

Development and Status of Water Saving Irrigation in Xingtai City, Hebei Province

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[Abstract]

Agricultural irrigation water accounts for the majority of water consumption in a region, and water-saving irrigation is necessary for today's agricultural development. Water-saving irrigation is aimed to harvest satisfying productive benefits, economic benefits and social benefits with less water. This paper conducts a field survey on agricultural water-saving irrigation in Weixian County of Xingtai City to learn about the background of the implementation of water-saving irrigation in some counties of Xingtai City and the status quo of development. Then, by analyzing the methods and achievements of water-saving irrigation, it discovers existing problems and tries to put forward some personal suggestions on the development of such irrigation based on research.

[Key Words] : Xingtai City Water-Saving irrigation Spray Irrigation Drop Irrigation Forms about water-saving irrigation

China is a significant agricultural country whose agricultural water consumption exceeds 60% of the total water consumption. With accelerated industrialization and urbanization, the proportions of domestic water and industrial water have risen sharply, which compounds the water supply and demand conflict and water shortage problem. Traditional agricultural irrigation which leads to great waste of water resources not only contributes little to the increase in grain output but also may result in damages to land resources. As a result, it can no longer meet with the rapid development of agricultural demand. Guaranteeing urban water use and compressing agricultural water consumption has become an inevitable tendency in order to adjust the composition of water resources consumption. Therefore, this requires water saving through the development of water-saving irrigation in addition to adjustment in agricultural structure, thus alleviating the conflicts in use of water. Among numerous pilot areas for water-saving irrigation, Xingtai City, relying on technological exchange and its own innovation under the background of the reform and opening-up, has gradually established a set of water-saving agricultural irrigation systems which demonstrate its unique characteristics.

Xingtai City is a significant agricultural city where the agricultural irrigation water occupies more than 77% of the total water consumption and also considered as the main region of grain production in Hebei Province . Meanwhile, Weixian County, which over 80% of the county's land is used for agricultural production, is the major grain-producing county of Xingtai. In recent years, the county has set up the only national modern agricultural park with comprehensive development of Hebei Province, spearheading the national agricultural reform. Besides, agricultural

water-saving irrigation remains the top priority of its modern agricultural reform, and the government offers great support in multiple aspects. Based on this, this paper selected Weixian County as the research site to probe into the superiority of water-saving irrigation in form of field survey.

This paper is divided into three parts: part one introduces the background of water-saving agricultural development in Xingtai; part two analyzes the advantages and disadvantages of current water-saving irrigation; part three explores the achievements and problems of water-saving irrigation while also provides some personal suggestions. The results of the survey show that water-saving irrigation technology demonstrates obvious superiority in such aspects as reasonable development and utilization of water resources, increase in agricultural production and increase in farmers' income.

1.The development background of water-saving agriculture in Xingtai area

1.1 Overview of Xingtai City

Xingtai is located in the central North China Plain, the central area of mid-south region of Hebei Province, and the eastern foot of the south section of the Taihang Mountains, with north latitude being $36^{\circ}45'-37^{\circ}48'$, and east longitude being $113^{\circ}52'-115^{\circ}50'$. The terrain ,which is mainly plain, is high in the west and low in the east, and from the west to the east, the three kinds of terrain including the mountains, hills and plain are arranged in a ladder form, with a ratio of 2:1:7. Xingtai is characterized by a warm temperate sub-humid monsoon climate, distinct seasons, large temperature difference during the year and concentrated precipitation. The annual average temperature is between 12°C and 14°C . It's the coldest in January with an average temperature of -2°C and the hottest in July with an average temperature of 27°C . In addition, the average amount of precipitation in Xingtai over the years is 521.5mm and the total amount of precipitation is 6.541 billion cubic meters. The distribution of precipitation is uneven while concentrated in the year. About 75% to 80% of rainfall happens from June to September, especially in the late July and the early August,which is mostly through rainstorm. The total land area of Xingtai is $12,433\text{km}^2$, including 10.3866 *mu* of cultivated land and 8.1342 million *mu* of basic farmland. Crops mainly cultivated here are wheat, corn, millet, peanuts and cotton. The area of grain sowing around the year is about 10.85 million *mu* ^[1].

1.2 The status quo of water resources in Xingtai area

The annual amount of precipitation in Xingtai is not much while most of the precipitation concentrates in the flood season. On the whole, it is lacking water. Details are as follows:

1.2.1 Annual precipitation

The distribution of precipitation in Xingtai is principally influenced by weather and terrain, being characterized by more precipitation in the west and less in the east, which is extremely unbalanced. The general tendency is that it decreases from the western mountains to the eastern plain. The average amount of precipitation in

Xingtai has been 525.10mm for many years, the number in the mountains is between 550mm and 750mm and it is between 450mm and 550mm in the plain area. The amount of precipitation in Xingtai is considerably concentrated in the year, mainly during the flood season (June to September)

1.2.2 Water supply

The total available water in Xingtai is 1.718 billion cubic meters, including 1.081 billion cubic meters of local water that can be supplied. Please refer to Table 1 for the available amount of water in Xingtai ^[2]. In Xingtai the per capita annual amount of water owned is only 192 cubic meters, stating that water resources are in shortage. Meanwhile the water resources per mu of cultivated land is 171 cubic meters, which is less than 10% of the average level around China. Water resources are utilized in a rough manner with inefficiency, thus making the supply and demand contradiction more distinct. In the last 20 years, influenced by weather changes, local water resources have taken on a declining trend, which compounds the supply and demand conflict.

(Sheet 1) Analyze on Water resource of Xingtai City

Recent water demand/a hundred billion/m ³	Recent annual water supply/a hundred billion/m ³				Water deficit/a hundred billion/m ³
	Local available water	Transitiona l water	Irregular water	Diverted water	
22.36	10.81	1.77	2.10	4.60	3.08

1.3 Xingtai Agricultural Irrigation Development History

The irrigation has undergone a tortuous course in Xingtai. From the founding of People's Republic of China to today, the agricultural irrigation of Xingtai can be summarized into the following periods:

1.3.1 Extensive irrigation period which relies on surface water.

The main water resource being utilized was surface water during this period which lasts from the early 1950s to the late 1970s. Back then, the Haihe River drainage basin where Xingtai is located was at the stage of ample flow, which indicated plenty of rainfall and sufficient water. The seven-day big storm in August 1963 brought about a precipitation of 2,050mm, which caused a severe flood disaster and gave rise to significant losses in agricultural production. Later, in 1965, 1968 and 1972, drought happened. The frequent occurrence of natural disasters motivated people to successively construct some reservoirs and water diversion projects. For instance, more than 30 small and medium-sized reservoirs were built during this period, such as Dongshiling Reservoir of Shahe, Mazhuang Reservoir of Neiqiu and Zhubi Reservoir of Lincheng.

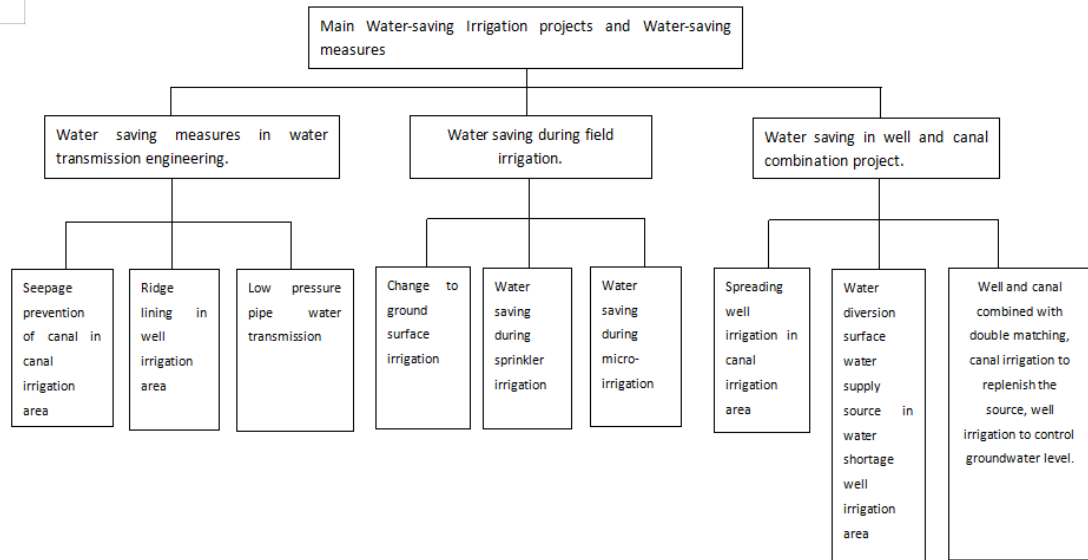
1.3.2 Continuous exploitation period that depends on underground water.

In the 1980s, as the global weather got warmer and the amount of precipitation in

North China declined year by year, along with the drought in 1980 and 1981 in succession, the rivers and springs in Xingtai were cut off and dried up, consequently the role of reservoirs and water diversion projects was increasingly weakened. With continuous population growth and greater pressure of grain production, agricultural water consuming began entering the period that underground water was continuously exploited. Due to excessive development and utilization of underground water, the average burial depth of water level in the plain area of Xingtai turned from 7.13m in 1980 to 18.79m in 2000 with an average annual decrease rate of 0.56m/a^[3]. In 2010, the total amount of underground water exploitation in the plain area of Xingtai was 1.523 billion cubic meters, including 1.16 billion cubic meters of shallow underground water. The amount of water resources was 734 million cubic meters and an excessive amount of 426 million cubic meters was exploited; the amount of depth underground water was 363 million cubic meters and the annual allowable amount of exploitation was 212 million cubic meters, with an extra amount of 150 million cubic meters being exploited^[4]. The severe over-exploitation of underground water resulted in underground funnel. On August 31, 2006, multiple cracks, the longest which reached 2.5 kilometers, appeared on the ground in Xidianzi Village, Longyao County, Xingtai, spanned two towns and three villages. This was the consequence of sinking ground caused by over-consumption of underground water.

2. Implementation of water saving irrigation in Xingtai City

The amount of agricultural water used in Xingtai has increased gradually to 76% of total because of the influence of continuous drought since the beginning of the 21st century. This provides an opportunity or quick development of water-saving irrigation technology. Also, Chinese government makes greater efforts to strengthen basic construction of irrigation and water conservancy. Therefore, the special funds invested in water-saving irrigation increase year by year and the investment environment for the development of water-saving agriculture is greatly improved. In the meantime, quite a few achievements have been made in such aspects through current-using water-saving irrigation approaches like low pressure pipeline anti-seepage technology, field spray irrigation, drip irrigation technology for fruit trees and vegetable greenhouses, anti-seepage technology for irrigated area and comprehensive water-saving technology. Hence, a certain capacity has been established using water-saving irrigation products, thus providing technical support for the implementation of water-saving agriculture strategy.



(Sheet 3) Statistics about the area of different water-saving irrigation approaches in Xingtai city (From 2011 to 2017)

Year	2011	2012	2013	2014	2015	2016	2017
Area of water-saving irrigation (thousand hectares)	245.5	259.2	276.8	300.83	319.27	365.86	390.16
Area of spray and drip irrigation (thousand hectares)	31.24	18.4	14.24	14.39	16.32	27.05	21.78
Area of low-pressure pipeline irrigation (thousand hectares)	180.03	207.75	220.65	239.08	257.95	261.75	287.72

2.1 Low pressure pipe irrigation.

Low pressure pipeline irrigation technology refers to the project of delivering water through low pressure pipelines for surface irrigation, using pipelines to replace open channels in the irrigation system. Low pressure which usually lower than 0.3kpa is adopted during irrigation. Water is transferred to fields through the pressure pipeline system to achieve the purpose of irrigation. This technology features water saving, energy saving, few investments and extensive application. Except sand land and hillside fields, the water-saving and energy-saving effects of low pressure pipelines are extremely prominent. Particularly it is suitable for rural areas where the contracted responsibility system is carried out. By 2018, Weixian country invested more than one hundred million yuan and constructed high-standard low pressure pipeline irrigation projects for 252,800 *mu*. The water delivery and water saving measures can reduce water leakage and evaporation along the pipelines. Compared

with furrows, water delivery via pipelines can reduce water loss by 5% meanwhile increases water utilization rate by 30% to 40%. In case of water delivery by furrows, the land occupied by field channels usually accounts for 1% to 2% of the irrigation area, sometimes even 3% to 5%. By comparison, the land occupied by pipelines only takes up 0.5%, which thus increases the land utilization rate. At the same time, water delivery by means of pipelines is fast, thus avoiding water leakage, shortening the irrigation period and saving costs ^[5].

2.2 Sprinkler irrigation

Spray irrigation indicates that the water pump and pipeline system or the fall of natural water is utilized to spray water of certain pressure to the air which then turns into small drops or fog that falls onto plants and ground. Depth underground water of Xingtai has been exploited for years in succession so the underground water level keeps dropping. Yet, with spray irrigation, the water-saving and energy-saving effects are extremely apparent. It can save water to the utmost, decelerate the decrease of depth underground water and gradually eliminate the negative influence caused by the over-consumption of water. In the western hilly area of Xingtai, the application of spray irrigation can further alleviate the burden of land leveling and make irrigation more even, producing evident effects of water saving and production increase.

In the field survey, the author noted that the benefits of water-saving spray irrigation in the pasture planting park of Aihe Group in Weixian County of Xingtai is quite satisfying. Aihe Group is the upstream enterprise of Junlebao Dairy which mainly provides grass and flowers that are needed by Junlebao's meadow. The pasture planting area focuses on self-traveling rotating sprinklers with traditional upright irrigation as the auxiliary (which are shown in the figure). While working, self-traveling rotating sprinklers will rotate around the axis of its central part, and each irrigation may cover 300 *mu* of land. Corners that cannot be covered will be irrigated in the form of upright spray irrigation.



self-traveling rotating sprinklers with traditional upright irrigation

In this way, under one-man operation, the speed of irrigation may reach 2 to 3 *mu*/hour, which increases by 50% compared with traditional manual irrigation of one *mu*/hour/person; meanwhile, the per *mu* water consumption dropped from 80m³ to

60m³, saving water by 25%. Therefore, it can be seen that the advantage is obvious. Besides, compared with traditional flood irrigation which cannot be controlled, self-traveling sprinklers may adjust the water amount, fertilizer amount and traveling speed at any time according to actual conditions such as the amount of precipitation and soil moisture content. Moreover, it can mix fertilizers into water to effectively control the amount of water and fertilizer, thus avoiding waste and presenting distinct water-saving effects.

2.3 Drip irrigation

Drip irrigation is the approach of using plastic pipelines to drip water through orifices or droppers on the capillary tubes with a diameter of about 10mm to the root of plants for partial irrigation. It's the most effective water-saving irrigation method in drought-stricken areas where water falls short. More importantly, the water utilization rate can reach 95%, which is high all over the world . Drip irrigation demonstrates greater water-saving and production increase effects than spray irrigation. At the sametime, it can increase the effects of fertilizer, being suitable for fruit trees, vegetables, commercial crops and greenhouses. Drip irrigation accounts for a small proportion in the water-saving irrigation of Xingtai, being about 0.7%, but its water-saving effect is significant.

(Sheet 4) Comparative statistics of drip irrigation and canal irrigation in cotton field

	Water consumption/m ³ /mu	Electricity cost/yuan/mu	Time/minute/mu	Labor/man/mu
Drip irrigation	15-20	7	20	1
Canal irrigation	70-80	30	60	2-3

According to Table 4, owing to reduction of depth seepage and ground evaporation, the water used in drip irrigation is saved by around 75%. The area of irrigation has increased from 300 *mu* per well to 600 *mu* per well. Moreover, it prevents the shortcoming of fertilizer being carried away by water, and thus enhances the effect of fertilizer by about 20%.

In the survey, the drip irrigation equipment adopted in Haisheng Pear planting base of Weixian County, Xingtai, was a revelation. Haisheng Group is the world's largest enterprise of condensed fruit and vegetable juice production and processing, and also the key leading enterprise in national agricultural industrialization. It employs the drip irrigation system introduced from Israel, automatic central control system imported from the U.S. and land inspection system of Germany which allow the adjustment of water and fertilizer for as precise as each pear tree.

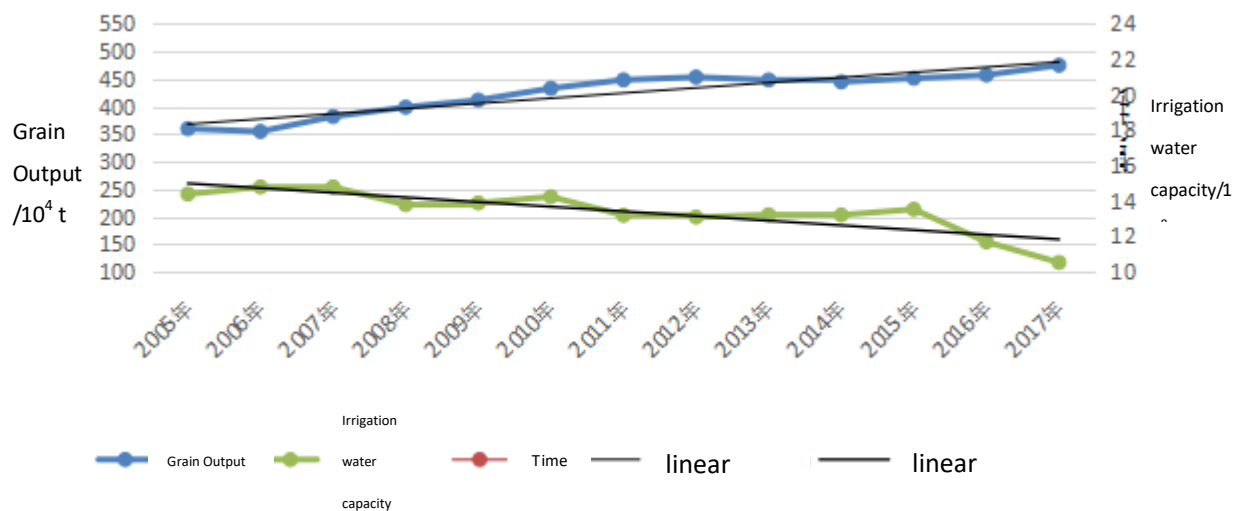
Haisheng Pear planting base utilizes efficient drip irrigation technology. It occupies 2000 *mu* of land but only 11 people are needed to complete all procedures; compared with traditional practice of 20 *mu* per person per day, it saves labor by 70%; in the irrigation process, with drip irrigation being adopted, water of 5,000m³ in total is consumed for 2,000 *mu* every month. Nonetheless, traditional flood irrigation requires at least 9,000m³. Therefore, it saves water by up to 80%, and meanwhile guarantees high quality of pears.

3.Problems and Prospects of Water Saving Irrigation at Present Stage of Water Saving Irrigation Achievements in Xingtai City

Through about two decades' development in Xingtai, the achievements made in the agricultural water-saving irrigation are obvious to all but some problems have been exposed during the period:

3.1 Result achieved

Through comparative analysis of information on the water used for agricultural irrigation and grain output of Xingtai from 2001 to 2017, the water consumption in agricultural irrigation took on a trend of progressive decrease while the grain output showed a rising trend and the agricultural water use efficiency evidently increased. In 2001, the water consumption of agricultural irrigation was $15.9293 \times 10^8 \text{ m}^3$ which was reduced to $10.5487 \times 10^8 \text{ m}^3$ in 2017, with an average annual decrease of $0.3165 \times 10^8 \text{ m}^3$. The grain output in 2001 was $361.0 \times 10^4 \text{ t}$ and the total grain output in 2017 was $475.1 \times 10^4 \text{ t}$ with an average annual increase of $6.7117 \times 10^4 \text{ t}$. The following figure displays the curves that indicate changes in agricultural water consumption and grain output of Xingtai. As grain output grew steadily, the irrigation water use declined year by year.



Contributing to the development of efficient water-saving agriculture, in the last three years, Weixian County has saved 176 million cubic meters of water in total and diverted 183 million cubic meters of water. A balance between exploitation and

replenishing of shallow underground water is basically realized. The water level of shallow underground water near the river channels picks up by about 10 meters, and the number recovers by about 7 meters within 2 kilometers along the river channels, and by about 3 meters within 5 kilometers. The annual average exploitation of underground water is 127.58 billion cubic meters.

Table 6 shows survey data on the benefits of water-saving irrigation in Xingtai. As shown in the table, in 2016, the sowing area rose by 10,196 hectares compared with the year of 2013, with an average annual growth of about 0.2%. The total crop output increased by 89,866 tons, registering an average annual growth of about 0.5%. Both ecological and economic benefits were enhanced.

(Sheet 6) The revenue of water-saving irrigation

Units: thousand hectares

Year	2013	2014	2015	2016
Sowed areas (hectares)	1018702	1018967	1024421	1029163
Total output of grain(hectares)	4484739	4447854	4511001	4574605

3.2 Problems found in the survey:

3.2.1 The scale of planting is the major cause for limited development of efficient water-saving irrigation.

In particular, projects such as spray irrigation and micro irrigation, given their large scope of irrigation, tend to involve multiple households in each irrigation. Accordingly, it is difficult to promote by household while the operating effects are also hard to ensure. In addition, it's found in the field survey that spray irrigation and micro irrigation are suitable for large-scale planting areas. For instance, the first-phase project of modern pear industrial demonstration project built by Haisheng Group in Weixian County covers an area of 2,000 *mu*; later on, the second land third phase will be successively developed, and a pear planting base of ten thousand *mu* is planned to be constructed.

3.2.2 Individuals and enterprises are not willing to invest in efficient water-saving irrigation, and few efforts are made.

As farmers value the benefits of irrigation, their awareness of active water saving is insufficient. Chinese policies focus on pipeline construction, and emphasize project construction and operation management but without offering incentive and restraint over water users. As a result, farmers are unwilling and incapable of throwing themselves into the construction of water-saving irrigation.

3.2.3 "Water saving first" has not become the conscious action of the whole people.

Much as the public awareness of loving, cherishing and saving water has been apparently heightened, there's still lack of cognition with respect to water crisis, water concern and water safety. Besides, the unfavorable habit and form of water use which

has been developed over a long time have not fundamentally changed, and water saving has not become the conscious action of each individual.

3.3 Personal advice based on the above questions

3.3.1 Governments and enterprises should make greater efforts to boost rural land transfer, and establish technical standards and systems for water-saving irrigation, and standardized demonstration bases.

To be more specific, they should set up technical standards and systems that integrate project standards, product standards, agricultural standards and management standards. Centering on rural households, they should take active part in land transfer, realize uniform planting, uniform irrigation and uniform fertilizer application, and build an integrated standardized and normative agricultural water-saving irrigation demonstration base, thus substantially implementing such standards.

3.3.2 Governments and enterprises should establish sound water-saving laws and regulations.

Water-saving irrigation is a systematic project which must be managed through comprehensive means of law administrative technology, economic publicity, education and management while also requires jointly promoted by the concerted efforts and collaborative forces of the entire society. It needs a full-scale improved and refined water-saving standard at the earliest date so as to provide powerful guarantees for the implementation of water-saving irrigation. In addition, they should formulate scientific indicator systems for total water consumption control and quota management to increase prices for extra consumption and reward for water saving, and gradually establish an agricultural water distribution and management mechanism which is in line with China's national conditions and water conditions.

3.3.3 Governments and enterprises should organize extensive publicity and education activities to enhance the water-saving awareness of the whole people.

Water-saving publicity can increase farmers' water-saving knowledge and make the society identify with the governments' water-saving policies. They should fully use diverse media such as TV, radio and newspapers to make Chinese guidelines and policies about water saving win popular support, and make farmers realize the preciousness, finiteness, importance and irreplaceability of water resources; strengthen public awareness of the water crisis, keep heightening the awareness of saving and cherishing water, and thus achieve the effect of proactive participation in water-saving irrigation.

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