUSIONS

(1) Under the driving of opening-up and reform policy, Dalian City is prospering, as the planned economic system was transferred into a market one. Its urban enormous change can be seen everywhere. It is known for its harbour, industry, commerce and tourism. It is showing off its attractive mien through a good transportation, flourishing economy and gorgeous scenery.

(2) Whichever remote sensing data or statistic data were used, all reflected obviously change character of

urban area. The results of correlation analysis applying TM and statistics data have proven that they have better consistency (WANG *et al.*, 2002; BO *et al.*, 2000).

(3) Since the reform and opening-up, Dalian City has gone through the urbanization process—rapid economic development, industrial restructuring and obvious land-use change.

(4) In recent 10 years, with the high-speed economic development of China, Dalian City has also experienced a high-rate growth period of economy and population. Population grows from 1.4219 million in 1986 to 2.0009 million in 1998; urban area expands up to 234km<sup>2</sup> in 1998 compared with 90km<sup>2</sup> in 1986 and GDP rises to 64.922 billion yuan(US\$7.84 billion) in 1998 while only 13.243 billion yuan(US\$1.6 billion) in 1990.

## 6 PROBLEMS AND SUGGESTIONS

From the view of the practical situation of Dalian, due to the limitation of fresh water source and hill topography, the government should control the speed of the expansion of the built-up area. The over-rapid development of the city would lead to the insignificant increase of population and economic development. Some irreplaceable resource supply will present the tension status, particularly cultivation land and water resource (which is lower than the average level of the whole country). While the economic rapid development will put forward a new demand for these resources. Therefore, the development speed of the city should be properly controlled, especially population growth. The enterprises with the great consumption of energy and water will be restrained from the environment pollution. The large-scale unplanned expansion will restrict the economic development and rise of the living level.

Hence, the municipality should fully take advantage of its port city, tap its great potential of the synthesis resources, positively develop extensive enterprises and high-tech industry based on the science and technology, further bulge in the export of foreign trade and multi-function banking as well as culture, education

and sanitary. It needs to adjust the industrial structure, enhance environment protection and boost the tertiary industry, which basically form the economic scale and synthesis power of a regional central city. In this way, Dalian will finally become a layout of further opening to both home and abroad(BO, 2000 and WANG, 2002).

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