Research on Dujiangyan Irrigation System

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1 Abstract

DuJiangYan Irrigation System,created more than 2000 years ago,irrigates the land of more than 670,000 hectares,ensuring the water supply for industrial and agricultural production till today.However,problems still exist. Major issues are the shortage of the irrigated water resources and the water pollution.Projected methods we plan to adopt contain consulting relevant files,on-the-spot investigation,interviewing local staff,and conducting experiments.We infer that real causes for the first two statements of the problems are the weak awareness of the water conservation,the aging of the facilities,the overexploitation and the rising demands for water .We expect to verify the existence and severity of the problems.

2 Keywords

water resources,water conservation,irrigation

3 Purpose of the research

DuJiangYan Irrigation System is created more than 2000 years ago by LiBin and his son. In 2000, it was listed in the World Cultural Heritage. DuJiangYan, located in the west of Chengdu Plain, irrigates the land of more than 675,000 hectares ,ensuring the water supply for industrial and agricultural production. Therefore, the operation of DuJiangYan plays a crucial role in Chengdu and its surrounding cities' development.

However, problems still exist, which contain the shortage of water, the hysteresis of water prices, weak awareness of water conservation and the lack of the informatization standard system construction. We are going to show you how severe these problems are. At the same time, we expect to raise the social awareness of the water reservation and encourage the related departments to improve the management mechanism.

4 Method of the research

The process of research is mainly about gathering and analyzing data and information qualitatively. We collect information from reliable resources such as China National Knowledge Infrastructure. To further our research, we also conduct surveys with the public to get more specific information about the issues.

5 Results of the research

5.1 Water resources

Dujiangyan Irrigation system has covered more than 675,000 hectares of land. The water resources, however, are facing rather serious challenges. Our group has conducted exact research to verify our hypothesis.

Ahead of discovering the problems, we must find out the components of the water resources. The supplying area's water resources mainly come from upper reaches of Minjiang river, local water resource and runoff in marginal mountain areas. Upstream flow of Mingjiang river reaches 14.32 billion cubic meters, taking up about a half of the total resources. With these reliable data, we could figure out the available quantity of water resources by dividing it into the three parts mentioned above (The available quantity of water resources=average surface water resource - river course ecosystem water demand - average flood which is out of control).

With this formula, we could work out the available quantity of water resources is about 15.566 billion cubic meters.

5.2 Water resources development

From the data above, we find out that there are differences between the three parts. As for the water resources development, upper reaches of Minjiang river have been overexploited. Dujiangyan Irrigation system water diversion takes up 72 percent of the flow of Minjiang river.It could do harm to the ecosystem. In contrast, runoff in marginal mountain areas is underdeveloped. What's more, the irrigation water efficiency is less than 0.45, and every 1 percent could save 100 million cubic meters of water. So it's of great significance to manage to increase the water resources development.

5.4 Water supplies decrease

As the main water supply of Dujiangyan, upper

reaches of Minjiang river are very important. However, runoff of Minjiang has been decreasing during the past decades. Every 10 years, it drops 540 million cubic meter water. What's worse, the problem tend to be more and more serious, which has increased the pressure of water demand and supply.

表6 岷江来水量变化趋势统计

年份	1930	1940	1950	1960	1970	1980	1990	2001	2002
水量（亿 m^3）	174.1	157	157	158	145	143	138	130	107
平均值（亿 m^3）	174.1	157.3		142				118.3	
递减率（%）	9.6			9.7			16.6		

5.5 Water Resources Spatial-temporal Distribution

Minjiang river's water resources are distributed unevenly throughout a year. The water supply from May to October takes up about 78.6 percent, which leads to the shortage of water during the dry season. And the weak regulation ability has aggravated the problem.

6.1Water prices

It is widely known that prices have an impact on the demands. As a necessity of life, water prices are capable of making influence to the awareness of water conservation. We have analyzed the history of water prices in Dujiangyan from 1951 to now. At the same time, with the comparations between the costs and the prices to figure out if the water prices have problems. If so, how severe it is?

6.1.1 history of water prices

1.1951-1978, 4 to 5 kilograms of rice was collected per mu of land. Water price in the old irrigated area differs from that in new area.

2.1979-1983, after the establishment of the Dujiangyan Administration , the plain irrigated area unified water prices that 5 kilograms of rice are collected per mu and one kilogram of rice was collected in dry farm.

3.1984-1998, 9 to 10 kilograms of rice was collected per mu.

4. Since 1999, the water price turned to 20 yuan in which used to collect 9 kilograms of rice, and that turned to 22 yuan per mu in which used to collect 10 kilograms according to the regulations of price bureau aiming at promoting the improvement of water prices and adapting the policy. In 2003, these numbers are up to 28 and 31 yuan per mu.

5. From 2003, Sichuan Provincial Water Resources Department (SPWRD) planned that metering water would cover the whole irrigation area within 5 years. Although water charges were based on actual water consumption, it must not exceed a certain number. The certain number was 30 yuan in average due to different levels of economic development.

6.In 2017, SPWRD planned to increase the water prices which could guarantee the operation and maintenance costs of the project. Water prices and quotas vary according to the type of crop and region. In the area that has comprehensive water metering equipments the water prices were 0.04 yuan per cubic meter of grain and oil crops and that of cash crops was 0.05 yuan per cubic meter.

An additional 0.02 yuan per cubic meter would be charged for water exceeding the quota by 10%or less; and that will be added 0.04 yuan per cubic meter if exceeding the quota by more than 10%.

From the above information, we can conclude that Dujiangyan experienced from gathering water charges in material objects to cash charges, from gathering water charges generally to accurately by water metering. The water prices differ due to different conditions of each region, which has been improved with the development of society.

6.1.2 Existing problems with water prices

1.water prices is excessive low that it can not offset the cost of water supply. Even though the water prices indeed improve as time goes by, but its lag is very obvious. From the following table we could know that the cost of water supply per cubic meter was 0.059 yuan in 1999 while the water prices in 2017 still lower than this number. With the continuous extension and the maintenance of Dujiangyan as well as the water volume in Mingjiang river decreases, the growth rate of the cost should be higher than that of water supply.

Therefore, the water prices have severe hysteresis.

project(in plain area)	
Investment in agricultuaral water supply(yuan)	1,896,030,200
water supply(cubic meter)	3,186,440,000
Cost per cubic meter of water supply(yuan)	0.595

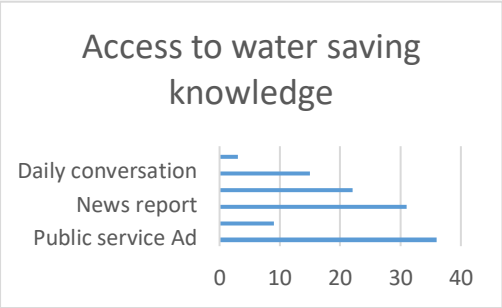
	prices: yuan per cubic meter	part exceeding by 10% or less	part exceeding by 10% or less
grain and oil crops	0.04	add 0.02	add 0.04
crops for cash	0.05		

7.1 Water conservation

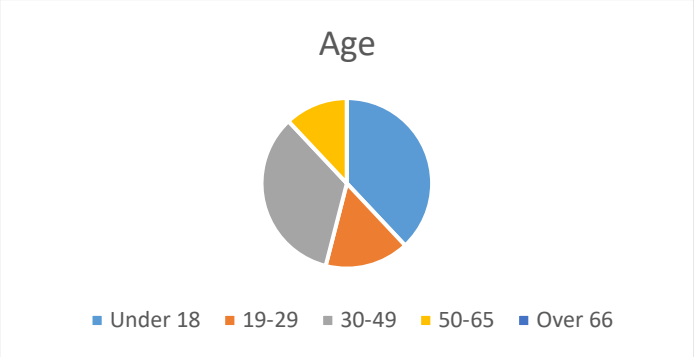
With the quick development of China, Southwestern areas, Sichuan Province in particular, have seen a surge of population, which has put great pressure on Dujiangyan Irrigation system. The total amount of water is in fact too little to meet all needs. Therefore, we decide to investigate people's awareness of water conservation, in order to find any problem existing and make suggestions for the future.

7.1.1 Methods and contents of Investigation

1. Method: Electronic questionnaire
2. Samples: Randomly chosen Dujiangyan citizens
3. Process: decide the aspects; choose appropriate questions; investigate along the planned route; form a report .
4. Questionnaire: 9 questions in total, the 9th will be shown only when people choose a certain one in the 8th .
5. The number of valid questionnaires filled out: 50, according with 6 ~8 times the number of the questions.

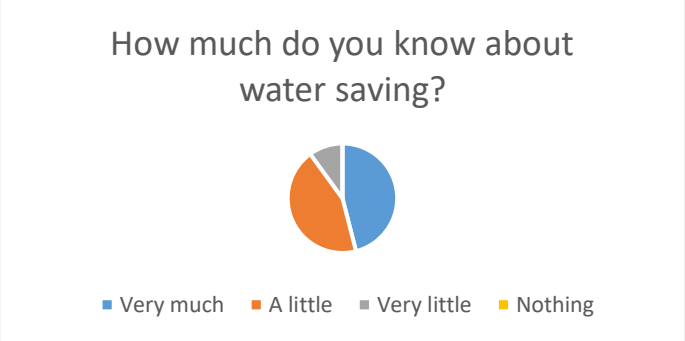


7.1.2 Results of the investigation



Result 1： The investigation is based on electronic questionnaire, which requires people to scan the QR code with their cellphone to obtain the questionnaire. Therefore, people over 66 are not included.

The percentage of each group basically conforms with the popularity of cellphone in different ages.



Result 2: 46% 44% 10% 0%

Analysis: The publicity of water saving is great, with all samples showing some knowledge of water saving.

Result 3： The 3rd is an indefinite multiple choice, most people have ways to acquire knowledge of water saving.

Analysis: the quick development of electronic media offers a wide variety of ways to get information. The local community has also played an important role in spreading such information.

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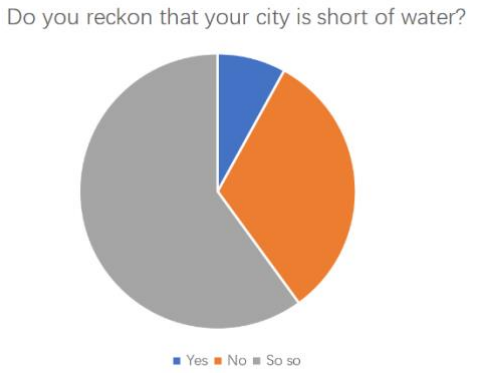
Result 4: 74% 26% 0%

74% appears to be less than those who know something about water saving, in comparison to Result 2 and 3.

Analysis:

1.Calculation of water fee：China adapts step toll system to charge water bills, compared to the US simply using meterage .To be clear, the more water one uses, the higher the unit price.

2.Some people don't save water on purpose, even though they know it's of importance.

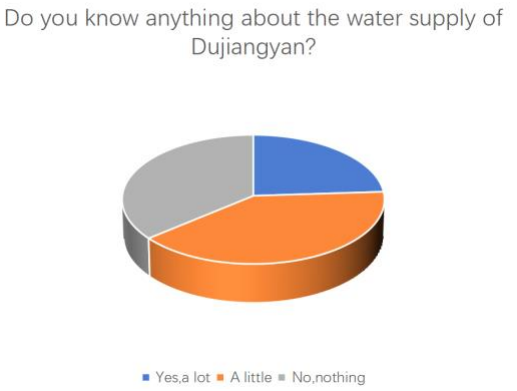


Result 5： 8% 60% 32%

Analysis：The result basically suits our expectation. Dujiangyan Project enjoys great reputation for its history and practical use. It is more than a simple irrigation system, therefore it is normal to think that Dujiangyan City is no short of water.

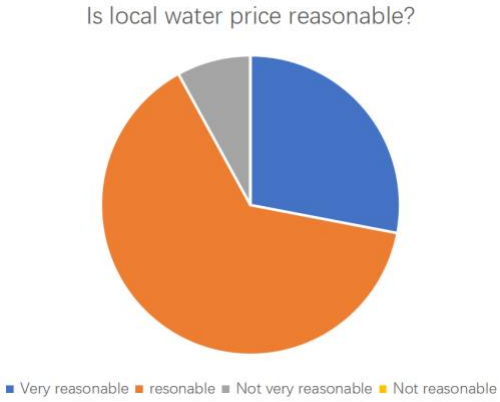
Result 6： 24% 40% 36%

Analysis： It is for the same reason to the last question. Most people only know about the long history and the function of the project. They don't have more specific or detailed information about the project, letting alone 90% of them don't even think that the project is already in a tense situation.



Result 7： 26% 44% 30% 0%

Analysis：The result is a little unexpected, since so many people have shown very good awareness of water saving. According to our speculation, local citizens probably agrees that its publicity still has little influence on people's actual measure to save water.



7.2 Conclusion of questionnaire

From the analysis of the data above, we consider：

In the mass ,the government has done the publicity of water saving well, spreading information in many ways.

The citizens in Dujiangyan have great awareness of water saving. Because those living in Dujiangyan should be less likely to save water due to the existence of the project, typical and representative is the result of the investigation.

We suggest strengthening the publicity of water saving , especially adding more professional and specific information into it. Not only can citizens have more scientific understanding of water saving, but the children

and students can be interested in water knowledge, making the public learn more about why we are saving water and how it works.

Looking at the history of water prices, whether collecting water charges by material things or cash settlement, water prices show a public and welfare nature. Although the government has released some policy to promote water conservation, the idea that water is communal is deeply rooted instead of water is a kind of good. In terms of water price, we suggest the government do a more detailed research with more extensive coverage to determine an appropriate water price, because obviously water price plays a more important role in how much water people use, than the idea of water saving.

As for the project itself, we reckon that there is little publicity about the scientific theory of Dujiangyan irrigation system, while only 24% of people showed an understanding of it.

In fact, the development of water resource in Dujiangyan is as high as 39.4%,right next to the limit of 40% according to international standard. There are also constructional issues on the system, after all, it's a 2300-year system. The irrigation system is no more with so much water like most people may have anticipated, it is reaching its own limit as well. Water saving is rather significant at present.

8.1 IoT perception standard system

At present, the flow monitoring equipment in Chengdu can only provide on-site meter reading, which cannot meet the requirements of remote monitoring. There are some differences in the monitoring results mainly due to human factors. In addition, the GPRS signal of telemetry station data transmission sometimes stops due to arrearage, and the data of each acquisition terminal will have a small deviation from the data read manually due to the different acquisition frequency.These problems may have a negative impact on the emergency mediation efficiency and water resources mobilization and regulation of Dujiangyan,more impotantly,affecting the correctness of related regulations of governments(After all,"Information is the premise and basis of decisions.")

In view of the above problems, the following measures are proposed: establish industry standards for Dujiangyan equipment selection, equipment parameters, etc; build a standard system of basic information collection frequency;complete the formulation of relevant standards in terms of data collection standards, information transmission and exchange.

8.2 Data sharing standard system

The unified data center and online service platform have not been established, and information resource sharing channels are lacking. Log in to Dujiangyan Water Conservancy Development Center, and the information of Dongfengqu Management Office, Waijiang Management Office and Tongjiyan Management Office in the irrigation area is not updated synchronously, and the information lags behind and is missing.These problems may lead to unnecessary waste of valuable water resources, untimely collection of water fees, and deterioration of water quality without timely tracking due to improper management.

In view of the above problems, the following measures are proposed: unify data standards, and build an emergency transmission network; Establish an integrated water management platform to provide a unified data center and online service platform for key businesses such as water management, safety operation, disaster prevention and mitigation, water quality monitoring, water fee collection, etc.

8.3 Operation and maintenance standard system

Some of the office systems of Dujiangyan

Administration can no longer meet the needs of modern office; There are great potential safety hazards in the central motor room;In terms of operation and maintenance, there is a lack of professional technicians to carry out patrol and inspection,so failure of the system can not be repaired in time; The telemetering stations lack technicians for maintenance, and some of them are in the wild, so there is a great risk of damage and theft.These problems will not only lead to illegal and criminal acts, but also have a huge impact on the daily operation of Dujiangyan, thus affecting the water consumption of residents' lives and factory production.

In order to ensure the effective implementation of subsequent operation and maintenance, requirements should be specified, including system establishment, work requirements and safeguard measures.

9 Conclusion

By collecting information we find that the water supplies decreasing, the overexploition of water resources and water Resources Spatial-temporal Distribution have existed for many years. On the other hand, the demand for water resources is increasing continuously. We conducted the research in the aspects such as the informatization standard system, the hysteresis of water prices and the weakness of water conservation to provide some measures, which are probably beneficial to the whole society. In term of stewardship, more digital equipments should be used in irrigation system. For the economic sustainability, water prices should be raised step by step not only for some offset of the costs but also promote the awareness of water conservation. For people's awareness, government should add more professional and specific information into this project. Not only can citizens have more scientific understanding of water saving, but the children and students can be interested in water knowledge, making the public learn more about why we are saving water and how it works. In short, it is with sincere gratitude that we hope the condition of water resources could be improved and the society would like to attach great importance to water and environment.

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