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Assessment and exploitation of the waterfront resources in the middle and lower reaches of the Yangtze River

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Waterfront resources are important and special kind of natural resources in the marginal area between land and water. The Yangtze River, the longest river in China, is not only rich in waterfront resources, but also has favorable development conditions with great potentiality. Aided by large-scale underwater topographic map, the major factors of the waterfront resources in the middle and lower reaches of the Yangtze River, such as the stability, the water depth and the natural conditions for port construction, are assessed in this paper respectively on the basis of the overall investigations. The results show that: (1) the waterfront resources are abundant in the middle and lower reaches of the Yangtze River, but lack of perfectly combined high grade waterfront; (2) there exists an obvious regional difference in the natural quality of the waterfront along the Yangtze; (3) the fore-bank water depth and waterfront stability are the main natural factors related to the waterfront quality in the middle and lower reaches of the Yangtze River; (4) the waterfronts along the Yangtze are mainly used for port, warehouse and industrial purposes; and (5) the waterfronts near important cities are highly used, especially the high-quality waterfronts. In addition, some suggestions for the development and utilization of the waterfront resources are presented in this paper.

Assessment and exploitation of the waterfront resources in the middle and lower reaches of the Yangtze River WANG Chuansheng1, LI Jianhai2, ZHU Lidong3 (1. Inst. of Geographic Sciences and Natural Resources Research, CAS, Beijing 100101, China; 2. Lanzhou College of Education, Lanzhou 730000, China; 3. Faculty of Tourism and Resources Management, Zhejiang Normal University, Jinhua 320004, China) Abstract: Key words: CLC number: 1 Introduction Waterfront resources are important and special kind of territorial resources that combine water with land resources and take up a certain limit of space in the water and on the land (Liu, 1988; Yu, 1993; Yang, 1999; Wang, 1999). Most research on waterfront resources, both at home and abroad, sporadically appears in the relevant papers of port planning, drainage basin development and management, or rivercourse evolution and control (Wu, 1993; Zheng, 1991; Forward, 1970; Zhang, 1998; Li, 2001). The research on the waterfront resources in the Yangtze River began with an academic master dissertation finished by Yin Guoxing in 1991, which is entitled "The suitability appraisal for port building of the waterfront resources along the Yangtze River in Jiangsu province". With the construction of industrial zone of the Yangtze River, the researches on the waterfront resources of the Yangtze River have spread from the assessment and development of waterfronts for the purpose of port utilization (Cheng, 1995; Yang, 1999; Ou, 1999) to the survey, evaluation and utilization of waterfront resources by means of remote sensing and GIS (Yu, 1997; Yang, 1998; Cheng, 1996; Anhui, 1996), as well as methodologies for assessing waterfront resources (Huang, 1999; Huang, 2001; Wang and Sun et al., 2002). Moreover, most of them are on the lower reaches of the Yangtze River with high level development of waterfront resources. As the longest river in China, the Yangtze River not only has rich waterfront resources, but also owns favorable development conditions and great potentiality. Due to the extensive construction of the industrial zone along the Yangtze Valley, the waterfront resources here are further developed and used, moreover, the ecological protection in the Yangtze River Valley and the waterfront resource protection of the Yangtze has become increasingly important. An overall assessment and research on waterfront resources of the Yangtze River should be carried out for implementing the rational distribution and effective protection of waterfront resources along the Yangtze River. In this essay, the essential features and the suggestions for development of the waterfront resources in the lower and middle reaches of the Yangtze River (from Yichang to the Yangtze River´s mouth, excluding Shanghai section), the mainstream with highly exp

loited waterfronts and great development potentiality, will be presented on the basis of the integrated assessment. 2 Methodologies and index system of assessing waterfront resources The assessment here is divided into two steps: Th e first step is to appraise the stability and water depth conditions of waterfront resources. Along Yichang-Xinji Tow head riversection, the waterfront resources can be divided into three categories mainly according to their water dept h: (1) the deep waterfronts, with 100-200 m in fore-bank (the strip of land in front of the bank) water extent and ov er 10 m in depth; (2) the mid-deep waterfronts, with 100-200 m in fore-bank water extent and 5-10 m in depth; and (3) the shallow waterfronts with 100-200 m in fore-bank water extent and less than 5 m in depth. The assessment crite ria for the waterfronts along the riversection down Xinji Towhead are a little different from the ones above: (1) th e deep waterfronts, with 200-300 m in fore-bank water extent and over 10 m in depth; (2) the mid-deep waterfronts, wi th 200-300 m in fore-bank water extent and 5-10 m in depth; and (3) the shallow waterfronts, with 200-300 m in fore-b ank water extent and less than 5 m in water depth. The assessment for waterfront stability should be based on the lar ge-scale water depth map, as well as the on-site inspection of river course characteristics (such as curvature, wate r current variety, and bank slope) and the marginal conditions. Generally speaking, the waterfronts are steady along the bank with rocky mountain nearby or along a straight, a little curved riversection with no branches and the rivers ection with pairs of branches. Eroding waterfronts are usually located along steep concave riverbank being scoured, a nd silting-up waterfronts along the bank with a gentle slope and several beaches. The second step is to determine th e grade of waterfront resources based on four natural factors for port construction, such as fore-bank water depth, w aterfront stability, fore-bank water extent and land area at the rear of the bank. By the large-scale topographic ma p of the Yangtze River´s course and GIS, the waterfronts are divided into four grades according to the combinations o f the factors mentioned above: grade I, suitable for construction of port with a tonnage of 5,000-10,000 t; grade I I, suitable for construction of port with a tonnage of 3,000- 5,000 t; grade III, suitable for port with a tonnage o f 1,000-3,000 t; and grade IV, unsuitable for 1,000 t port construction (Wang and Sun et al., 2002). The assessment r esult is shown in Figure 1. 3.1 The essential features of waterfront resources in the middle and lower reaches of th e Yangtze River It is indicated in the assessment result that there exist some essential features of waterfront resou rces in the middle and lower reaches of the Yangtze River: 3.1.1 Waterfront resources are abundant, but lack of high grade ones with good combination conditions The total length of the waterfronts is 3,523.2 km in the middle and lowe r reaches of the mainstream of the Yangtze River, of which 1,804.6 km is for the left riverside, 1,718.6 km for the r ight riverside (measured on the large-scale underwater topographic map according to the riverbank). The longest part is in Hubei province, accounting for 44.9% of the total assessed (Table 1). The combined conditions of the deep water fronts and the stable waterfronts of 23 river sections along the middle and lower reaches of the Yangtze River are co mpared, of which the abscissa refers to the proportion of the deep waterfronts and the ordinate refers to the proport ion of the stable waterfronts (Figure 2). As is shown in the figure, two towns of Taizhou and Huangshi, which have bo th high proportions of stable and deep waterfront resources, are on the top right of the figure. There are eight town s with better waterfront stability, such as Jiujiang, Wuxi, Chizhou, Yichang, Echeng, Wuhu, Suzhou and Wuhan in the u pper left corner. Over half of the districts or towns (amounted to 11) lying in the lower left corner of the figure i ndicates that the waterfront resources in the middle and lower reaches of the Yangtze River are mediocre in view of t he water depth and the stability. The river sections with better quality of waterfront resources in terms of water de pth and stability are Yichang, Huangshi, Xisaishan- Qizhou, Dashuxia-Hukou, Pengze, Tongling, Wuhu, Nanjing-Zhenjian g, Cheng- tonghe and Nantong. The assessment result based on four natural factors of waterfronts for port constructio n shows that grades I, II, III and IV of waterfronts are 358.9 km, 748.7 km, 729.5 km and 1,686.2 km long respectivel y, which account for 10.2%, 21.2%, 20.7%, and 47.9% of the total length of the regional waterfronts separately. Amon g them, grades I plus II of waterfronts are 31.4%, less than 1/3 of the total, and grade IV of waterfronts are close to the half. That is to say, the high grade waterfronts suitable for port construction are limited in quantity, and m ost of the waterfronts need protection and management. 3.2 Regional difference in natural quality of the waterfronts along the Yangtze River is obvious The waterfronts at right riverside, either in the depth condition or in the stabil ity terms, are better than the ones at left riverside in the Yangtze River. It is mainly due to the influence caused by the deflection force of earth rotation that makes the right bank washed up and the left bank silted up. As a resul t, the favorable position of the right bank backing by the rock hills makes it more stable, whereas the accumulated a lluvial deposition on the left bank makes it more fragile owing to the constant change of silting. It is favorable t o the overall exploitation of the waterfront resources under the condition of strengthening protection of the left wa terfront. In addition, most goods flowing in harbours of the Yangtze River are supported by the goods from northern C hina, the energy base areas. The inharmonious distribution of the warterfronts along the Yangtze River is reflected w

ith the goods distribution resulting from differences of natural conditions in waterfront resources at the left and t he right riversides. The regional difference in natural quality of waterfronts between the provinces also shows clear ly, especially between the provinces located at the upper and the lower sides of Xinji Towhead. Jiangsu section occup ies 24% of the total amount and 42% of grades I and II of the waterfront resources along the middle and lower reache s of the Yangtze, but has 36.2% of the deep waterfronts, 26.9% of the stable waterfronts and 68.8% of grade I of the waterfronts. In terms of the regional distribution in districts or towns, grade I of waterfronts is mainly distribute d in the following districts or towns, such as Taizhou, Nanjing, Suzhou, Zhenjiang (all belong to Jiangsu Province), Jiujiang, Wuhu, Wuhan, and Huangshi. The eight districts or towns mentioned above own 78.7% of the total amount of gr ade I of the waterfronts along the middle and the lower of the Yangtze River. Grade II of waterfronts is mainly distr ibuted in Jingzhou, Nanjing, Wuhan, Chizhou and Anqing, which own about 49.3% of the total amount of grade II of wate rfronts. 3.3 Fore-bank water depth and waterfront stability constitute the main natural factors restricting waterfron t quality in the middle and lower reaches of the Yangtze River The waterfront resources with low stability or with in adequate water depth in the middle and lower reaches of the Yangtze account for 63.6% and 62.7% of the total respecti vely. The ones whose fore-bank water extent does not match to the water depth and prevent the relevant waterfronts fr om being evaluated to a higher grade are 602 km in length or 17.1% of the total, and the ones whose quality is limite d to the land extent are 373.2 km or 10.6% of the total amount of waterfront resources. The restrictive factors are d ifferent between the river sections. It is shown that the main restrictive factor is the water depth in the river sec tion above Xinji Towhead, and in the river section below Xinji Towhead, the waterfront stability is the main restrict ive factor. However, restrictions of the four factors mentioned above are getting weak and weak from the river sectio n above Xinji Towhead to that below Xinji Towhead (Table 2). In addition, the land extent of waterfronts in Jiujiang-Xinji Towhead section has more restrictions than the section above and below Xinji Towhead. 3.4 Port, storage and ind ustry are the main utilization of the waterfronts along the Yangtze River According to the statistics (Table 3) offer ed by the Habour Bureau, the waterfronts are mainly used for habours in Yichang-Xinji Towhead section and the length is 116.4 km, 52.2% of the total waterfronts in use. In Jiangsu section, based on the investigations of waterfront uti lization in 1997, the main utilization of waterfronts is for storage and habours, the waterfronts for these kinds of utilization respectively account for 39.5% and 37.0% of the total in use. 3.5 Waterfronts near important cities are h ighly used, especially the high-quality waterfronts The average utilization rate of the waterfronts along the middle and lower reaches of the Yangtze River is 9.80%, but the utilization rate of the high-quality waterfront is up to abo ut 20% (strictly speaking, 18.85% for the better waterfront in water depth, 20.94% for grades I and II waterfronts su itable for port construction.) The important cities usually have a high utilization rate (over 10%) of the waterfront s, especially of the high-quality waterfronts. The utilization rate of the cities with few waterfront resources, suc h as Huangshi, Wuhu, Wuxi, and Changzhou, is up to 20-30%. In some cities, such as Tongling, Suzhou, and Wuhan, thei r utilization rate of the high-quality waterfront is up to 30-50%; and for Huangshi, Wuhu, and Wuxi, it is even over 50%.. 4 Suggestions for the development and utilization of waterfront resources 4.1 Suggestions for the development o f the waterfront resources along the Yangtze River 4.1.1 Strengthening communication and cooperation between the nort h and the south riverbanks of the Yangtze River Owing to the obvious waterfront difference between various districts or towns and the unmatching of main input goods flow between different habours, the limited waterfront resources alon g the middle and the lower reaches of the Yangtze River must be developed by the north and the south riversides toget her on the basis of management and protection. The communication and cooperation between two riversides rationally co mbines the resource advantage with the shipping advantage. As a result, it breaks down the barriers between two river sides that exist for a long time and surely benefits the economic development of both riversides and the whole Yangtz e River Basin. 4.1.2 Implementing the overall protection and management of waterfront resources The number of high qu ality grade of waterfront resources is limited in the middle and the lower reaches of the Yangtze River, most of the waterfronts have 1-2 restrictive factors, a lot of waterfronts can only meet the demand for 1,000 tonnage port constr uction. The exploitation of these shallow waterfronts should be carried out following the principle of stabilizing ri ver course. It is inappropriate to create the so-called conditions for building ports without a comprehensive conside ration of their natural restrictive conditions, otherwise there would be no benefits at all after the completion of t he port construction and changes of the river course and degradation of the waterfront resources would be resulted a s well (Wang, 1999). Therefore, the prerequisite of waterfront resources development is to manage the important port s and urban waterfronts on the basis of the overall protection of waterfront resources. 4.1.3 Following the principl e of waterfront utilization according to areal cooperation and development of the waterfront resources step by step W ith the integration being strengthened between the north and south riversides, cooperation between various areas in w

aterfront resources development is necessary because of the regional difference in waterfront quality. The main development riversections or utilization ways should be determined for the higher level of areas or a certain riversection according to the actual circumstances. The administrative barriers should be broken down and the cooperation be strengthened so that the waterfront resources are exploited selectively, step by step, stage by stage and sustainedly.

4.1.4 Strengthening the information-based management of waterfront resources along the Yangtze River The inland waterfront resources, a kind of important natural resources, not only facilitate the transportation and port construction but also play an important role in protecting the river. The waterfront resources should not be developed for a unitary production project, but be given a comprehensive consideration of the utilization with ecological, social and economic benefits. As a result, it is necessary for the management authorities of the river basin to have a clear understanding of the whole state of waterfront resources, such as the water depth, stability conditions, natural conditions for port construction, development conditions, etc. The foundation of the information management system for waterfront resources will be greatly useful for the efficient management of the waterfront resources of the Yangtze River.

4.2 The main exploitation section of the waterfronts along the middle and the lower of the Yangtze River in the main utilization ways According to recent allocation of production of the Yangtze River Basin, the main river sections of the waterfront resources in the middle and the lower reaches of the Yangtze River for development should be the ones undeveloped and located near the important harbours and the larger towns. As space is limited, only the main development sections for the waterfront utilization of port, industry and storage are presented here (Table 4). 5 Brief summary The waterfront resources along the Yangtze River are a kind of natural resources important for both ecology and resources. It is essential for their sustainable use to stress on the protection while exploiting them. The utilization ways involved here are far from enough in meeting the needs of the sustainable utilization of waterfront resources. Both utilization ways for production and for daily life, recreation, protection, or harnessing are absolutely necessary for the continuous exploitation of waterfront resources. The latter ways mentioned above are essential to the rational distribution and the functional classification of waterfront resources. In this sense, the study here is only a beginning in studying waterfront resources. References

关键词： the middle and lower reaches of the Yangtze River; waterfront resources assessment; exploitation and utilization; suggestion

