

THE SYSTEMATIC STRUCTURE OF THE ENVIRONMENT AND RESOURCES OF THE HUANGHE RIVER DELTA

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ABSTRACT: On the basis of characteristics of the physical geographic environment and natural resources of the Huanghe (Yellow) River Delta, this paper studies the integral structure of the environment and resources system of the region with the Interpreting Structure Model (ISM). This paper chooses 9 environment factors, 7 superior resources and 6 disastrous or restrictive elements to make the structure matrix separately. And by using the ISM to tidy up the relations among the elements, three system structure graphs are obtained. Then they are integrated into a great environment-resources system of the Huanghe River Delta. The structure of the environment and resources system is an entirety. It should be studied and perfected with a comprehensive and systematic view. In regional development, the resources exploitation often occupies the key position. In the Huanghe River Delta, oil and land resources should be exploited first. This can bring about the comprehensive development of other resources. The region will finally be built into an oil energy base, an oil and salt chemical industrial base and bases of agriculture, animal husbandry and fishery. In the territorial management of the Huanghe River Delta, great attention must be paid to the root, middle links, result and appearance which constitute the resources and environment of the region. The harnessing of the Huanghe River Delta should focus on the river's mouth, ground water, saline-alkali land and ecological fragility. The final goal is to transform and overcome the bad conditions to promote a good cycle of the environment and resources system.

KEY WORDS: Huanghe River Delta, natural resources, interpreting structure model

The Huanghe River is a river with the highest sediment concentration in the world. Its mouth is a type of weak tidal, continental and wandering river mouth, which makes the course of the river mouth part extend rapidly and change frequently, and consequently a rapidly-growing delta has come into being. It is unique

both at home and abroad.

The Huanghe River Delta (HRD) has rich resources and is being developed on a large scale. So it is very necessary to gain a clear idea of the systematic structure of its environment and resources. On the basis of analyzing the characteristics of environment and resources in the HRD, this paper intend to make the complicated relationship between each element clear, set up an integral concept of the systematic structure of environment and resources, and discover the crux of regional development and territorial management by means of Interpreting Structure Model (ISM).

I. CHARACTERISTICS OF THE NATURAL ENVIRONMENT

1. Continent Environment

The HRD located in the northern part of Shandong Province of China, is on the south beach of Bohai Bay and the west beach of Laizhou Bay. Its environmental characteristics are as follows:

1) In geologic structure, this region is controlled by Neocathaysian NE NNE and NW structural system, belongs to a block indentation basin of Mesozoic and Cenozoic eras. Because of subsidence over a long period of time, the Quaternary stratum reach to a thickness of more than 400 m, and gradually becomes 100 m eastward.

The HRD's sediments formed in the later stage creates a special landform. The HRD body consists of three parts: upper delta plain, lower delta plain and subaqueous delta. The upper delta plain is formed by changes of the Huanghe River tail course. It can be divided into two delta systems, the modern HRD taking Ninghai as top and the current HRD taking Yuwa as top, the latter's top shifts lower superposes the former. Now the Huanghe River flows through the middle part of two delta systems. The high lands of paleochannels spread like palms from the two tops of deltas. The flat lands and low-lying lands are between every two high lands. There are also burst fans and back-river hollows along the Huanghe River. The lower delta surrounds the upper delta like a belt. It is formed by the alternate action of continent and ocean. Its landscapes are coastal beach and woodland. The subaqueous delta is shallow sea environment. If seen vertically, the whole delta is like a lozenge with a handle lying on the sediments of ancient delta and shallow sea.

2) The scope of the region is from 118°E to 119°E, and from 36°N to 38°N. It belongs to the warm temperate semi-humid continental monsoon climate area. The sunshine hours are 2,590—2,830 h/a. The amount of solar radiation is

514.2—543.4 kJ/(cm³·a). The annual average temperature is 11.7°C—12.6°C. The average amount of precipitation is 530—630 mm/a, of which 70% concentrates in summer. The amount of evaporation is 1,900—2,400 mm/a. The annual average wind speed is 3.1—4.6 m/s. The general characteristics of climate are full sunshine, rich quantity of heat, clear seasons, moderate temperature, high rainfall and high heat in the same season, and rich wind power resources; but in another aspect, its rainfall is not balanced, evaporation is more than precipitation; and some natural disasters such as drought, waterlogging and storm surge appear frequently.

3) There are about 20 rivers flowing into the Bohai Sea in this region. The Huanghe River is the longest one and has the greatest effect on the HRD. The water quantity transported by the Huanghe River is 94.2% of the total runoff discharge, and its annual sediment transport quantity is 99.8% of that of all rivers. Except the Huanghe River, the others are almost all draining rivers. The average runoff discharge of all rivers is 325 million m³/a. In the region, most of the surface water is from seasonal rivers. The Huanghe River is often dry from April to June. Most of the underground water is pore water of loose sediment. Bordering on the sea and lower plain, the level of ground water is high and the water quality is saline. The area of saline ground water is more than 70% of this region. There are short of fresh ground water resources.

4) There are different soil types because of different soil parent materials and different land-forming ages. The drab soil and a small area of calcium nodule chernozem are distributed on the south of the Xiaoqing River. The moisture soil and salinized soil sequence are mainly distributed in the HRD. The moisture soil is a main kind of agricultural soil resources extending to the coastal area with an elevation of 3—4 m. The saline soil which is distributed below elevation of 3—4 m and in seabeach area is the main problem for developing agriculture. Some interim soil types exist successively among drab soil, moisture soil and saline soil.

5) The zonal vegetation in this region is deciduous broad-leaved forest of the north temperate zone. There are many higher vegetation, up to 40 families, 119 genera and 164 species. The forest coverage is about 4%. The meadow especially halophytic meadow is the main natural vegetation. The dominant species of plant community are *Imperata cylindrica*, *Aeluropus litoralis*, *Suaeda heteroptera kitagawa*, etc. Natural grassland covers about 185,700 ha, which can be used for developing animal husbandry. Many economic tree species, shrubs and wild plants can to be developed and utilized. In the Huanghe River, pools and reservoirs, the fishes of fresh water can be divided into 13 families, 41 genera and 59 species. Main fishes such as carp, grass carp, silver carp, crucian carp, can be caught and cultivated.

2. Shallow Sea Environment

In the HRD region, the length of coast line is about 500 km, the area of mud foreshore is about 1,080 km², the depth of Bohai Bay and Laizhou Bay along the seabeach is less than 15 m. The characteristics of shallow sea environment are summarized as follows:

1) The temperature and salinity of sea water are affected by continental climate and the runoff of the Huanghe River. The water tongue of lower temperature and lower salinity exist near the Huanghe River mouth all the year round. In winter sea water ice up for about 3 months.

2) The tide is controlled by M₂ tideless point. The daily tidal district is from Shenxiangou to Wuhaozhuang, on both sides of which half-daily tide is irregular. As for the tide time, the west is earlier than the east. The tidal range is 0.22—1.00 m near Shenxiangou, it increases to 1.80—2.88 m toward west in Bohai Bay, and 1.00—1.78 m in the west of Laizhou Bay. The tidal current rotates as clockwise at the surface but moves back and forth at the bottom of the sea. There is a stronger tidal current district out off the Huanghe River mouth and Shenxiangou River mouth, its surface remaining current flows to south in winter and to north in summer as influenced by monsoon.

3) Among the basic chemical elements of sea water, dissolved oxygen quantity is greatly affected by water temperature; pH value changes a little; inorganic combined nitrogen, mainly ammonium salt, nitrate and nitrite, decrease gradually from the Huanghe River mouth and Laizhou Bay beach to the sea center.

4) The primary productivity is very high in the shallow sea. The Huanghe River and other rivers carry a lot of nutrition salt and organic matter into the sea, which provide good conditions for fishes, crawfishes and crabs. There are two shallow sea fishing areas, Bohai Bay and Laizhou Bay, producing eastern prawn. The vast and flat foreshore is good for marine cultivation and salt industry.

II. CHARACTERISTICS OF THE NATURAL RESOURCES

1. Land Resources

The characteristics of land resources in HRD can be summed up briefly. First, the land area has been growing continuously. Since 1855 when the Huanghe River course began to flow into the sea at this place, HRD has formed 2530.4 km² of land. The average rate of land-forming is 26.26 km²/a according to the real years of flowing water. Since the current river mouth part changed its course of flowing into the sea from Diaokouhe to Qingshuigou in 1976, the average rate of land-

forming had been up to 32.36 km²/a by the end of 1990. The HRD is such a region that the land resources increase fastest in the world, and is also the youngest territory growing continuously in China. Second, the land resource is much richer. The total land area of this region is 12,057 km²^①. Since the average density of population is less than 200 person/km², the average useable land per capita is 94.5 ha, which is more than twice as much as that of Shandong Province. There are also vast foreshore in this region, which are the largest areas among the coastal provinces in China. Third, the land of this region has greater developing potentiality. Now the cultivating rate of land is less than 30%, about 90×10⁶ ha have not been developed. Even the cultivated lands still have transforming potentiality because most of them are middle-or lower-yield fields. Fourth, the general quality of the land in this region is poor, there are vast areas of saline and waste land. The ecological conditions of newly-formed land are generally vulnerable. The land is easy to cultivate, but quick to degenerate and difficult to restore. We must take measures of comprehensive management, and expand land-use measures of comprehensive management, and expand land-use ways according to their suitabilities, so as to bring about the potentiality of land resources. In a word, the rich reserved land resources of the HRD is much more outstanding among the whole coastal regions in the east of China. The vast lands provide basic condition not only for great agriculture, but also for the development of industry, traffic, and cities as well. I

2. Mineral Resources, Mainly Oil and Natural Gas

The HRD located in the eastern part of Jiyang depression is rich in oil and natural gas and has broad developing prospects. Thirty years of hard work has gradually made Shengli Oil Field an important industrial base in the east of China in spite of the complex geologic conditions. At the same time, the exploration and construction of Shengli Oil Field also can provide markets for the development of other industries.

In addition, the HRD is rich in geothermy resources, coal, rock salt and gypsum deposited in deep layers of the underground, and underground bittern resources along the southwest seabeach of Laizhou Bay and the north seabeach of Mashanzi area, which is one of the salt producing regions with the highest developing potentiality in China.

3. Marine Resources

The marine resources of the HRD region are richly endowed by nature. At

^① It is the area of the "Huanghe River Delta region" that includes 3 counties and 2 districts of Dondying City and 2 counties of Binzhou City.

present, the marine biological resource and marine salt resource are the easiest to be developed. In the Bohai Sea, this water area has richest phytoplanktons, zooplanktons, benthons, and many kinds of economic invertebrates oviposit and grow, where the resource quantity is over 10,000t. According to the statistics of investigating seabeach zone, there are 517 species of marine organisms and 195 species of intertidal zone organisms. The vast shallow sea and foreshore are good places for marine cultivation and shellfish increase culture.

This region has a historical tradition of producing salt. In the north is Chengkou saltern (the second largest saltern of Shandong Province); in the southeast is Yangkou saltern. In addition, there are many medium or small-sized salterns. The flat and vast seabeach with great evaporation is favourable to producing salt, which provides good conditions for developing salt industry and salt-chemical industry.

Moreover, marine oil and other marine resources are being developed and will be developed in the future.

4. Water and Sediment Resources of the Huanghe River

The Huanghe River flows through this region and brings us water sediment resources. As an "above ground river", the Huanghe River is almost not polluted. Therefore, the good-quality water becomes an important source of freshwater for life and production. In consideration of the unevenness of the water quantity, and the frequent drying of the Huanghe River, some plain reservoirs have been built. If the storage rate of the tail water of the Huanghe River is up to 10%, more than 4 billion m³ of water can be stored each year, which is sufficient for the industrial and urban construction and people's life. It is also an effective measure of developing agriculture and managing territory to warp soil for improving soils by utilizing the water and sediment.

5. Climatic Resources

The light and heat resources of this region can meet the needs of diversified economy such as agriculture, marine cultivation and salt production. As a northern region with long-time sunshine, it has about 200 days of frostless season. The $\geq 0^{\circ}\text{C}$ accumulated temperatures (AT) is 4,562–4,287 $^{\circ}\text{C}$, and $\geq 10^{\circ}\text{C}$ AT is 4,113–4,385 $^{\circ}\text{C}$, which can support the cropping system of triple harvest in two years and some double harvest in one year by means of intercropping and interplanting, and is also suitable for the growing of rice and cotton. The simultaneous rainfall and heat is favourable for the growing of crops. Wind-power resources of the north

part should be paid attention to. The total amount is more than $1,100 \text{ kw} \cdot \text{h}/\text{m}^3$, The effective wind hours are over 50%, which has great potentialities of development.

6. Biological Resources

This region is rich in animal and plant resources, and has some famous specialities and local fine products. It has some rare birds preserved by the state, such as whooper swans, white storks and great bustard.

The natural grassland in this region is a rare landscape in east coastal regions. It not only provides condition for building animal husbandry base, but also is a kind of tourist resources with distinguishing features.

III. ANALYSIS OF SYSTEMATIC STRUCTURE OF THE ENVIRONMENT AND RESOURCES

The environmental and resources structure of a region includes not only its state and superiority, but also the relations between each elements. Only by making clear these relation can we set up a systematic integral concept.

This paper uses ISM (Interetive structure Model), an American technology handing systematic problems, to analyse the systematic structure of the environment and resources of the HRD.

1. The Method and Function of ISM

Suppose S is a system, it has n elements, namely

$$S = (S_1, S_2, \dots, S_n)$$

According to the interrelation among S_i , we can set up a structure matrix $A = (a_{ij})_{n \times n}$, in which a_{ij} expresses whether or not S_i affects to S_j directly, if yes $a_{ij} = 1$, and if no $a_{ij} = 0$. This model can deduce indirect influence from direct influence, handle a disorder pattern about the relations between each element, and put the root, middle link, result and phenomenon in order, which can be shown with graph.

The development of a region has both favourable and unfavourable aspects, including not only resources but restrictive elements as well, which can be regarded as one system and two subsystems. The analysis of the situation of the HRD is that of environment system, resources subsystem, subsystem of disasters and restrictions.

1.1 Natural environment system

$$E = (E_1, E_2, E_3, E_4, E_5, E_6, E_7, E_8, E_9)$$

in which, E_1 — geology, E_2 — landform, E_3 — climate,
 E_4 — surface water mainly the Huanghe River,
 E_5 — ground water, E_6 — soil, E_7 — vegetation,
 E_8 — animal, E_9 — ocean.

1. 2 Natural resources subsystem

Only take superior resources:

$$R = (R_1, R_2, R_3, R_4, R_5, R_6, R_7)$$

in which, R_1 — land resources, R_2 — oil and natural gas resources,
 R_3 — salt and bittern resources, R_4 — marine resources,
 R_5 — water and sediment resources, R_6 — climate resources
 R_7 — continental biological resources.

1. 3 Subsystem of disasters and restriction

Only take main restrictive elements:

$$D = (D_1, D_2, D_3, D_4, D_5, D_6)$$

in which, D_1 — tail course of the Huanghe River wandering, flooding or dry,
 D_2 — soil salinization,
 D_3 — high level and high mineralization of ground water,
 D_4 — natural disasters such as drought and waterlogging,
 D_5 — store surge, D_6 — vulnerable ecological system.

The structure matrixes $E = (e_{ij}) 9 \times 9$, $R = (r_{ij}) 7 \times 7$ and $D = (d_{ij}) 6 \times 6$, can be input to computer, then output the structure graphs of each systems through closure transmission. Finally, they are merged into a large system of environment and resources (Fig. 1).

2. Analysis of the Systematic Structure Graph

By analysing the above graph of systematic structure, we can see that:

1) The “natural environment system” is divided into two subsystems, “natural resources” and “disasters and restrictions”. The development of natural resources can improve environment and also reduce disasters and restrictions, which is a positive effect. But the action of natural disasters and restrictive elements is a negative effect, which can worsen environment and hinder the development of natural resources.

2) The “natural environment system” consists of 4 levels. The root of the environment formation is the Huanghe River and geologic condition. The Huanghe River’s sediment influences the Quaternary geology, and the geologic structure also influences the Huanghe River’s course. They jointly affect the ocean-continent structure and landform formation in this region. At the same time, marine power also influences landform types. Then, rough landform control the level of ground

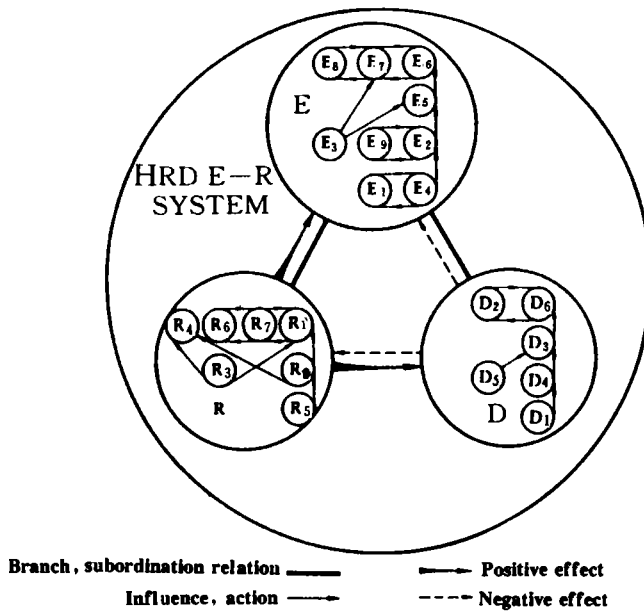


Fig. 1 Structure of environment and resources system in the HRD

water. And the level and mineralization of ground water directly influence the types of soil. The climate element is on the second level together with landform and ocean, which mainly affects vegetation and soil in this region. On the super level, soil, vegetation and animal affect each other and form a group, namely, a biosphere. It clearly shows the characteristics of the landscape of the HRD.

3) The “natural resources subsystem” includes 3 levels. The water and sediment resources of the Huanghe River plays a key role in the subsystem. It directly affects the exploitation of oil and natural gas resources and development of land resources, as well as the development of biological and climatic resources. Both oil-natural gas resources and salt-bitten resources belong to mineral resources at the same level. Of course the oil and natural gas resources hold dominant position. Both of them have natural connection with land and ocean. As the land resources and marine resources belong to two big systems, they are at the same level. But land resources, biological resources and climatic resources are relative to each other and form a group. They are commonly put into effect in development, so is agricultural resources. Fig. 1 also shows that all resources, except marine resources are relative to land resources, so land resources is the most comprehensive.

4) The “subsystem of disasters and restriction” is divided into 4 levels. The source of many restrictive elements is the Huanghe River’s tail course wandering, flooding or drying, which has greatest effect on this region. It can make drought or waterlogging more seriously. As we know, drought and waterlogging can influence the level and mineralization of ground water, frequent storm surge also raise

the level and mineralization of ground water, which make ecological environment of the region very vulnerable. Most of the land in this region have been deposited over 100 years. Moreover, the evaporation is more than precipitation, and so much salt rise up to land surface easily, which caused soil salinization. On the other hand, irrational cultivation also reduced soil fertility rapidly and caused salinization, which formed a kind of vicious circle. The structure's upper level reflects these situations.

5) From three systematic structures of E,R and D, we understand that the Huanghe River is a precursor in the forming of natural environment, especially landform formation in this region. The Huanghe River's water and sediments is a key factor of developing natural resources. Meanwhile the Huanghe River's mouth wandering, flooding or drying are important sources of unsteadiness of the great environment and ecological vulnerability. This reminds us that we must pay special attention to the harnessing of the Huanghe River mouth and the utilization of its water and sediments in regional development and territorial management of the HRD.

In E and D systems, ground water is an important middle link. Ground water is controlled by landform and affected by climate. At different landform positions and under various climate conditions, relevant modes of water-salt motion may occur, thus they influence soil types and salinization degree, then influence vegetation, which are reflected at whole landscape and ecological environment. Therefore, in order to improve salinized soil and ecological environment, we must make efforts to reduce level and mineralization of ground water by various ways, for example, building water conservancy project, completing drainage and irrigation networks, warping and raising ground surface, setting up tidal barrage to resist store surge. The above measures are really effective.

This region's land is broad and flat. The landscape feature of soil and vegetation is the result of many elements' action, and is also a mirror reflecting the quality of ecological environment. In three systems of E,R and D, Soil and vegetation are all at upper level and appear as groups, which display the close relationship of their interaction and quick feedback. In the history of the region, in order to develop agriculture, wasteland was predatorily reclaimed and farmland was extensively cultivated, which resulted in the land's salinization. Because the ecological environment is so much vulnerable, the nature's retaliation came quickly and mercilessly. We must keep these lessons in mind. So, developing action must comply with objective law. Territorial management should seek permanent benefits instead of temporary relief.

IV. CONCLUSION

To sum up what is mentioned above, the following conclusions can be drawn:

1) Environment and resources system is an entirety. All the parts and elements of the whole are interactive, intereffective, and interrestricted, which shows regional characteristics of integrated physical geography. We should study and perfect its structure with a comprehensive and systematic view so as to have a macro and overall regulation and control. Only with the superiority of the entire function can the real superiority of environment and resources be realized.

2) "Natural environment" includes two aspects, "natural resources" and "disaster and restriction". In regional development, the resources exploitation often occupies the key position, especially in such developing region as the HRD. According to the systematic structure of natural resources, oil and land resources should be exploited first. This can bring about the comprehensive development of other resources. In addition, more attention would be paid to the utilization of the Huanghe River's water and sediments resources so as to improve the conditions of developing oil, land and other resources. The region will finally be built into an oil energy base, an oil and salt chemical industrial base and bases of agriculture, animal husbandry and fishery.

3) In the territorial management of the HRD, great attention must be paid to the root, middle links, result and appearance which constitute the resources and environment of the region. The harnessing of the HRD should focus on the river's mouth, ground water, saline-alkali land and ecological fragility. The final goal is to transform and overcome the bad conditions to promote a good cycle of the environment and resources system.

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