mainly of the round-grained nonglutinous rice. It shows that the age of differentiation of the two kinds of rice may be 5,000 a B.P. based on a number of paleoclimatic events in China. During 5,000-4,000 a B.P.; which is in keeping with the climate change due to there was a cool period of about 5,000-1,000 a B.P. the kind of cultivated rice was chiefly of the cool-like one either south China or north China.

The relationship between the propagation of rice cultivation and climate can also be seen from following facts. It is generally considered that three warm climate periods were occurred in China since 5,000 a B.P., the epoch of Longshan Culture and Yin Dynasty ruins (4,000-3,000 a B.P.), Spring and Autumn Period and Warring States (about 2,500 a B.P.) as well as Sui Dynasty and Tang Dynasty (1,500-1,000 a B.P.). The three stages of rice propagation are also the same being influenced by the change of climate in China. In Japan the stages of rice cultivation during 2,500 a B.P. and 1,000 a B.P. are also consistent with the warm climate periods of Yayoi and Nara, respectively.

During the ancient times the development of paddy rice was related to the fluctuation of sea level in some degree which is in keeping with the climatic change. The period of expanding of rice cultivation is consistent with the rise stage of sea level. The sea level fluctuated by an amplitude of 2-3m since 5,000 a B.P. in China. Being influenced by the rise of sea level, the level of ground water rose, resulting in the extending of swamp, and a favorable condition for the development of paddy rice has been provided at that time.

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# URBAN INVESTMENT ENVIRONMENT INFORMATION SYSTEM FOR CHINA'S COASTAL PORT CITIES

Su Yafang (苏亚芳)

*(State Key Laboratory of Resources and Environment Information*
*System, Institute of Geography, the Chinese Academy*
*of Sciences, Beijing 100101, PRC)*

**ABSTRACT:** The paper mainly applies multi–disciplinary theories, methods and geographic information system (GIS) technology to study the investment environment for coastal port cities. The methods of studying urban investment environment using GIS prompted. In this paper, it is mentioned that the study of investment environment with GIS can be divided into 3 layers of macro scope, medium scope and micro scope in the paper. A powerful user–friendly UIEIS (Urban Investment Environment Information System) has been designed to study the urban investment environment. A series of application analysis models (including investment environment assessment models, investment site selection models, documental data management models, statistical data graph display model, economic analysis and prediction models, network analysis models) are developed for investment environment studies in coastal port cities. Ningbo, a very important coastal port city, is chosen as a pilot study city.

**KEY WORDS:** port city, investment environment, urban information system, geographic information system

## I. INTRODUCTION

China's coastal region covers 12 provinces with the land of 15% of the mainland and a population of 475 million that was 41.2% of the total population of China at the end of 1992. While the gross value of industrial output, national income and GNP (gross national product) are 60.2%, 54.7% and 53.9% of the whole country's respectively, and the total value of foreign trade is 90% of the whole country's. Of 517 cities in China, 191 located in the coastal region, and the city population is 50% of the whole country's city population.

The inclination of China's economic strategy to coastal area since 1980's has driven the rapid economic growth along coastal region especially in port cities. The region becomes the most fascinating investment place. Therefore, to study the investment environment of this region is very urgent and necessary[1].

By the study of investment environment, local government, investors, enterprisers and businessmen can understand the investment environment in a certain area more scientifically and systematically so as to do better planning, improve the investment environment, and guide the investors to make full use of investment environment. Besides, China, as a developing country, is still lack of capital. By the study of investment environment, more overseas and domestic capital can be attracted.

## II. METHOD OF STUDYING INVESTMENT ENVIRONMENT BY GIS

On the view point of regional geography and GIS, investment environment can be defined as an integration of various essential elements and their interactions supplying for the investment in a certain economic area. The elements mainly include the conditions of physical environment, location, traffic and information, population and labour, socioeconomic and policy, politics etc. This definition can not only represent the essence of investment environment, but also make the GIS to study investment environment available, because GIS is particularly good at integrated spatial analysis of various elements.

The investment environment of a city includes not only its internal environment such as physical environment, social environment and basic facilities etc., but also its connection with outside region, such as traffic convenience etc., so it is very difficult to study investment environment by conventional methods. According to the characteristics of investment environment and the advantage of GIS, the study of investment environment can be divided into three layers:

### 1. Macro–Scope Layer

This is for the large region and countryside which are closely related to the city. It will include global, national and regional politics and economic environment and the city's geographical place. For a port city, especially an international port city, its connection with hinterland and other ports of the world is very important. Port is a gathering and spreading "source" of goods and materials. In the connection modes, except information exchange can be realized by modern communication equipment, most of goods trade and some of the information exchange are realized by air, water and land transportation. The radiation power of the city can be modelled by GIS network analysis function.

## 2. Middle–Size Layer

This is for the area under the city's jurisdiction. The study scope will include the analysis of various elements' impacts on the investment environment. The analysis will include spatial convenience analysis, information database establishment, investment environment quality assessment and suitability assessment for some of important enterprises. The results will help the investment environment planning and reasonable industrial location.

## 3. Microscope Layer

This is for the investment project. Each project can establish its own information base such as spatial location, workshop layout, production, energy and material supply etc. The project can be assessed by GIS by adding some special functions.

## III. DESIGN OF URBAN INVESTMENT ENVIRONMENT INFORMATION SYSTEM[2-3]

### 1. Data Sources

According to the demands of the user and analysis of the system, the geographical database of the system will include:

countryside traffic networks,
regional traffic networks, administrative boundary etc.,
terrain maps both of the land and sea,
thematic maps on various elements such as pipelines, public facilities etc.,
urban landuse maps,
satellite images or air–photos,
statistical data,
documents of the history and development of the city, socioeconomic environment,
policies etc.

They can be concluded as four kinds of data:

map data,
statistical data,
image data,
documental data.

The data flow of above four kinds in urban investment environment information system (UIEIS) can be briefly represented in Fig.1.
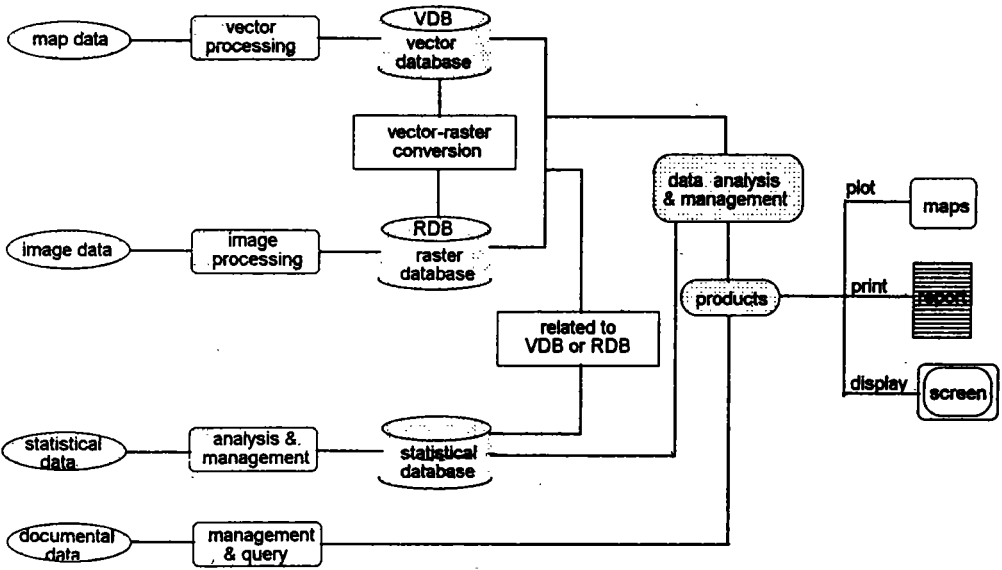


**Fig.1Data flow chart in UIEIS**

## 2. The Structure of the System

The structure of the system can be represented as Fig.2. In Fig.2, the vector subsystem is mainly use PC ARC/ INFO software, the raster subsystem is mainly use EPPL7 software, the application subsystem is developed by the author. There are interfaces between subsystems for data conversion. Data can be flow on bi−direction.

## 3. Application Analysis Models

The study of investment environment is a very complicated subject, many kinds of analysis work can't be done by general GIS software. Therefore, many application models are developed. the followings are some of them:

*3.1 Investment environment assessment models[4]*

Analytic Hierarchy Process (AHP) model, Expert Score model and Fuzzy Assessment models have been developed to assess the quality of investment environment and suitability analysis for different industries.

## 3.2 Investment site selection models

Expert Decision-making model, Site Matching model and AHP model have been designed to select the optimal investment site.
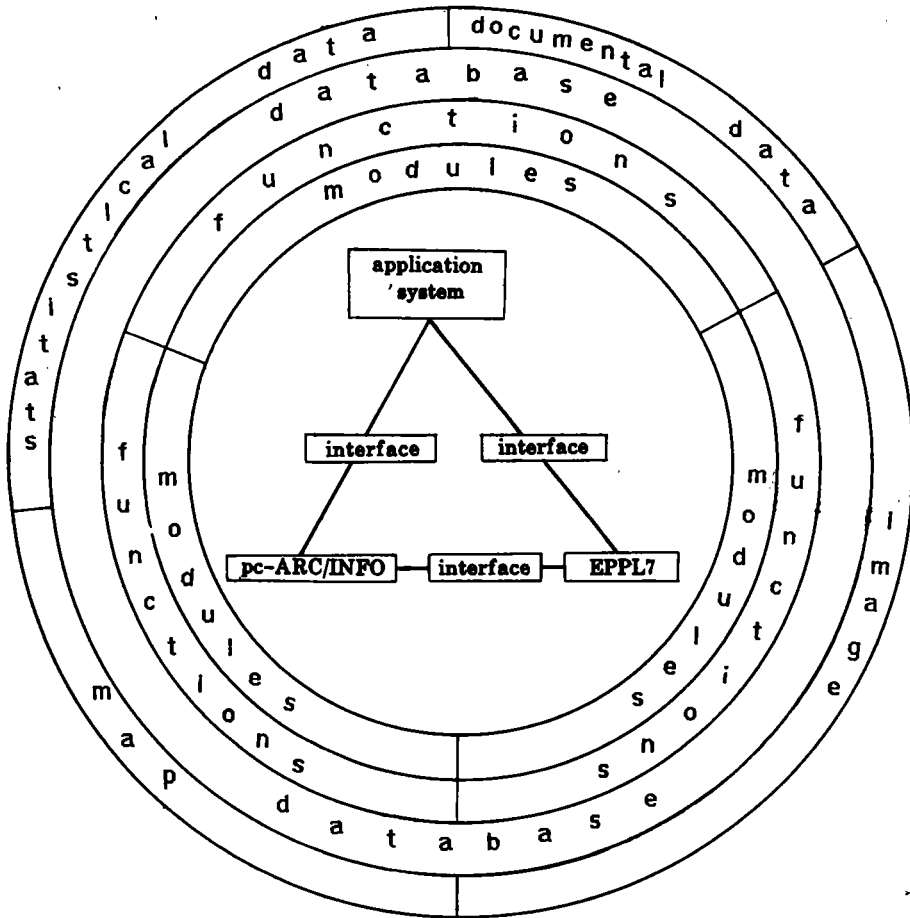


**Fig.2** System structure of UIEIS

## 3.3 Documental data management models

The information of brief introduction of the city, the procedures of investment, the preferential policies of investment and the relative organizations etc. are also important contents and display of these data is developed. In the model, the data can be inputted by an editor. Each subtopic is stored as keywords under the pull down menu. Once the subtopic is selected by mouse, the information under this topic can be displayed in a window. Many popup windows can be displayed on one screen. The window can be zoom in

and out.

## 3.4 Statistical data graph display model

In the study of investment environment, statistical data is also an important data source. Graphic display of statistical data can show the sequential phenomenon very directly and impressively. In the system, three kinds of graphs of Bar, Pie and Curve are developed. Different time, different variable of statistical data can be displayed on one screen.

## 3.5 Economic analysis and prediction models

In order to analyze and predict the changing trend of socioeconomic data, several models are developed as follows:
Time sequential models such as moving average and growing curve methods,
Regression models such as one variable multi-nominal regression and multi-variable regression,
Grey system model such as GM(1,1), GM(1,N) and GM(1,1) remainder model,
Input-output model.

## 3.6 Network Analysis models

PC ARC/ INFO has the network functions of Allocation and Route. They are applied to stimulate the transportation time and cost by traffic network and search the optimal path from one place to another place.

Other models such as Terrain Analysis model has been improved. Above models together with the models possessed by the software system of PC ARC/ INFO and EPPL7 can complete the study of investment environment.

## IV. APPLICATION EXAMPLES

Ningbo, also named 'Yong' for short, situated in the middle of China's coastline, is a typical port city. She is chosen as a pilot study city. At present, the municipality consists of five districts and six counties, and covers a total area of 9,356km$^2$ with a population of 5.2 million, of which 1,033km$^2$ and 1.1 million is in the city proper at the end of 1992. The gross value of industrial output increased from 11.1 billion in 1985 to 48.5 billion Yuan in 1992. Ningbo port is called "Oriental Grand Port", which is a comprehensive port of multipurpose with various sizes of berths for ships ranging from 5,000, 18,000 to 200,000 tonnages, with a total of more than 50 berths. Presently, the port has cargo shipping linking

with more than 239 ports in 65 countries and regions. There are international container terminals of third and forth generation with the size of 30,000 to 50,000 tonnages. After completion, the annual handling capacity will be increased up to 100 million tons in 2000.

## 1. Ningbo Investment Environment Assessment

In the investment environment assessment of the city of Ningbo, regular raster grid of 100m × 100m is chosen as an assessment unit. The test area is the main investment area with the units of $210 \times 620$, of which about 856km$^2$ land and 446km$^2$ water areas. AHP method is used to select the relevant elements. The variables can be divided into three types:

points: such as schools, post offices, hospitals, plants etc.,

lines: such as various pipelines and traffic roads etc.,

polygons: such as tax preferential areas, different administration area etc.

Analysis models mentioned above are applied integratively[4]. Five main results are obtained in the test area:

comprehensive assessment for the quality of the investment environment,

suitability investment environment assessment for heavy industry,

suitability investment environment assessment for light industry,

suitability investment environment assessment for high–tech industry,

suitability investment environment assessment for service trades.

Above results are in coincidence with the real status in Ningbo at present.

## 2. Analysis of Ningbo Port

Ningbo port here mainly indicates one of the three port areas: Beilun port, for its dominant position of deepwater. Terrain analysis of water depth in port operation area and navigation courses near the port area has been done. The result shows the condition of water depth is very good. Comparisons the port with other china's big ports of Dalian, Guangzhou and Shanghai port have been done by traffic network analysis of China (refer to another paper). The results shows Ningbo port is the best of all along China's coastline at present. Therefore, Ningbo port is potential to be one of the great international ports.

## V. STRATEGIC ANALYSIS OF ESTABLISHING UIEIS FOR COASTAL PORT CITIES

Both the developed and the developing countries have made all efforts to develop seaport and port cities in modern society. The geographic characteristics of China lead to

that the coastal port cities are the main windows and gates for the international exchange in economy, culture etc. Although there are only about 32 coastal port cities in different size, they have played crucial role in the economic construction and development of China. Since the 1980's, the investment environment in the coastal port cities has changed rapidly with the high speed economic growth. Therefore, to establish the investment environment information system for these cities in urgently needed. The scientific study of investment environment can help the sustainable development of the coastal region. This paper is the first example of exploring the method of establishing the investment environment information system for coastal port cities. It is expected that there will be more investment environment information systems in the near future.

## VI. CONCLUSIONS

By the design of UIEIS and the case study of Ningbo, it can be concluded:

1) It is necessary to divide the study of investment environment into three layers of macro-scope, middle-size, and microscope by GIS.

2) New type of information system for the study of investment environment is designed and developed. It not only opens a new way for the study of investment environment and made it more systematic and scientific, but also open a new field for the application of GIS.

3) By using NEBEIS, application examples of Ningbo port and urban investment environment assessment were analyzed. The results can assist urban investment environment planning and investment decision making. The system is exemplified to be popularized in applying to the investment environment study for other China's coastal port cities.

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