

# Research on Water-saving Reform Modes on the Paddy Irrigation District in Northeast China

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**Abstract**—Northeast China is the traditional old industrial bases and one of the main marketable grain bases, in which the paddy planting area occupied 72.0% of that in the north of China. And the agricultural water-use amounts to 70% of the total water consumption in Northeast region, among which about 95% was utilized for paddy field irrigation. In this study, we investigate the actual problems and difficulties in the Northeast rice irrigation districts in the recent years, such as the reducing irrigation water supply, waste of agricultural irrigation water-using, low water price, low efficiency of water management, old and unmatched water conservancy facilities, and so on. According to the serious situation, some concrete Water saving reform modes were put forward to promote the sustainable development of Northeast China irrigation districts.

**Keywords**—rice production; water saving reform; irrigation district; northeast China

## I. INTRODUCTION

Northeast China, with advantaged agricultural producing conditions, is the old industrial base and one of the most important commodity grain production bases, which plays a significant role in food security in China for with about 16% of total area of the national cropland area and 17% of the total amount of grain production. According to related statistics in 2005, the paddy planting area occupies 72.0% in the north of China[1].

However, the rice production in the northeast region depends much on existing irrigation and drainage facilities. The total water consumption of the northeast area is 60.5 billion m<sup>3</sup> in 2007, accounting for 10.4% of China, in which, the agricultural water-use amounts to 70% of the total water consumption in northeast area, and among them about 95% was utilized for paddy field and irrigated land[2]. Although the precipitation here is relatively rich, space and time distribution of which is not very uniform, so the precipitation can not exactly fulfill water requirement of the paddy in its different growth stages. According to some concerned researches<sup>[5,6,7]</sup>, water requirement of crops in rice growth stages is about 400mm to 900mm during the average drought year. That is to say, some parts of the northeast region have relatively rich cultivated land resources, where natural resources such as light, temperature, heat and so on, can satisfy the requirement

of rice production, while in most parts, water requirement of rice is much larger than the precipitation. Therefore, there must be enough and reliable irrigation conditions in order to ensure needs of paddy growth.

## II. MATERIAL AND METHODOLOGY

### A. Study Area

Northeast China includes Liaoning, Jilin, Heilongjiang three provinces and the east of Inner Mongolia Autonomous Region (Figure1), with 1240 thousand km<sup>2</sup> total area and 120 million population[1]. Plain was the primary terrain about 400 thousand km<sup>2</sup> above, 1/3 of the total plain area of China, included Songneng Plain, Sanjiang Plain and Liaohe Plain.

Meanwhile, The cultivated area reaches 215 thousand square kilometers, and the average cultivated land in China Northeast is 0.309 hectares (3 times that of the country), which has 39 large-scale irrigation districts at present, and most are paddy fields. The effective irrigation area is 630.5 thousand hectares which accounts for 4.71% of the national large-scale irrigation district area[3](table1).

### B. Methodology

To fulfill the objective of this study, relevant water resources data from Heilongjiang, Jilin, Liaoning three provinces and the east of Inner Mongolia were collected to analyze the water problems involved in the paddy fields. The systematic analysis methods were used to evaluate the current development of the rice irrigation area and water-saving reforming trend in the coming future

TABLE I LARGE SCALE IRRIGATION DISTRICTS AND ITS AREA DISTRIBUTIONS IN NORTHEAST CHINA(2008)

Province	Amount of Large scale irrigation	Effective irrigation area	
		Area (ha)	Percent to the country (%)
China	434	1779.4	100
Liaoning	11	31.81	1.87
Jilin	8	13.66	0.77
Heilongjiang	20	17.58	2.07
Total	39	63.05	4.71

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Figure 1. Location of study area

### III. RESULTS AND DISCUSSIONS

#### A. Agricultural Irrigation Area

According to the relevant prediction[1,3], about 60% new increased grain production in China will come from the Northeast China in the next 15 to 20 years. That is to say, 40 billion kilograms of additional grain will be produced in northeastern region, equivalent to 50% of the status quo productive capacity in this area. Anyway, Increasing rice production will be the future development direction in agriculture.

In the case of maintaining existing cultivated land area, according to the present land use and development potential in the Northeast China, farmland irrigation area were expected to reach 7.86 million ha in 2030, among which, paddy field area can reach 4.3 million ha, approximately 54% of farmland irrigation area, with an increase of 1.2 million ha compared

with 2000. Because Songhua River Basin has better conditions of water and land resources in the Northeast China, the rise of farmland irrigation area, particularly in rice irrigation area, is mainly concentrated in this area.

#### B. Main Problems of Paddy Irrigation Area

Most of the paddy field irrigation area in the northeast was gradually developed with rice cultivation expanded, which played a huge role in the development of national economy and the construction of commodity grain bases. But with rapid economic and social development, more and more irrigation infrastructures are now needed for rice production. As Most existing large irrigation areas were built in 1950s ~1970s, plus China is in socio-economic transformation period, without large financial support, many water conservancy engineering facilities are working in poor conditions. At present, lots of problems are appearing.

##### 1) Regional distribution of water resources and irrigation water-use

The total amount of normal average water resources is 198.7 billion m<sup>3</sup> in Northeast China (table 2). Per capita water resources is around 1672m<sup>3</sup>, and 515 m<sup>3</sup> for per acre. According to prevailing international standards, water is deficient in Northeast region, where Liaoning province is the serious water shortage area. Regional distribution of water resources in Northeast China appears the situation that "northern region is abundant, but the south is scarce, and the eastern region is much, but the west is little". Among that, the total amount of water resources is 96.08 billion m<sup>3</sup> in Songhua River Basin, account for 75% of that in Northeast China, where Per capita water resources is around 2327m<sup>3</sup> which is higher than the average level in Northeast China. And the normal average water resources is 49.53 billion m<sup>3</sup> in Liaohe River Basin, account for 25% of that in Northeast China, in which Per capita water resources is around 905 m<sup>3</sup>, belonging to the area of severe water resources shortage.

TABLE II. WATER RESOURCES INVESTIGATION AND EVALUATION RESULTS IN NORTHEAST CHINA (1956-2000)

Subzone	Calculation area/km <sup>2</sup>	Precipitation /×10 <sup>8</sup> m <sup>3</sup>	Total amount of Water resources/×10 <sup>8</sup> m <sup>3</sup>	Per capita water resources/m <sup>3</sup>	Per acre water resources/m <sup>3</sup>	
Songhua River watershed	934802	4718.8	1491.7	2327	544	
Liaohe watershed	309733	1691.2	495.3	905	445	
Provinces	Hei-longjiang	454817	810.3	2124	460	
	Ji-lin	187400	1144.6	399.0	477	
	Liao-ning	143796	977.0	339.6	811	546
	East of Inner Mongolia	458522	1862.0	438.1	3719	688
Total	1244535	6410.0	1987.0	1672	515	

From the late of 1970s, affected by the arid climate and increase of cities and industrial water, China Northeast region has appeared crisis on water resources supply and demand. With the expanding scope of urban water shortage, more and more irrigated water was reduced to turn to industry and the city life water supply. So irrigation water had to be developed from the other ways (such as using city waste sewage, pumping groundwater, etc) or carried out deficient irrigation and some water-saving measurements. At present, industrial and municipal water use is squeezing agricultural water, which is becoming increasingly serious in Northeast region.

##### 2) Efficiency of water-using

Insufficient surface water supply and excessive ground water exploitation exist at the same time in Liaohe River basin. Songhua River basin has relatively rich water, but in lack of water resources regulation engineering. Anyway the water demand is growing significantly faster than water supply in Northeast China. In addition, in many irrigation areas, rice production is so dependent on wells pumping, that resulted in underground water levels continuing to decline, which has been making regional eco-environmental deteriorate gradually.

In addition, the irrigation infrastructure and equipment are

inadequate in paddy fields, some water conservancy facilities is too old to work well, some are working in poor conditions, and so on, which results in the present irrigation water use efficiency being only about 47% in the Northeast. So, on one hand, effective irrigation water is lacking, on the other hand, the limited irrigation water is wasting a lot, which often seriously affected the normal growth of the rice, and added irrigation costs and rice growers' economic burden.

### 3) *Irrigation and drainage facilities and middle & low yield paddy fields*

According to related statistics, annual average yield for rice per Chinese acre is only 438.2kg from 2001 to 2005 in Northeast region[3], but it is 500~600kg in high yield rice field, some super high-yielding irrigation area can reach 700~800kg. The middle and low-yielding and high-yielding rice fields difference can reach 40% to 50%. It is often not matched for irrigation and drainage facilities in Low yield fields, which are fragile to prevent from drought, flood and waterlog.

### 4) *Ecological environment in rice irrigation areas*

At present, soil and water loss of in Northeastern black soil region has reached 275,900 km<sup>2</sup>, which is more than one-fourth of the total land area in Northeast China. Original thickness of organic soil was 80~100cm years ago, but it is only 20~30cm now. Soil organic matter content has been reducing significantly in the last 20 years, so land productivity declined. Owing to the low utilization of rice irrigation water, coupled with poor drainage, it resulted in the secondary salinization in some paddy fields. In addition, in some irrigation area, over groundwater was drafted, which resulted in underground water levels dropping and destroyed the ecological environment. For example, Sanjiang plain of Heilongjiang province reclaimed wetland, drained surface water, and drilled too much groundwater for planting rice, which made local wetland area gradually shrank[4].

### 5) *Irrigation management mechanisms*

It is a prevalent phenomenon in Northeast irrigation area that people emphasize the construction but ignore daily irrigation management. Many large-scale irrigation area management organizations work in low efficiency. The running mechanisms in irrigation area do not meet the needs of the Socialist market economy, the irrigation management is to a certain extent disorder, and responsibilities and rights are not very clear. In addition, managers are lacking of knowledge of modernization management in irrigation area, whose technical quality is low, can not adapt to the needs of modern irrigation management.

### 6) *Water price and irrigation water- using management*

The irrigation water price is far below water supply cost in Northeast paddy irrigation area, and the water charged policy is not reasonable. In some irrigation areas, it is difficult to get water-using fee, some charges are in arrears, intercepted, and misappropriated seriously, which not only makes irrigation area management units have less income, in that lacking daily-life running maintenance fund, but also making farmers have got used to following extensive and backward of flood irrigation. If all above exists for long time, it is easy to cause

more serious waste of water resources, and restricted the sustainable development of rice irrigation area.

## C. *Water Saving Modes for Paddy Fields*

### 1) *To strengthen the maintenance and reconstitution on canal head and canal systems facilities*

First of all, it is to strengthen the reform and reconstruction for the canal head and the important facilities of the canal systems. Secondly, it is of great importance to select suitable canal seepage-controlling materials and sectional structure. As the same time, it is necessary to improve concerning engineering corollary equipments. Due to the Northeast China is located in the Alpine region, canal seepage water-saving reforming need to protect from frozen heaving problems, especially in high underground water level of irrigation lands, also should solve well the problem of seepage-controlling canals and drainage.

### 2) *To carry out measures on management of water-saving and establish water-saving incentive mechanisms*

Firstly, try to distribute agricultural water resources with unified plan, and try the best to improve the water management policy in the paddy fields. Secondly, try to implement scientific irrigation methods for "three concentrations and two shortenings". That is to say, in order to save irrigation water-use, reduce carrying canal water loss and shorten the period of rice transplanting time, the irrigation organization concentrate to supply water, the farmers concentrate to pond paddy fields and concentrate to transplant rice seedlings in a fixed time. Thirdly, try to carry out participatory irrigation management, collect suitable water management fee according to the quantity of water-using. Through establishing quantity charge system and water-using evaluation system, and setting up the necessary water measuring equipment networks, try to timely account the amount of water use, irrigation area and concerning water fee, try to be "open, fair and equitable" for rice farmers.

### 3) *To carry out water-saving and high yield irrigation methods*

Due to the reduction of water resources, irrigation area need to vigorously promoted advanced water-saving irrigation methods. Wet-shallow irrigation, controlled irrigation and Wetting irrigation in place of the traditional irrigation system, should be promoted in Paddy fields of Northeast China. Irrigation experiments and local practices show that adoption of a scientific and reasonable water-saving irrigation methods, not only can greatly reduce irrigation quota, but also increase crop water productivity, and improve the rice yields.

### 4) *To combine water-saving reform with new irrigation area rebuilding and extension*

Because actual irrigated area did not attain the design standard in most irrigation district of Jilin and Heilongjiang province before, it is very necessary to combine old irrigation area reform with new irrigation extension nowadays. The new built irrigation areas have many advantages than before, such as application of new engineering technologies, the improvement of saline-alkali, wetland protection, rehabilitation of ecological environment, which are all good combination.

Many modern management measurements can be undertaken from the planning stage of the new irrigation region.

5) *To combine the use of surface water with groundwater and improve irrigation guarantee rate*

In recent years, due to the lack of surface water, groundwater is massively developed in Northeast plain. For example, agricultural water used by paddy irrigation area is mostly groundwater, which nearly accounts for 60% of the total water in San-jiang plain of Heilongjiang province. Groundwater exploitation is increasing so rapidly there, which resulted in groundwater level dropping year by year. The average level was 5.2 m in 2000, even over 9 m in some districts. Spacing of many wells was less than the radius of influence, which made many wells can not pumping enough water, so they were scrapped. In this case, people should be encouraged to priority use of surface water in the irrigation area, and well-canal combined irrigation patterns can be used to reduce the exploitation of groundwater. At the same time, irrigation-drainage canal system should be well constructed to retain rainfall-runoff, and increase rainfall infiltration to groundwater. In addition, try to improve surface irrigation canal systems, make full use of surface water, promote the increase of irrigation efficiency and guarantee the sustainable development of irrigation area.

6) *Extensive publicity for water-saving and enhancing training for rice farmers*

Water-saving publicity should be developed more extensively by all sorts of medias, which is helpful to help rice farmers gradually changing their irrigation habits which were formed for a long time before, and let them recognize the present water crisis and the importance of water-saving irrigation. Besides, experts in agriculture and water resources fields can be invited to give courses for water-saving irrigation training for farmers, local technicians and administrators, which can make new contributions to the sustainable supply of irrigation water resources and national food security.

#### IV. SUMMARY

There are relatively rich land area and water resources in Northeast China, and the potential of developing agricultural

irrigation is huge in the future. In order to develop water-saving irrigation, promote water-using efficiency and enlarge paddy area in Northeast China, some combined countermeasures must be utilized together, such as water resource engineering technology, water-saving irrigation policy, agronomic water-saving technology, advanced water management modes, and so on. All of that should be suitable to the North-East characteristics of rice irrigation area, and can promote irrigation changes from traditional irrigation mode to the modern model.

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