

An Ecological Management Model of Sustained Environment in Arid Settlement of Downstream Shiyang River Basin

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Abstract — This paper explores ecological management of sustainable environment in arid settlement of Downstream Shiyang river basin. We study ecological evolution and tracking of venation to: i) analyze quantitatively the evolution mechanism and venation of ecological environment in different periods of settlement, ii) dissect the issue of ecological management in recent settlements, and iii) propose sustainable development model. The results show that ecological conservation mainly relies on: i) two natural river barrier in east (BaiTing river) and west (Daxi river), and ii) protection effect of rump lake in Minqin oasis. Because of frequent uncontrolled activities of the population in the upper and middle basin of Shiyang river, as well as taking too much from natural resources and energy, the arid area of its downstream faces: i) the reality of drying up of natural lakes, ii) vanish of rump lake, and iii) deterioration of ecological environment. In this paper, the author proposes the Daxi river output model and ecological management model.

Keywords- Shiyang river basin; Settlement environment; ecological evolution; sustained development; management model.

I. INTRODUCTION

Settlement refers to the places human inhabit and centre where human carry out activities, including rural and city. The settlement environment is the living environment which is created by human transforming purposefully, which is most closely and directly related to the human production and life[1]. In the arid desert area place, as the place for human survival and development, dryland settlements is the urban– rural inhabitation system formed by The long-term water diversion transformation and construction based on the natural oasis and desert. Shiyang river is one of the arid inland river in Northwest China, located at the eastern end of the Hexi Corridor in Gansu Province. Drainage area is 41600 km², including Liangzhou district, Gulang county, the entire Minqin county in Wuwei City, and Yongchang County, the entire Jinchuan district in Jinchang city. The Qilian mountains, Wuwei basin and Minqin County are located at the upstream, the middle and the lower reaches of the river, respectively[2]. Because of frequent uncontrolled activities of human beings in the upper and middle basin of Shiyang river, as well as taking too much from natural resources and energy, the arid area of its downstream faces the reality of drying up of natural lakes, vanish of rump lake, and also shrinking of the proportion of oasis. The environmental and ecological situation becomes more and more severe. Under the support of our government, the Shiyang river Management Project is carried out, so the microclimate and ecological environment is modified a lot. But there are still some problems in studying and exploring in aspects of ecological water utilization input and the groundwater

recharge process. This paper focuses on the following three problems: (1) The evolved mechanism and venation of ecological environment in different periods of settlements; (2) Ecological management and problem analysis in recent settlement; (3) Sustainable mode of ecological governance in settlements.

II. RELATED WORK

Minqin settlement as the one of the typical desert oasis at the downstream of Shiyang River is surrounded by the Tengger Desert in northeast and by Badan Jilin desert in northwest, respectively, in the middle of which narrow and flat oasis belt is formed under the impact of the river washing. According to the Minqin County records, during more than 200 years since the beginning of nineteenth century, the desert had embezzled 260000 acres of farmland and villages more than 6000 villages [2]. The Triangle city ruins of the han dynasty and the Lian city of tang dynasty has been hid deep in the desert up six kilometers away (Figure 1)[11]. The excessive concentration of population, uncontrolled human activities and excessive extortion of resource and energy from nature made the rivers be dried up, the terminal lakes disappear, which led to the deterioration of the ecological environment of Minqin settlement. The vegetation was withered. The aggravation of desertification, salinization, plummeting water table and rise of mineralization had adverse effect to the survival of part of the masses in the northern settlements. They were forced to abandon land and leave their hometown, and became “ecological refugees”, “Lop Nor” phenomenon has been revealed in the local region [3]. This phenomenon has

attracted national attention. Premier Wen Jiabao has instructed repeatedly: "never let Minqin become the second Lop Nor!" Under the high attention of the prime minister and support of governments, Shiyang River basin comprehensive management was promoted to national engineering. It is vital to making objective analysis, finding out the existing problems, and propose the corresponding measures in order to promote the ecological restoration of settlement environment in Shiyang River basin[11].

Data is collected mainly relying on spot investigation, including referring to historical files in study area, exploring watershed runoff sites in settlement, observing recent changes of basin management, surveying the number of people on each settlement over the years, and the changes on farmers' living style (the methods of farming and irrigation, the survival scope of settlement cut) to extract the relevant data and graphic data of spatial distribution in different periods. At the same time, we also have some predecessors' research results in field survey, such as Mr Feng Shengwu [3] on water system evolved from prehistoric to late Ming and early Qing dynasty in Minqin oasis. So it is beneficial to identify the authenticity, to improve reliability comparing the survey data with predecessors' achievement.

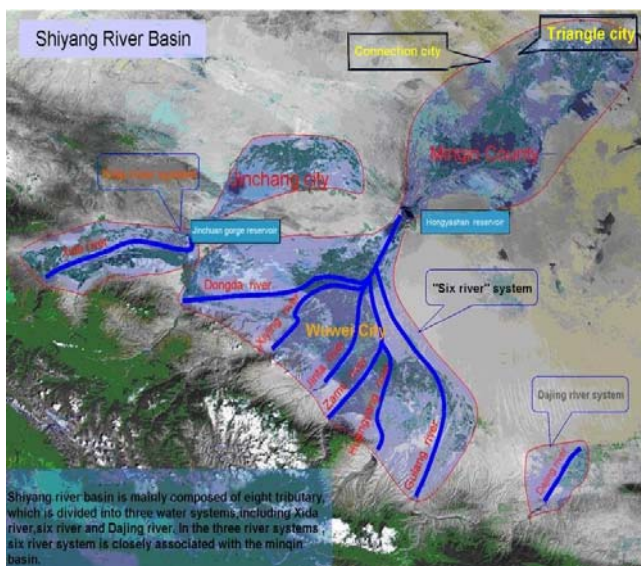


Figure 1. The status chart of Shiyang River Basin.

In this paper, the author mainly used the method of ecological evolution to analyze evolution mechanism of ecological environment in study area, and to diagnose evolved venation based on data comparison of the ecological environment evolution in different periods. At the same time, the method of tracking venation is used to dissect ecological management situation in recent settlements, to find the cause of poor governance, and also to discuss and build management mode of sustainable ecology on settlements' environment.

III. ANALYSIS OF RESULTS

A. The ecology drift of basin settlement

In the prehistorian, the Minqin basin was called "ancient Yezhuze lake" with more than one hundred kilometers length and tens of kilometers width. Withdraw of inflow and silting, the ancient Yezhuze lake was separated into east and west part, and then continues to shrink into several small lakes. During 1360s-1840s, the downstream of Shiyang River was divided into Daxi River and Baiting River, and formed two terminal lake: Qingtu Lake and Baiting Lake (Figure 2)[4]. Till the end of 1890s, the Baiting River and Baiting Lake were vanished, and all the rest of Mingqin basin became bogs or wet lands except Dajing River and Qingtu Lake. At the beginning of the 20th century, Qingtu Lake, the terminal lake of Shiyang River was about 120 square kilometers, reedy and rippling. Following the growth of population and the development of irrigated agriculture in the Minqin basin the water area of Qingtu Lake kept on shrinking. During the late 1940s, the water area was only 70 square kilometer. In the 1950s, the water area shrunk faster[4]. In 1959, with construction of Hongyashan dam, the inflow of Daxi River was cut off, making the Qingtu Lake dried up (figure 3).



Figure 2. Simplified Constitution of Solid-plug Conveying Element.

Minqin settlement is traditionally "seeking water and earning their livelihoods", which makes settlement be distributed along several oasises in Shiyang River basin, and the development of village is based on the water. The boundary between oasis and desert in the settlement is defined in terms of the water. As the sayings goes, where there is water, there is oasis, otherwise consequent desert is formed. By studying the evolution of the Shiyang River basin, the main reason why Minqin oasis acts like a wedge to insert between Badain Jaran Desert and Tengger Desert is the barrier effect of Baiting River and Daxihe River (figure 2). Through the water supply the underground water by the

two nature river, kilometers of the woods growth belong the river, which protects the basin settlements. However, the development of economic and more and more frequent human activity, such as water conservancy, over-development of irrigation, replacement for the natural water system by artificial water system, resulted in the nature river drying up. Construction of Hongyashan Dam destroyed the downstream which originally connected the Shiyang river (figure 3). Since then, the protection of Daxi River and Qingtu lake was completely lost. Consequently, settlement oasis shrank rapidly, and the ecological environment deteriorated.

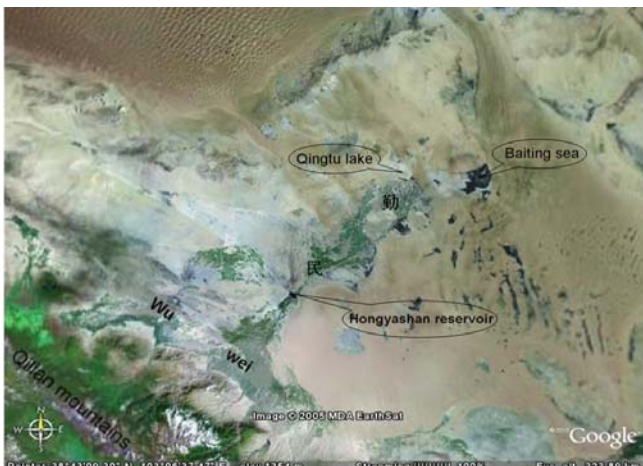


Figure 3. Shiyang River Basin in the 21st century.

B. The progress of basin settlement ecological management

The ecological crisis of downstream settlement in Shiyang river basin has drawn nation attention seriously. Since 2008, the national government and local government together has renovated the environment of Shiyang river basin. They increased the water delivery to Hongyashan reservoir. During the water distribution, not only the problem of water for irrigation is resolved, but the water delivery to Qingtu lake is taken into account. In 2010, 12.9 million m³ of water supply for Qingtu lake and finally up to 8.6 million m³ into the lake made more than 3 km² of water area be formed [5], and the lake was revitalized after 50 years of shrink. In 2011, 180 million m³ of water to supply for the lake and up to 12.6 million m³ into the lake made 10 km² of seasonal water area be formed. The 3.6 million m³ of water in the lake was released to the lake forest, and 7.67 km² of desert forest is irrigated. [6]. During 2012, keeping on supplying water to the lake made the 50-years-dried-up lake had 10 km² of stable water area, and the ecological environment deterioration of Qingtu Lake has been initially restrained. The groundwater was increasing, and the lake is rippling, reedy, water birds are sploring, all kinds of sandy vegetation are revitalized (figure 4:Xinhuanet). The vegetation coverage increased from 10.86 % to 11.52 %, the environment was initially improved.[6]. With recover of the function of Qingtu lake the local environment had a obvious

change. According to the report of GanSu observatory, in 2012, the sand storm in Minqin settlement decreased, and there was no strong storm all over the year, and the times of sand storm was the least in recent years. In recent 50 years, the average occurrence times of sand storm in Shiyang river basin are 9 per year, and in Minqin are 26.7.[6]. In 2012, there was no sand storm, which is the lowest record since aerograph has been used. All this means the recovery of Qingtu lake has good effect on local environment and climate.



Figure 4. Qingtu lake after the key management of Shiyang River Basin.

C. The deep analysis of the ecological management of basin settlement

The Hongyashan reservoir was constructed in 1958, which is the plain reservoir by holding up the Shiyang river. The reservoir area is 30 km² and the design capacity is 127 million m³. [2] The western of reservoir is Hongyashan mountain and the eastern and northern is artificial reservoir. The reservoir is the largest desert reservoir in the Asia, which controls the 13.4 thousand drainage areas (figure 3). According to the statistics, the reservoir could irrigate 1.49 thousand km² of agriculture areas; the efficient agriculture areas are 590 km². The reservoir is in the middle of Shiyang river, 130 km from Qingtuhu Lake. [7]. After the building of Hongyashan reservoir the 100 km of the rest of Daqing river was abandoned, and the terminal lake-Qingtuhu Lake was dried up. The reservoir changed the connection between rivers and lake. [7]. Some people say that the construction shifted to upstream by 100 km the Qingtu lake from the end of the Shiyang river, the artificial lake replacing original natural lake, and Hongyashan reservoir replacing Qingtu lake. This shift caused the disappearance of 100 km of downstream natural channel, the disappearance of Qingtu lake and exsiccation of sand-proof vegetation along the river channel [6]. Consequently, the sand walked through the green barrier and easily eroded the oases and, causing the expansion of desert which threatened the existence of people and development of economy.

Supplying water to Qingtu lake from 2010 to 2012 has initially changed ecological environment of microclimate in the watershed. The way of supplement was irrigation channels which did not supply water to the 100 km downstream natural channel and did not maintain the underground water supplement balance, “two ends heavier, but not the middle”. This means the Hongyashan reservoir and Qingtu lake as two ends of the oases have more underground water while the original ecology of the more than 100km long sandstorm region in the West of the oasis has no water supply leading to the original ecological environment unrecoverable. The protection in the river could only depend on the artificial measures such as desert ban, building windbreak and sand-proof barrier. All these artificial protections are easily broken; they need to renew every year wasting a lot of human and material resources.[8]. So, in order to form the benign ecological effect, the way of irrigation and replenishment of underground water is the urgent issue on the management of the Shiyanghe River basin.

IV. DISCUSSION

The importance of the ecological recovery of inland lake is to take full advantage of the self-recovery function of the system of lakes and streams, which helps improve ecological environment.[3].The Minqin settlement located in the downstream of Shiyang River should make the protection and recovery the function of the systems of natural lakes and streams, and the reconstruction the destroyed environment uppermost priority. To do so, regulation of human living behaviors and prohibition of continued devastation towards the environment should be highly emphasized. These strategies may promote the already wrecked desert oasis zones to adapt the local natural condition, maintaining it in a relatively stable and good situation and achieving harmony between human and nature.

A. The Ecological Effect of Recovering the Original Daxi River

The downstream of Shiyang River refers to the Daxi River which origins from Shiyang River that passes through Hongya Mount Nek (i.e., the trunk stream of Shiyang River from Hongya Mount Nek to Qingtu Lake, typically called “Daxi River”)[2], which extends to the interior of desert and finally ends in the rump lake through the boundary between the oasis and Badanjilin Desert. Owing to the supply of groundwater for the river, natural sand-tolerating plants occur in several miles, often known as “Chaiwan”. These plants, plus with Qingtu Lake located in the end, formulate a natural defence for Minqin oasis, preventing Badanjilin Desert to expand towards the east (see the heavy line in figure 5).

With respect to the governance of Shiyang River in recent years, only the ecological recovery of Qingtu Lake by supplying water is taken into consideration. However, the



Figure 5. The downstream branch is proposed to restore in Shiyang River Basin.

mode of water provision is by the means of irrigation, other than in a natural way-----supplying the water to Qingtu Lake from Shiyang River. From the standpoints of recovering the ecological functions of rivers and lakes, a better way to do so is to supply water from Daxi River to Qingtu Lake, linking the rivers and lakes located in the west of the oasis. In order to achieve this goal, the water provision from Hongya Mount Reservoir for Qingtu Lake should be fixed by the means of system, preventing the casualness of deploying water resource. In order to restrict management and deployment of water resource, scientific solution of water resource dispatch should be administered. On the basis of sufficient amount of water for Caiqi section, a careful and scientific deploying solution of water resource and dispatch solution of Hongya Mount Reservoir should be planned to determine the total amount and the quota of the water for living, manufacturing, and ecological usages. Particularly, the amount of water supplied for Qingtu Lake is surely not dispensable. Considering the link between rivers and lakes and the amount of water used in ecological environment per se, the amount of water supply should range from 20% to 30% [9]of the total amount of incoming water flow of Hongya Mount Reservoir. On the basis of the current situation of Shiyang River, the yearly incoming water flow of Hongya Mount Reservoir reaches over 300,000,000 m³ (the water amount of Caiqi Section in 2012 was 300,000,000 m³)[5]. Therefore, based on the calculation of the water needs of inland rivers, the basic ecological function of river can be recovered only if 60,000,000 m³ [10]of water is supplied to Qingtu Lake from Daxi River each year. This measure not only replenishes the groundwater of Minqin Oasis, but it also helps recover the plants in the downstream of Shiyang River. A river is incomplete without downstream. Supplying Qingtu Lake with water from the downstream and efficiently providing groundwater for both riversides from natural rivers are conducive to reverting the ecological effect of Daxi River. This strategy helps reestablish a defence against sand in the west of Minqin oasis, which is helpful to protect and preserve the oasis of settlement, and this, in turn, promotes the sustained development for economy and society.

B. Restore the Oasis Effect of Water Ecological Balance

Rivers and lakes are the surface water carrier. In the past, the construction of all reservoirs in Shiyang watershed and Hongyashan reservoir has indeed played an important role in solving the problem of Oasis water production, but the maintenance of rivers and lakes as well as the environmental water demand in the ecosystems were not considered. The negative ecological impact of river cutoff and lake drying was also not calculated in the modulation of water in rivers and reservoirs, which not only caused the rivers and lakes have dried up but also exacerbated the contradiction between the upstream and downstream water. The ecological water use should include two parts based on the actual situation of water resources allocation in Shiyang River Basin. One is the water demand for irrigation of farmland shelterbelts and woodland, and the other part is required to restore the underground water table, which is referring in a period of time to achieve the appropriate amount of water needed for the gradual recovery of groundwater level [10]. To achieve the gradual rise of groundwater levels in the downstream Minqin Basin and protect the rivers, lakes and wetlands in the watershed, when water-saving countermeasures are implemented vigorously, the water control should be carried out innovatively where the allocation of water needed in the ecosystems should be highlighted [12].

1) *“Two ends develop simultaneously, the torso also keep up”, to maintain the Oasis effect of water ecological balance.*

The disappearance of Shiyang River tributary in Minqin Basin is an important reason for the drying up and Qinghai Lake and the deterioration of the ecological environment. The recharge of groundwater in Minqin Basin depends mainly on the vertical infiltration of surface water, however, in some arid areas where rainfall is limited, it can only rely on natural river water to recharge, if there is not river water supplies, to restore the ecological water balance of Minqin Basin is difficult to achieve in the short term [8]. Nowadays, the artificial river is gradually replacing the natural river channels; the replenishment of groundwater is very limited after lining. And following the comprehensive management, the field irrigation quota allocation became smaller and the complement of groundwater is also minimal. Facing with the status of ecological water distribution, dumbbell-shaped "heavy ends, light torso" where in most parts within an oasis the groundwater recharge depends on the natural river 100km far away, the allocation of surface water should break through the current management system following innovative water control concept. When the replenishment of Qinghai Lake is carrying on, a certain amount of surface water could be transfused to the natural river channels 100 km far from the downstream Shiyang watershed to form a "two ends (Hongyashan Reservoir and Qingtu Lake) develop simultaneously, the torso (natural rivers 100km away) also keep up" pattern of ecological water replenishment, to replenish the groundwater basin. When the surface water recharges the groundwater, a joint scheduling of surface water and groundwater is implemented. By the same

proportion of substitution of surface water and groundwater water, the ecological water balance of oasis is maintained.

2) *“Surface water and groundwater supply mutually”, to form a good circulation pattern in the downstream basin.*

The joint scheduling of surface water and groundwater is an effective measure to solve the water shortage problem in Minqin Basin in the downstream Shiyang watershed and is of great importance in the rational allocation of water resources in this region. The exploitation of groundwater in Minqin has long been mainly used for agricultural production. The development and utilization of groundwater has played a pivotal role to promote economic development in Minqin County and the improvement of people's living standards. With the implementation of key governance projects in Shiyang River Basin, the surface water in Minqin County has increased, and the overexploitation of groundwater has been effectively controlled. It did have a positive effect on the groundwater level recovery in Minqin Basin, and also improved the ecological environment. In the future scheduling of water, the extraction of groundwater should be determined according to the situation of surface water runoff. In the years when the surface water is relatively abundant, the groundwater can be used less; In the years when surface water in relatively limit, groundwater mining can be implemented appropriately, but the total amount cannot exceed the total amount of water quoted in "The Management Plan the Shiyang River Basin", which is to make Minqin oasis form a " surface water and groundwater supply mutually " good circulation pattern. If the surface water runoff cannot timely supply the demand, the exploitation of groundwater could be considered, but exceeded amount in the exploitation of surface water must be recharged within one year to ensure the balance. Only following this way can restore the rivers, lakes and wetlands in Shiyang watershed and ensure Minqin will not become a second "Lop Nor."

V. CONCLUSIONS

Downstream Shiyang river basin, the settlement of the severity of the ecological environment problems in arid, has caused the party and the state attaches great importance to, river basin comprehensive treatment work has been nearly six years, considering soil lake ecological restoration problem, implemented to the green earth lake ecological filling water, ecological water conveyance mode: Hongyashan reservoir - artificial irrigation - green earth, shiyang river basin by use of, at the end of its natural channel system of lakes is missing, unable to form a ecological barrier, groundwater recharge dumbbell shaped. To solve these problems, it puts forward the model of Daxi river (Hongyashan reservoir - Daxi river -Qingtu lake) and the "two head, torso follow up", "complementary, up and down with abundant fill owe" measures of groundwater recharge, western natural oasis ecological barrier, form a pattern of watershed downstream water resources sharing good circulation, restore the oasis water ecological balance effect.

From downstream shiyang river basin in the Ming and Qing dynasties tributary map (figure 2) analysis, in order to make the settlement completely from the Badain Jaran desert and Tengger desert oasis, must rely on the east river (Bai Ting) west two natural (large) Kosi river barrier function and its rump lake of self-restraint. Through the Shiyang river basin comprehensive treatment, and create a water-saving society, open source throttling, try our best to save more ecological water, and then injected into the Bai Ting river and Bai Ting sea, form a palisade oasis crude dashed part (figure 5), the eastern barrier Minqin settlements in Shiyang river basin, the ecological problems facing to completely solve, also will be fundamental improvement in the living environment.

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