Water Resources and the Approaches to Alleviating Irrigation Water Shortage in the Hebei Plain, China

J.R. Cao and G.S. Zhang[1]

ABSTRACT

THE HEBEI PLAIN is located on the east side of the Taihang Mountain in the Hebei Province. It consists of three parts--the foot-hill plain, the low plain and the coastal plain--with a total area of 60,000 square kilometers (km^2). It takes up one-third of the total area of the Hebei Province and two-thirds of the arable land of the province. It is an important region, not only for Hebei agriculture production, but also for all front economic development of the province. The temperature and heat resources in this region are sufficient for various crops such as wheat, corn, cotton, etc. However, because the wet air is stopped by the mountain range in the southeast, rainfall in this area is 100-300 millimeters (mm) lower than that of the surrounding area and evaporation is 50-100 mm higher. The problem of water shortage is very severe. At present it has become a key factor constraining agricultural development. Coping with the problem of increased demand for water against a deficient supply has drawn a great deal of attention from personalities of various circles. This paper discusses the characteristics of water resources and puts forward some ideas to alleviate the problem of irrigation water shortage, both in terms of water management and water saving technology for the region.

CHARACTERISTICS OF WATER RESOURCES IN THE HEBEI LOWLAND PLAIN

Rainfall

On the Hebei Plain, rainfall is relatively sparse with an annual average of 545 mm. In the driest region, the annual rainfall is less than 500 mm, which can only meet the water requirement of one crop a year. In addition, rainfall varies greatly between different years and seasons. Eighty percent of the annual rainfall is concentrated in the months of June to September. Evaporation is greater than rainfall most of the time. Especially in March, April and May, evaporation is 3-7 times larger than rainfall. Only in July and August is the rainfall larger than the evaporation. Therefore, a spring drought occurs very frequently, almost 9 out of 10 years. Spring droughts severely affect the growth of winter wheat and also results in poor seedling establishment for spring seeded crops such as cotton, spring corn, and soybean. Furthermore, the annual rainfall variability is about 26 percent. In a wet year, rainfall could be as high as 679 mm, while in a dry year it can be as low as 323 mm (Huang et al. 1987). Consequently, flood and drought occurs alternatively. Limited water resources cannot be fully used.

Surface Runoff

It is reported that on the Hebei Plain, the average annual runoff is four billion cubic meters (m^3) (Ibid). Surface runoff occurs mainly in the July/September period during the rainy season, while in the other seasons, surface runoff is very small. Almost all the rivers on the Hebei Plain are seasonal. In spring when drought occurs, all the rivers dry up. In the rainy season, surface runoff passes by in the form of floods, very quickly towards the sea. Thus it is difficult to use surface water resources for agriculture purposes.

Groundwater

In the western foothill plain, groundwater quality is good because of the hundreds of meters of sediment of the quaternary period. Salinity is less than 1 gram/liter (g/l). In the eastern low and coastal plains, groundwater is shallow and evaporation is high. There is a vast area of salty and alkali land in this region. Groundwater salinity is more than 2 g/l. The salty groundwater occupies an area of 37,700 km^2, which makes up 63 percent of the total Hebei Plain (Ibid). There is a great potential for the development of salty water irrigation.

[1]Hebei Academy of Agricultural and Forestry Sciences, Shijiazhuang City, Hebei Province, China. 050051.

ALLEVIATING IRRIGATION WATER SHORTAGE IN THE HEBEI PLAIN

There are only two possibilities to resolve the irrigation water shortage problem: one is to increase the water resources supply; the other is to save the water resources currently available. In accordance with the real conditions of the Hebei Plain, the three approaches towards the problem are as given below.

Diversion of Water from Yangtze/Yellow Rivers

Diverting water from Yangtze/Yellow Rivers to augment the surface water supply in Hebei Plain has been explored for a long time. At present, waters from the Yellow River have been diverted to the Hengshui region. However the amount of water diverted is limited. Currently, annual diversion water is normally only between 30 million to 130 million m^3. Diverting the Yangtze River water is in the planning stage. The Yangtze River has a sufficient water supply. Thus diverting water from the Yangtze will play a very important role in alleviating the problem of water shortage on the Hebei Plain. According to the plan, nearly 5 billion m^3 of water will be allocated to the Hebei Province (Wang 1992). Its economic benefit will be of great significance, especially for water supplied to the cities and to the industrial base along the diverting canal. But for the purpose of agriculture use, it cannot solve the fundamental problem. That is because: (i) the cost of water from Yangtze or Yellow Rivers, is high, while for irrigation it has to be lower (it is estimated that the cost of the Yangtze River diversion of water will be between 13-18 cents per cubic meter (Ibid)); and (ii) the diverted water supply is concentrated both in area and in time, while agriculture water use is dispersed over a wide area. Therefore, diversion of water from Yangtze/Yellow Rivers, while it helps to improve the water supply situation and improve the agriculture ecosystem, cannot be seen as fundamentally changing the drought situation.

Strengthen Water Resources Management

Implement Floating Price for Water Supply

The water supply from hydraulic departments is very stochastic. The amount of water supplied is very much affected by the climate. During the rainy season, the supply is greater than the demand. Limited by the capacity of the irrigation project, excess water needs to be discharged. At this time the price should be decreased. The users may in the future use their own infrastructure facility to save the water for their future use. During the dry season, the water supply is less than the demand. At this time the price should be increased. Using the principle of price leverage would save water resources and ensure the best use of the limited water supply.

Implement Quota System for Water Supply

In China, water resources are very limited. However, farmers use water for irrigation extravagantly. In many townships and villages, flood irrigation is still widely practiced. Irrigation rate per mu per time in some cases is over 100 m^3, which is twice the quantity normally needed (Wei 1993). In the irrigation region, a quota system should be enforced to allocate water for every crop during growth periods. If water used exceeds the quotas, the users should pay double the amount. In Hebei Province, a quota system has been practiced in some regions. In reservoir irrigation, quotas are allocated in advance, according to the cropping patterns in the region. A contract for water use is signed between the user and the supplier. This provides an added incentive to farmers for planning water use and saving water. The problem of extravagant water use is resolved. In river/canal irrigation districts, a "three fixed system" has been developed, that is, the area, rate, and time are fixed in advance. Planned and balanced water use between up- and down-stream regions is guaranteed (Wei 1993).

Extend Irrigation Forecast Technology for Main Crops

As successfully demonstrated in many cases, irrigating crops at critical stages would ensure water use efficiency and save water resources. In Gaocheng County, a winter wheat irrigation forecast technique has been developed (Zhang 1989). This technology can reduce 2 irrigations during the wheat growing season, which saves water by 90 m^3 per mu. In addition, the irrigation is based on the wheat growth pattern. Therefore, the best soil water condition is maintained. The technology not only saves water but it also increased yield by 27.3 percent.

Jointly Invest to Refine Water Conveyance System

At present, almost half of the water is lost during water conveyance in the canal. The major reason is that water conveyance structures are old and need to be repaired. It is reported that in Hebei Province, 10 billion yuan needs to be invested in order to rehabilitate systems to minimize seepage. (Shen 1992). It is obvious that to rely solely on government investment is not possible. An alternative approach might be for the hydraulic departments that use the revenue from the water supply, to rehabilitate the larger projects. For the smaller and in-field projects, such as setting up underground pipes, digging wells, purchasing sprinkler irrigation systems, a joint investment by farmers is an alternative. In some areas in the Hebei Plain, joint development has been practiced successfully. In these cases, a farmer may contribute cash, labor or materials. The principle is that the one who benefits is the one who invests. Joint investment projects increase farmers' incentives, not only in saving water, but also in project maintenance.

Improve and Extend Water Saving Technology

Water Trapping

Since rainfall and surface runoff in the Hebei Plain vary greatly in different seasons and years, it is difficult to realize the full benefits. To increase water use efficiency, an effective approach is to use the available ditch, pit, pool or pond to trap water as much as possible. Water trapping has been very effective in the Hebei Plain. At present, a total of 4,500 ponds have been made with a water trapping capacity of 150 million m^3. Also, 150 flood gates have been constructed along flood drainage canals with a water trapping capacity of 800 million m^3. This has contributed much to local agricultural production. Still, there is a great potential for water trapping. Of the 9,480 natural ponds in Cangzhou Prefecture, only half are in use. There is considerable potential to develop water trapping technology in this region (Lu 1985).

Salty Water Utilization

In the Hebei Plain, there is a vast area of slightly salty water, which has a great potential for enhancing the water supply. The trend towards rationing groundwater utilization, will minimize the use groundwater in the foothill plain, strengthen the exploitation of shallow groundwater, and effectively use the widely available slightly salty groundwater which has a salinity level of 2-5 g/l, in the lowland plain area. In the Hebei Plain, the salty groundwater mainly contains Na_2so_4 and NaCl, which can easily be leached down. Slightly salty water can be used directly for irrigation. Many experiments show that crop yield increased sharply by slightly salty water irrigation. Moreover, there is no salt accumulation in the soil layers after the rainy season. A ten-year case study in Nanpi County showed that salty groundwater irrigation does not cause salinity build-up in the root zone of soil. Salty water irrigation can increase crop yield significantly in dry years compared with nonirrigation (Guo 1992). Experiments in Yanshan County showed that by adding ordinary superphosphate, salty groundwater with a salinity of 5.8-7.3 g/l, can be safely used for irrigation and increase crop yield. By the application of 50 kilograms (kg) of ordinary superphosphate, soil salinity decreased by 34.1 percent (Cui 1994). In the Longhua County of Hengshui Prefecture, mixed irrigation of shallow salty water and deep fresh groundwater diluted water salinity, thus making shallow salty water safe for irrigation. Salty groundwater development has generated very successful results in Longhua County and has a great potential for enhancing the water supply for agriculture.

Seepage Control

Large amounts of water are lost during conveyance along the canals at various levels. In some cases, water loss in the canal and the field ditch can be as high as 60 percent. In addition, seepage also creates the problem of building up salt and alkali in the soil. Using available techniques to control seepage is a very important measure. In Canada, clay lining, concrete lining, soil and asphalt suspension lining, cement and soil lining and plastic film lining have been used successfully for seepage control. The method of using soil with asphalt can reduce the cost sharply. Research has shown that this method can reduce costs by 58 percent. But the efficiency of seepage control is the same with pure cement lining (Cao 1994). In China, it has been reported that the use of coal-ash combined with cement-lime to line canals has been effective. Water use index by lining with this material can reach 0.918. The cost was reduced by 30-32 percent compared with traditional concrete lining (Su 1991).

In the Hebei Province, in order to reduce water loss in the ditch and increase water use efficiency, various ground and surface pipe irrigation techniques have been developed in recent years. It has been reported that by the end of 1989 in the well irrigation region of Hebei Province, a total of 51 million meters (m) of underground pipes were installed in the field, controlling an area of 11 million mu (Xing 1991). Compared with soil ditch, pipe line irrigation can increase the water use index to 0.95, and reduce water use by 30-40 m^3 per mu.

Improve Surface Irrigation

Surface flood irrigation is the most widely used method. Water use efficiency is very low. Improving the techniques of surface irrigation will be an effective way to save water for agricultural use. At present, the Hebei Academy of Agriculture and Forestry Sciences is introducing the surge irrigation technique from Canada, by implementing a joint dryland project. Studies in Canada show that surge irrigation can increase water efficiency. It is an advanced irrigation method both in theory and practice. The mechanism of saving water by surge irrigation is that it provides a uniform water supply in the field so that the water penetrates to the same depth. Water loss from unnecessary deep leaching is greatly reduced. The Hebei Academy will make a further study to test its effect on water saving on the Hebei Plain.

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