Status and Evaluation of the Benefits of Developing Efficient Water-saving Irrigation Infrastructure in Gansu Province

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Abstract. Since the 20th century, national investment in agricultural irrigation has been increasing, indicating that the state is paying more and more attention to the “Three Rural Issues”. Along with the national emphasis on the "Three Rural Issues" and the background of increasing economic investment in agricultural irrigation, irrigation technology has been developing rapidly in Gansu Province, which is reflected in the year-on-year expansion of efficient water-saving irrigation area. The goal of water-efficient irrigation technology is to improve the water utilisation coefficient, thus optimising the planting structure of crops and increasing crop yields. Therefore, a variety of high-efficiency water-saving irrigation technologies such as pipe irrigation, sprinkler irrigation and micro-irrigation have been vigorously promoted and applied. The article analyses the current status and benefits of high-efficiency water-saving irrigation infrastructure in Gansu Province, and aims to provide data support and theoretical guidance for the development and improvement of high-efficiency water-saving irrigation in the province.

1. Introduction

In terms of the development of high-efficiency water-saving irrigation, Gansu Province has explored a development model that combines agronomic water-saving, engineering water-saving and management water-saving [1-3]. And, while guaranteeing a stable water supply to irrigated areas, it is also constantly looking for more efficient irrigation techniques. From 2011 to 2018, Gansu province has built 29.51 thousand hectares of high-standard farmland, 22.97 thousand hectares of water-fertiliser integration application area and 31.53 thousand hectares of high-efficiency water conservation area. In this case, farming conditions have been substantially optimised, forming a pattern of "square fields, forested networks, connected canals and roads" of high standard farmland. By the end of 2018, a total of 744.67 thousand hectares of high-standard farmland had been built in Gansu Province, with 65.45 thousand hectares under construction in 2019 and 26.78 thousand hectares of high-efficiency water-saving irrigation under construction. By 2025, Gansu Province plans to build 1846.67 thousand hectares of high-standard farmland with high and stable yields, which will be protected from drought and floods.
2. Current status of efficient water-saving irrigation infrastructure

2.1. Irrigation and water conveyance works

High-efficiency water-saving irrigation engineering is a kind of field-efficient water-saving irrigation engineering, which uses drip irrigation, sprinkler pipe irrigation and other high-efficiency water-saving technologies as an effective means and the existing backbone irrigation engineering and water diversion locations as infrastructure. Water saving irrigation area in Gansu Province in 2017 as shown in Table 1. Seven years ago, a total of 1451775 channels have been built in Gansu Province, including 482272 main and branch canal, total 31731.58 km, accounting for 33.2% of the total canals, 20555.34 km have been lined, with a lining rate of 64.78%; 969503 bucket and agricultural canal, total 125.66 km, accounting for 66.8% of the total canals, 38819.55 km have been lined, with a lining rate of 30.89%. 1451775 buildings of various types were built, including 482272 main and branch canal buildings, and 969503 bucket and agricultural canal buildings. Among them, the lining ratio is relatively high in dry and branch canals, while the lining ratio of doon canals is far below the seepage control requirements, which in turn affects the control and distribution of water distribution and distribution, resulting in a conflict between water supply and water use and the inability to meet the demand for efficient water-saving irrigation water [4-6].

Table 1. Water saving irrigation area in Gansu Province in 2017. (Unit: thousand hectares)

| Prefecture level | Sprinkler and Drip Irrigation | Micro irrigation | Low Pressure Pipeline Irrigation | Other water saving measures | Total |
|------------------|-------------------------------|------------------|----------------------------------|-----------------------------|-------|
| Jiuquan          | 0.43                          | 47.39            | 30.30                            | 101.40                      | 179.53|
| Jiayuguan        | 0.00                          | 5.61             | 1.82                             | 0.00                        | 7.43  |
| Zhangye          | 3.96                          | 50.29            | 61.16                            | 71.90                       | 187.31|
| Jinchang         | 1.13                          | 19.42            | 11.24                            | 24.58                       | 56.37 |
| Wuwei            | 3.03                          | 58.71            | 30.57                            | 84.29                       | 176.61|
| Lanzhou          | 7.26                          | 5.29             | 11.67                            | 47.03                       | 71.26 |
| Baiying          | 1.67                          | 16.92            | 13.08                            | 82.22                       | 113.89|
| Linxia           | 0.86                          | 0.49             | 1.48                             | 40.93                       | 43.77 |
| Dingxi           | 2.55                          | 2.42             | 6.69                             | 28.18                       | 39.85 |
| Tianshui         | 1.68                          | 6.07             | 11.02                            | 13.99                       | 32.77 |
| Pingliang        | 0.54                          | 5.61             | 7.94                             | 23.61                       | 37.71 |
| Qingyang         | 3.31                          | 7.70             | 12.28                            | 9.20                        | 32.49 |
| Gannan           | 4.23                          | 0.00             | 0.43                             | 2.36                        | 7.03  |
| Longnan          | 2.31                          | 5.30             | 7.11                             | 17.46                       | 32.19 |
| Total            | 32.96                         | 231.22           | 206.79                           | 547.15                      | 1018.13|

2.2. Water engineering

The most important aspects of water supply engineering are reservoirs, diversion hubs and pumping stations [7-8]. Seven years ago, Gansu Province has built 1560186 water conservancy projects of various types, the current total annual water supply is 12.17 billion m³, including 337 water storage projects (6 large reservoirs, 33 medium-sized reservoirs, 298 small reservoirs), total storage capacity is 1.86 billion m³, accounted for 15.3% of total water supply of Gansu Province, water supply volume is 1.86 billion m³; 776 water diversion projects, the total diversion flow reaches 440.37 m³/s, and the water supply volume is 4.57 billion m³, accounted for 37.5% of total water supply of Gansu Province; 107128 water lifting projects, including 60426 electromechanical wells, 3554 electromechanical pump stations, installed capacity is 929041kw, lifting water flow is 505.74 m³/s, water supply is 5.24 billion m³, accounted for 42.9% of total water supply. It can be seen that the construction of water source projects in Gansu Province has achieved great growth in both quantity and scale, which provides a
strong water source guarantee for further implementation of large-scale efficient water-saving irrigation. Water diversion, pumping and storage are the main methods of water extraction. However, the existing outdated irrigation sources and infrastructure and field distribution works are not adapted to modern, efficient water-saving irrigation, so that the operational capacity of the infrastructure requires a complete renovation of the water sources and canal systems [9-10].

3. Current status of efficient water-saving irrigation management

3.1. Management mechanisms and institutions
In accordance with the relevant legislation, the staff of the water resources construction management station shall act as the project legal person for the project. In addition, the water management unit of the project area and the staff of the water conservancy construction management station should be involved in supervising the construction of the highly efficient water saving irrigation project throughout the construction process. Representatives of water user associations or beneficiaries should also be involved in the construction and management of on-site projects. In addition, the management of efficient water-saving irrigation projects can be strengthened only if the beneficiary townships have set up an extensive leadership team responsible for organising, leading, coordinating, inspecting and supervising the management of efficient water-saving irrigation projects. In addition, administrative authority is divided according to the principle of 'who cares, who benefits' under the unified leadership of the leading groups for water conservation and efficient management at all levels. After the projects are completed, farmers' water cooperative organisations will be actively cultivated under the principle of "active, prudent, pragmatic, government-led, voluntary and farmer-run" [11-13]. At present, in the western part of Gansu Province, farmers 'water users' associations are established on a village basis or on a hydrological boundary according to the principle of "one village, one council". In the areas along the Yellow River, rural social water management organisations, water conservancy cooperatives, farmers' associations and other forms of farmers' water cooperative organisations have been established in accordance with the principle of "one village, one group". In addition, irrigation districts and water management units are also actively exploring and practising more practical management methods [14-15].

3.2. Management systems and models
Proper management and use systems and construction of irrigation districts play a vital role in the use of irrigation districts. However, canals at all levels are now damaged to varying degrees and some projects are unusable due to the lack of experience in effective management and maintenance in most irrigation districts. In addition, the completion rate of canal construction in the province is low due to local conditions as well as inconsistent project investment and construction targets. Based on current statistics, the level of completion rates also varies among efficient water-saving irrigation facilities. In general, completion rates are high for piped irrigation (around 80%) and low for sprinkler and micro-irrigation [16]. In some irrigation districts, all facilities have been destroyed and irrigation capacity has been almost lost [17-19]. The reliance on villagers and village communities to manage irrigation projects illustrates the current lack of a relatively unified management body. Maintenance costs are high in drip and sprinkler irrigation, and there is also a growing problem of 'missing' management entities – a lack of initiative and motivation on the part of farmers.

3.3. Operation and management costs
In recent years, governments at all levels have actively sought funding to increase local financial investment, which has greatly supported the maintenance and construction of irrigation projects. However, these support mainly focused on the construction of irrigation areas and the main renovation of channel maintenance, there is a relative lack of funds in some areas of the project, often "someone to use, no one to manage". The county's current maintenance of water-saving facilities still relies mainly on farmers' self-funding. In addition, the high cost of management and maintenance of
sprinkler and micro-irrigation irrigation makes farmers reluctant to carry out the work, so they give up on maintenance, which ultimately directly affects the construction of water conservancy projects and prevents the steady development of effective water-saving irrigation facilities [20-21].

4. Current status of efficient water-saving irrigation management
The construction of efficient water-saving irrigation systems in Gansu province will result in a higher guaranteed area of irrigation/number of beneficiaries and higher food production, which will also bring good results in terms of increased farmers' income and social benefits. According to relevant literature, arable land area can be saved by about 1% after the implementation of efficient water-saving irrigation technology. Efficient water-saving irrigation of the existing 2.87 million hectares of cropland will increase the effective irrigation area by 2.87 thousand hectares. The land benefit of RMB 18 million is calculated on the basis of RMB 6150 yuan per hectare of effective irrigation [22]. At the same time, with reference to research on projects that have already been implemented, an average labour saving of 45 people per hectare can be achieved after the implementation of highly efficient water-saving irrigation projects. It is calculated that the current savings of 0.13 million man-days and the economic benefit of 517 million RMB for provincial workers are calculated on the basis of 40 RMB per man-days [23]. At present, the province saves 2670 m$^3$ of water per hectare of efficient water-saving irrigation per hectare, saving a total of 766 million m$^3$ of water. 70% of this is used for ecological protection and vegetation building [24]. With reference to the relevant data, the value of the indirect benefits calculated on the basis of the ecological area restored is 228 million yuan. In addition, it also leads to an increase and stabilisation of food production and a direct and indirect increase in economic benefits.

5. Conclusion
Improving agricultural production, protecting ecological safety and safeguarding food production is very important for the development of efficient water-saving irrigation projects in Gansu Province, where water resources are very scarce. At the same time, the fact that only 19.48% of Gansu Province's irrigation area is highly efficient and water-saving is worthy of our attention, so the potential for the future development of highly efficient water-saving irrigation in Gansu Province is still very large. In order to alleviate the shortage of water resources in Gansu province and at the same time ensure social, economic and ecological sustainability, it is necessary to comprehensively develop and promote advanced water-saving technologies and to continuously stimulate water-saving irrigation technologies.

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