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Water resources optimization and eco-environmental protection in Qaidam Basin

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Abstract: In order to realize sustainable development of the arid area of Northwest China, rational water resources exploitation and optimization are primary prerequisites. Based on the essential principle of sustainable development, this paper puts forward a general idea on water resources optimization and eco-environmental protection in Qaidam Basin, and identifies the competitive multiple targets of water resources optimization. By some qualitative methods such as Input-output Model & AHP Model and some quantitative methods such as System Dynamics Model & Produce Function Model, some standard plans of water resources optimization come into being. According to the Multiple Targets Decision by the Closest Value Model, the best plan of water resources optimization, eco-environmental protection and sustainable development in Qaidam Basin is finally decided.

Water resources optimization and eco-environmental protection in Qaidam Basin FANG Chuang-lin1, BAO Chao2 (1. Institute of Geographic Sciences and Natural Resources Research, CAS, Beijing 100101, China; 2. Dept. of Geography, Peking University, Beijing 100871, China) During the development of Qaidam Basin, which is an arid area in Northwest China, rational water resources utilization and optimization are primal prerequisites, and the main restrictive factors include the following facts: scarcy water resources are non-substitutional and uneven distributed in time and space. Based on the essential principle of sustainable development, this paper adopts Multiple Targets Decision by the Closest Value Model, and succeeds in getting the best plan, which can optimize water resources, protect eco-environment, and develop Qaidam Basin continuously. 1 Design thinking of water resources optimization and eco-environmental protection in Qaidam Basin Water resources are relatively rich in Qaidam Basin now, but in the future, they will be inadequate, because the total quantity of water utilization will rapidly increase during the development of Qaidam Basin. In this connection, water resources optimization of Qaidam Basin is put forward and such principles must be followed: the development must be sustainable; ecological and daily water utilization must be guaranteed first; and the benefit of water utilization must be the best. According to those three principles, the following subjects are the main problems to be solved: 1) How to combine the macroscopic economic system and water resources system in Qaidam Basin. The strategy of water resources optimization, which mainly aims at the sustainable development of regional PRED, should be carefully explored, and the relationship between multiple targets should be quantitatively revealed. 2) How to reveal the relationship between the input and output of the economic departments, and the benefit of water utilization according to the analysis of input and output of Qaidam Basin's macroscopic eco-departments, and System Dynamics Stimulated Model. Besides, the development and eco-environment of Qaidam Basin, which are corresponding to each plan of water resources optimization, need forecasting and an early warning. 3) How to analyze the balance of Qaidam Basin's water resources supplies and demands according to different optimization models and economic development models. According to Multiple Targets Decision by the Closest Value Model and other mathematic models, all kinds of balance relationships on water resources optimization can be analyzed, and how different optimization plans have effects on different regions and departments of Qaidam Basin can be revealed. In order to solve such problems, the core of water resources optimization in Qaidam Basin is to find the rational structure between agriculture, forestry, animal husbandry and industry. According to this, Figure 1 illustrates the general idea of water resources optimization in Qaidam Basin. According to the essential principle of choosing the best target and the regional macroscopic economic system and water resources system, some targets called Gi are chosen. By some qualitative methods, such as Input-output Model, AHP M

odel and Experts Seeking Counsel Method, plan 1 (high plan, called A1), plan 2 (middle plan, called A2) and plan 3 (low plan, called A3) are obtained. And then, plan 4 (high plan, called A4), plan 5 (middle plan, called A5) and plan 6 (low plan, called A6) are gotten by some quantitative methods such as System Dynamics Model, Economy Measure Model, Produce Function Model and so on. From those six plans, a plan aggregation of water resources optimization that is called {Ai} forms. Based on the target aggregation {Gi} and the plan aggregation {Ai}, and supported by Excel and DSS (Decision Supporting System), the best plan form {Ai} can be decided by Multiple Targets Decision by the Closest Value Model. That is just the best plan of water resources optimization in Qaidam Basin. 2 The process of how multiple competitive targets identification with water resources optimization and multiple plans in Qaidam Basin forms 2.1 Identification of the competitive targets of water resources optimization and eco-environmental protection Which competitive target of regional water resources optimization to choose has a direct effect on the result of water resources disposition. According to the principle of sustainable development, the following four targets of water resources optimization in Qaidam Basin should be included: 1) Target of economic development. As Qaidam Basin is undeveloped at the present time, three quotas can be chosen to show economic development, such as per capita GDP (Gross Domestic Production) (G1), per capita agricultural output value (G2) and per capita meats production (G3). 2) Target of the structure of water resources optimization. According to the principle of system analysis, after the rational structure of water utilization in Qaidam Basin is decided, the maximal value of output corresponding to certain water utilization can be gotten if the quantity of water utilization is unchangeable. Besides, the total quantity of each trade's water utilization is equal to the total quantity of water utilization, and water utilization follows plan 1, so the target of structure optimization can be decided. 3) Target of the resources restraint and the utilization benefit. Target of the resources restraint means that the total quantity of water utilization should be limited, and that it must be lower than the water resources supporting capacity. So the total quantity of water required (G7) is taken as the regressive target of water resources optimization, and it will be better if G7 is smaller. Per cubic meter water GDP (G4) is taken as the direct object to show the benefit of water resources optimization. 4) Target of eco-environmental protection. According to the principle of guaranteeing ecological water utilization first, the area of both woodland and grassland that needs to be irrigated (G5) is taken as the target of eco-environmental protection. In Qaidam Basin, waste water pollution is the main pollution whereas waste gas and dregs pollution has less effect. So the discharge capacity of waste water (G6) is taken as the regressive target to show environmental pollution in Qaidam Basin. Figure 1 The general designing idea of water resources optimization and sustainable development in Qaidam Basin To sum up, the competitive targets of water resources optimization in Qaidam Basin include the following seven targets: per capita GDP (G1), per capita agricultural output value (G2), per capita meats production (G3), per cubic meter water GDP (G4), area of woodland and grassland (G5), discharge capacity of waste water (G6) and the total quantity of water required (G7). In 1998, G1=6224.57yuan/person, G2=3284yuan/person, G3=17.49kg/person, G4=3.51yuan/m3, G5=26.35×104ha, G6=5.71×1010kg, G7=7.06×108 m3. Those seven targets are competitive and conflicting. If one object's value increases, the others' values may decrease correspondingly. So the best plan of water resources optimization should be the plan with minimum target conflicts. Table 1 The forecast values of multiple targets on macroscopic economic development and water resources optimization in Qaidam Basin Note: GDP--hundred million yuan, G1—yuan/person, G2—kg/person, G3—yuan/m3, G4—104 ha, G5—104 ton, G6—104 m3. 2.2 The process of how the standard plans of multiple targets decision on water resources optimization and eco-environmental protection forms 1) By some qualitative methods such as Input-output Model and AHP Model, we can get standard plans from A1 to A3. According to the total design thinking, the prerequisite of using Input-output Model to forecast the development of economy is that input and output coefficients are stable or it will have a stable regularity if they change. But from the input-output table of Qinghai Province in 1992 and 1998, we can see that the input and output coefficients of each industry in 1998 differ greatly from those in 1992. The changeable ratios of many trades' direct consuming coefficients surpass 40%. Among them, the changeable ratio of oil and natural gas mining industry's direct consuming coefficient to that of the secondary industry reaches 844.92%. According to the input-output table of Qaidam Basin, the total consuming coefficients and increased value coefficients of many departments are relatively stable. So we can forecast the total value of product according to the model if we know the increased value, or forecast GDP if we know the total value of product. For example, in 1998, the total consuming coefficient of the primary industry in Qaidam Basin was 0.296, that of the secondary industry was 0.645, and that of the tertiary industry was 0.477. And the increased value coefficients were 0.704, 0.355 and 0.523 correspondingly. According to this, the increased value of the primary industry can be calculated, so can that of the secondary and tertiary industries. In Qaidam Basin, over 80% of the main trades' investments come from Qinghai Province and the central government, and over 90% of production equipments come from other regions. So we must thin

k over exterior conditions when we forecast the development of macroscopic economy in Qaidam Basin. According to Input-output Model, Analysis of Circumstances, AHP Model, Experts Seeking Counsel and Field Investigation Method, the scale of the development of Qaidam Basin's macroscopic economy from 2001 to 2050, the quantity of water required by all departments, and the plan of multiple targets on water resources optimization can all be obtained. The result from A1 to A3 can be seen in Table 1. 2) By some quantitative methods such as System Dynamics Model and Production Function Model, some standard plans can be gotten from A4 to A6. According to the essential principle of System Dynamics Model, the total system can be divided into six subsystems, including population, water resources, agriculture, industry and tertiary industry, environmental pollution and GDP. And according to the principle of decomposing system coordinately, those six subsystems can be divided into twelve modules, including population, water resources, cultivated land, per unit area yield of food, industry, building industry, trade, transportation industry, waste gas pollution of industry, waste water pollution of industry, waste dregs pollution of industry and GDP. Those twelve modules affect each other and make up a flow diagram of causality that has multiple feedback loops. Based on the flow diagram of causality and the relational data from 1986 to 1998, a System Dynamics Model supported by the software of Professional DYNAMO Plus is set up. Its target is to realize water resources optimization and the sustainable development of Qaidam Basin's PRED. This model is made up of 12 stative variables, 16 speed variables, 242 auxiliary variables and constant equations. And 9 parameters that have a dominant effect on the intersection of the main feedback loops and the sectional feedback loops are chosen. Those 9 parameters include coefficient of migration (EQR), structure of investment, structure of labor force, quota decline coefficient of water utilization that the industry's value of production is over 10000 yuan (WJL), coefficient of reclaiming wasteland that is suitable to agriculture (NNDKL) and coefficient of reaching a standard of draining of waste water from industry (FSPDL). Then, those 9 parameters are taken as the controlling parameters to have experiments. Finally, A4 (high plan, or plan for economic development), A5 (middle plan, or plan for coordination) and A6 (low plan, or plan for protection) can be obtained. A4 takes economic development as the main object. A5 pursues the sustainable development of regional PRED. However, A6 attaches importance to resources and environmental protection. From Table 1, A4, A5 and A6 can be recognized easily. 3 Analysis of the best choice according to Multiple Targets Decision by the Closest Value Model of water resources optimization and eco-environmental protection in Qaidam Basin 3.1 The essential principle of Multiple Targets Decision by the Closest Value Model of water resources optimization Suppose there are n targets such as G1, G2, G3, ..., Gn-1 and Gn and m plans such as A1, A2, A3, ..., Am-1 and Am to decide. Corresponding to the target Gi, the plan Ai is equal to aij. And aij is the main basis of the decision. Then a rectangular array (A) can be obtained, which is the target rectangular array of A i concerning Gi. Usually, targets can be divided into direct targets and regressive ones. In order to calculate easily, the regressive targets can be changed into direct ones. Suppose: Then a standard rectangulary array ® is obtained: And AI=(ri1, ri2, ..., rin)(1-1,2,...,m) can be taken as "the decision point". To get the best plan, suppose: AY stands for the best point of the plans from A1 to Am, and AL stands for the worst point. To get the best plan, the decision point that is close to AY and far off AL as possible is chosen from {Aj}. The distance from Ai to AY is called DYL and that from Ai to AL is called DAL. And stands for the power of the target Gj., and Cai is called the closest value of Ai. It can show how Ai is near A+ but far off A-. To the plan aggregations that are not bad, d+¹ O, , , the n, , then: CAi³ O While, , CAi=O and Ai is closest to the best point A+. While CAi >O, Ai is far off the best point, and Ai will be further off A+ if CAi is larger. So the best plan, which CAi is the smallest, can be decided according to the arrangement of CAi. 3.2 Result and evaluation of the best standard plan of multiple targets decision concerning regional sustainable development and water resources optimization According to Multiple Targets Decision by the Closest Value Model, the target rectangular array of water resources optimization in Qaidam Basin has 6 horizontal rows and 7 straight columns. Supported by the software of Excel, the results of CAi in 2000, 2010, 2020 and 2050 can be obtained. Then, the corresponding code of the best plan can be seen from Table 2. And Table 3 illustrates the plans of the macroscopic economic development and water resources optimization in Qaidam Basin corresponding to the best plans' codes of each year. Table 2 The closest values of multiple targets decision on water resources optimization and eco-environment protection in Qaidam Basin from 2000 to 2050 Table 3 The quantity of water required and the structure of water utilization supported by the best plan of water resources optimization and eco-environmental protection in Qaidam Basin (108m3, %) Note: Q--Quantity of water required; S--Structure According to the analysis of the contrast between Table 1 and Table 2, the following conclusions concerning water resources optimization and eco-environmental protection in Qaidam Basin can be arrived at: 1) Supported by the best plan of water resources optimization, it can be seen that Qaidam Basin will pursue regional sustainable development instead of rapid economic growth. By the year 2010, the strategy of developing West China will be carried out. The resources exploitation in Qaidam Basin will co

me to a new climax. Regional policy-makers and investors from other regions will concentrate their efforts mainly in the economic development, but ignore the protection of resources and environment. So, from 2000 to 2010, the best plans ' codes are all A1 (high plan). From 1995 to 2010, the Qaidam Basin 's GDP will be 78.07×108yuan, instead of 24.78×108yuan. The average of increasing speed will maintain over 7.95%. In these 15 years, the total quantity of water required by every economic department will be 13.96×108m3 instead of 7.22×108m3. The average increase rate will be 4.55%. After 2010, the best plans will all be A5, because Qaidam Basin will be developed and the protection of resources and environment will be attached great importance to. At that time, the growth rate of economy will be less than 6.89%, and the total quantity of water required will be 21.89%×108m3 in 2050 instead of 13.96×108 m3 in 2010. Though the total quantity of water required goes up, the average increasing rate will drop to 1.13%. This is the result of resources protection, water saving and improvement in efficiency of water utilization. 2) Supported by the best plan of water resources optimization, the structure of water utilization will be rationalized. Table 3 illustrates this kind of tendency. The main manifestation can be seen as follows: (1) The proportion of industrial water utilization will increase continuously. In 1995, it was 6.91%, but in 2020, it will be 16.43%. However, in 2050, it will reach 26.59%. As Qaidam Basin is entering into the mid-term of industrialization instead of the initial stage, a more rational structure and a better benefit of water resources optimization will be pursued. (2) The proportion of water for daily use will increase slowly. In 1995, it was 2.60%, in 2020, it will be 3.03% and in 2050, it will reach 3.73%. (3) The proportion of agricultural water utilization will go down rapidly. In 1995, it reached 90.49%, but in 2020, it will decrease to 79.97%, and in 2050, it will be 68.30%. Among all trades of agriculture, the proportion of water utilization for farming will go down. It will be 41.10% in 2050 instead of 59.98% in 2000. However, the proportion of water utilization for forestry and meadow industry will increase continuously. 3) The best plan of water resources optimization in Qaidam Basin is more rational and satisfying than the second-best one and the worst one. From the former part of this paper, it can be seen that the best plan of water resources optimization in Qaidam Basin will change regularly, and that the regularity can be described by " A1--A1--A5--A5 ". This illustrates that Qaidam Basin will pursue the sustainable development of regional PRED instead of high-speed economic development. This is just the target of Qaidam Basin 's development. So the result can be satisfactory. Contrasting to the best plan, the second-best one that will change irregularly can be described by " A2--A5--A1--A6 ". In other words, the second-best plan will first pursue regional sustainable development, then high-speed economic development, and finally resources and eco-environmental protection. However, the worst plan after 2050 is primarily A3. According to A3, the scale of the macroscopic economic development and water resources utilization in Qaidam Basin is especially small. The quantity of Qaidam Basin 's GDP will be only 526.62×108 yuan in 2050 and its average speed of increase will be only 5.71%. The total quantity of water required will be only 15.98×108 m3 and its average speed of increase will be less than 1.45%. In a word, A3 is a plan of bad benefit that excessively pursues resources and eco-environmental protection, and it doesn 't fit in with the requirement that Qaidam Basin will come to a new climax of resources exploitation and will pursue regional sustainable development. So A3 is gotten rid of as the worst one from all the reserve plans. References

关键词： water resources optimization; Multiple Targets Decision by the Closest Value Model; eco-environmental protection; Qaidam Basin

