AGRICULTURAL DEVELOPMENT AND ITS INFLUENCE ON WATER RESOURCES IN WATER DEFICIENT SALINIZED REGION, CHINA

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Environmental problems such as water shortage and waterlogging and ecological problems, are the most serious problems human face.

1. Agricultural Background of Huang-Huai-Hai plain in China

Huang-Huai-Hai plain, so called three river plain in Japan, including 316 counties from 5 provinces and 2 cities, covering an area of 350,000 km^2 with 18 million hectare of arable land occupied by 200 million people, is the greatest plain and the most important agricultural region in China. It produces 20% of grain, 57% of cotton, 17% of oil and 14% of meat for the whole China.

According to the statistics, the increase of Chinese grain production during the last 40 years is showed in table 1:

TAb. 1 Analysis of increase of food supply in China (billion kg)

stage	one	Two	three	four	five	
Lasting period	1949-58	1959-78	1979-84	1985-93	1994-2000	true yield
(years)	9	20	6	9	7	in 1993
3 provinces in Northeast China	6.65	14.02	13.09	11.70	12.5	5.99
7 provinces in North China	18.09	31.5	20.7	29.47	15.0	125.66
5 provinces in northwest China	4.96	6.94	4.42	6.77	5.0	29.92
5 provinces in southwest China	13.29	18.71	12.67	5.23	5.0	76.28
10 provinces in southeast China	27.65	52.65	43.40	-3.99	12.5	164.75
total increase	70.63	123.82	94.28	49.18	50.0	456.48
average yearly increase	7.85	6.19	15.71	5.46	7.14	
total national yield	200	304.75	407.3	456.45	506.45	
yield per unit(kg/hm^2)	1642.5	2527.5	3607.5	4132.5	4590	
t/ha	1.6	2.5	3.6	4.1	4.6	

From 1949 to 1993, the national grains production increased by 343.28 billion kg, which was 3 times of that in 1949. Grain production from 5 provinces and 2 cities in Huang-Huai-Hai region increased by 99.76 billion kg, which made up 29% of the total national increase, and mainly on plains areas.

2. Comprehensive control of drought, waterlogging, alkalization, and salinization and change in water and soil condition in Haihe plain

In order to improve grain yield, aside from development in sciences and technology and in society, an important way is to optimally utilize natural resources. The improvement of yield depends on the utilization of water resources. Generally, yield increase results from a higher input of water. This results in another problem, since Haihe plain is already lack of fresh water.

Climate in Haihe watershed is mild. Although the precipitation varies from 400 to 600 mm, the difference between different years is very big. The unevenly distributed precipitation, which is generally illustrated by 70 to 80% of rainfall taking place in the period from July to august, and 40 mm to 60 mm of rainfall and sometimes no rainfall in more than one hundred days period in spring, always results in dry spring and waterlogging summer. Thus, flooding always results in the upward move of salt from ground water and furthermore causes salinization and alkalization problem. Just as described by farms, soil surface in spring is white and covered by water in summer.

To increase crop yield, the cycling of drought and waterlogging needs changing. A best way to do so is to make use of irrigation system. Thus, during the last 40 years, a comprehensive control method for drought, flood, alkalization and salinization is summarized. This method includes constructing reservoirs in upper streams, draining salty water by digging rivers and digging wells for irrigation. Up to now, reservoirs in upper stream in mountainous areas hold a big amount of runoff and rivers in low land drain a big amount of water directly to the sea, thus the waterlogging problem is basically solved. By developing agricultural irrigation system, drought in spring is offset, meanwhile the ground water table drops. Thus the possibility of secondary salinization is decreased. At the present, 60% of field can be irrigated. Crop yield is improved greatly.

Many ways can result in the increase of crop yield. But the use of ground water is very critical. Generally, to produce every one kilogram of grain, one cubic meter of water is needed. Therefore, to improve grains yield, the uptaking of ground water must be increased. This has result in over- exploitation of ground water. For example, in east part of Haihe plain, the recharge of ground water is 60,000-80,000 $m^3/km^2\ a^{-1}$, but the water discharge is about 120,000 $m^3/km^2\ a^{-1}$, which creates a overdrafting of 20,000-60,000 m^3/km^2a^{-1}. In west part where near the mountain, the overdrafting of ground water is about 100,000 $m^3/km^2\ a^{-1}$. That means yield increase is contributed from the over utilization of ground water. Then, water deficiency results in a drier soil condition and desertification, local hot stove and worsen climate. Under the premise of settling the exigent food problem which is closely related to human beings, the cycle is getting more and more serious.

3. Water shortage is the critical barrier of agricultural development and soil

improvement

The present situation of water resources in Haihe watershed can be described as follows:

- Depletion of surface water.

From the mid-1970s, after the transformation of rivers in Haihe plain, boat transportation disappeared and all rivers dried up except the upper stream of Baiyangdian lake. Even in rain season, there is hardly any river with water flow.

- Limitation in transferable water.

During the history, a certain amount of water could be transferred from Yellow river to Haihe plain through big Canal. But since the increased utilization of water in Yellow River, the water transfer was broke off in 1980. In 1993, with the government interference through the negotiation of different provinces, 10 billion m^3 of water was transferred from Yellow river to Hebei during the period from November to February next year. But in recent years, since, in spring, Yellow river always dried out, available water for transferring was very limited.

- Dropping of ground water table.

The exploitation of ground water results in dropping of ground water table. In the low plain areas, the density of deep wells is 0.3 wells/km^2. Ground water table drops in a speed of one meter per year to present 35-55m. Shallow ground water table in east is now 3-8m below the ground, and 20-28 m in piedmont plain. Most natural lakes such as Ningjinbo and Daluze dry up.

- Decreasing of soil water content.

As the precipitation distributes unevenly and ground water table drops, soil water can't be recharged, especially in spring season when crops request water. Usually, soil in top 40-50 cm is very dry or nearly exhausted. Even after rain or irrigation, soil water in the top layer still can't be raised up totally which result in a drought situation similar to losse platue in Northwest part of China.

- Salinization problems.

  In large scale, since the dropping of ground water table, saline soil and alkali soil areas are shrinking, However, in some special parts, the decrease of runoff results in an accumulation of salt in soil. According to the estimation by Shi Yuanchun, salt accumulation in soil can be 2788.5 kg/ha.a. According to the experiment from some certain sites, an increase of 0.01% in soil salt content can averagely result in an decrease in winter wheat yield by 187.5kg/ha. In addition, the serious shortage of fresh water stabilizes soil salt content.

So, the shortage of fresh water is the greatest barrier to crops yield increase and soil improvement.

4. Water saving and water transfer

Is there no way to settle the present agricultural problems? The answer is no. To protect ecological environment and increase agricultural production to meet the food request of increased population, water saving technologies and water transfer projects are taken into

effect in China. Water saving technologies are intended to improve water use efficiency. In fact, water saving technologies in Haihe plain have a great potential which can be suggested through the comparison of WUE in different regions in Haihe plain, as listed in table 2.

Tab.2 Comparing water use efficiency in different areas in Haihe Plain

Areas	piedmont areas	west part of Heilonggang	east part of Heilonggang	coastal plain
biomass(g/m^2)	1350	492	407	222
WUE*(g/m^2mm)	1.59	0.87	0.71	0.40
grain production (g/m^2)	542	175	144	60
WUE for grain (g/m^2mm)	0.64	0.31	0.25	0.11

* WUE: Water use efficiency.

Water saving agriculture is an effective way to increase grains' yield and WUE. It can be developed through the application of high efficient irrigation system, plastic film covering, proper fertilizer addition and good varieties.

To utilize land resources and solar energy effectively, transferring water across watershed is also a measurement to develop agriculture. Now, water from Yellow river is been transferring into Hebei province. But because of the high content of sands in Yellow river during flood season (200-300kg/m^3, even to 600kg/m^3), water can only be transferred after the flooding period when several provinces along Yellow River also need water for agricultural purposes. Thus, water supply from Yellow River to Haihe river plain is only 1.5-2.0 billion m^3/a which is far from the request. In 1997, resulted from the overdrafting of water from Yellow river, Yellow River was dried out from February to June. Thus, available water for water transferring is very limited. The project to transfer water from Yangtze river to Beijing, Tianjin and Hebei Province may need several decades of time and a huge investment to be implemented.

5. The effect of South-to-north water transfer on climate and soil environment

Transferring water across watershed is a way to settle the problem of water shortage in north China. But it may also causes many ecological problems.

- Transferring water in winter for spring utilization needs to store a lot of water in ditches and reservoirs. This way can easily result in ground water table rise up and secondary soil salinization.
- Storing water in large scale could change the local climate especially in rainy seasons, a contradiction of draining and storing water could happen.

All above problems are very important aspects for attentions. At the present, Dalangdian reservoir has been constructed to store water transferred from Yellow River to Hebei Province. Fortunately, this reservoir is very near to our Nanpi Experimental Station. This provides us a basic opportunity to study the effect of South-to-North water transfer on environment.