Research article

The Present Condition and Problem of Agricultural Water Management in the Northern Part of Taklamakan Desert

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Abstract Irrigation is indispensable to guarantee the agricultural production in arid regions like the Tarim Basin. In this region, administrators and farmers have reclaimed waste land such as gravel and sandy desert, and have attempted agricultural development by securing the water resources. But the poor plan has resulted in a conflict between agricultural land reclamation and water resource development this has resulted in an acute shortage of water in this region. Also, this condition has caused ecological damage. In this paper, problems about agricultural water use were discussed in relation to the real conditions of the water resource utilities and farmers activities. Most of the data on water use and management were provided by the Xayar Water Resource Agency. Interviews with representatives of the branch offices of the agency and farmers were conducted between 2003 and 2009. It was shown that water supply volume per unit of the farmland is tending to decrease because of the changed relations between quantities of intake from the river and the cultivated area during the past ten years. It is clear that the water supply from the river has decreased greatly in the region where irrigation by groundwater pumping had been introduced. Water-saving irrigation is being introduced to overcome water shortages and create new water resources. Though it seems water resources can be effectively saved in this way, improper management will limit effective irrigation in farmland where the water saving irrigation was introduced. In particular, consideration needs to be given to the different water management practices among landowners and farmers. It is there are many problems: lack of adequate management systems; lack of training systems for facilities maintenance. These need to be overcome to enable water saving irrigation to be introduced to the entire region.

Keywords arid area, irrigation, water saving irrigation, Ugen River

INTRODUCTION

In arid regions, agricultural production requires water provided through irrigation. In other words, in these regions agriculture is possible only where there is a source of water. Desert oases exist because of the water resources located there. The Taklamakan Desert, also known as Taklimakan, is a desert in Central Asia, in the Xinjiang Uyghur Autonomous Region of the People's Republic of China. The border area of the Taklamakan Desert contains a large area of farmland, made possible by the development of water resources and the construction of irrigation facilities. Expansion of food demand and industrial output through population increase in China are major factors in the development of agriculture in such regions where water resources are inadequate. Development of farmland and water resources has been facilitated through an injection of both capital and technology involving (1) the Xinjiang Production and Construction Corps (a unique economic and semi-military governmental organization existing in the Xinjiang Uyghur Autonomous Region) and (2) the Great Western Development Strategy, a governmental policy aimed at opening up less developed regions of China. These projects are geared toward agricultural promotion through the reclamation of farmland from desert and the development of water resources. However, water shortages have occurred because of poor planning of land reclamation and water resource development (Abdisalam, 2005). In addition to water shortages for agricultural production, the regional and river basin ecosystem has become degraded by human activity (Feng et al., 2004). The effective use of groundwater, which exists in large amounts, and reduction in water loss through the lining of canals are both effective measures to combat water shortages in this region (Fan et al., 2002). On the other hand, as groundwater levels depend on the extent of seepage of irrigation water (Ma and Li, 2001), the groundwater resources decrease if the seepage is prevented. Moreover, exhaustion of groundwater resources by widespread pumping has been recorded by Xinan et al. (2005) and others. To summarize, we believe that sustainable and effective utilization of groundwater is difficult.

In this paper, problems relating to agricultural water use are discussed against the background of actual conditions of water resources and agricultural activities under irrigation in Xayar County, Tarim River basin. Future water management and effective water resources are also examined.

METHODS AND OUTLINE OF INVESTIGATION AREA

The investigation targeted Xayar County located in the Taklimakan desert in the northern part of Xinjiang Uygur Autonomous Region. Xayar County is part of Aksu Prefecture, and it is located in the lower reaches of the Ugen River which is a tributary of the Tarim River (Fig. 1). The cultivated area was 72,700 ha and the irrigation area was 84,800 ha in this county in 2008. The main crop in the area is cotton, and the irrigation water is supplied from the Kyzyl dam in the upper reaches of the Ugen River. The Kyzyl dam supplies water to three counties: Xayar, Kuqar and Toksu. The administrative district and the irrigation district are assorted. The lower part of the administrative organization of the county is "township and town" and there are eight areas classified as "township and town" (these include Honqi, Yingmaili, Nuerbake, Hailou, Xayar town, Xinkennongjiao, Gulibake, Tuoybao) of the Xayar county in the Xayar irrigation district.

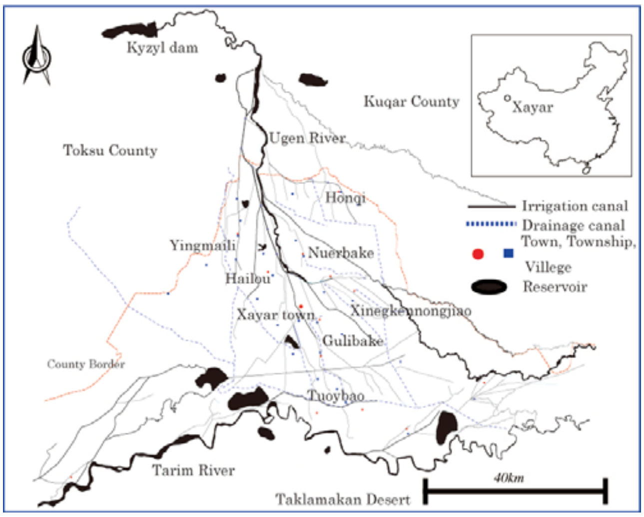

Fig. 1 Investigated area

The irrigation water from the Ugen River is supplied to these townships and towns. There is also a part of water offtake from the Tarim River to the Tuoybao Township. There are many family farmers in this irrigation district. On the other hand, farmland development is managed by a national enterprise in Xinkennongjiao, and there are many capitalists in farmland ownership together with a few family farmers. In order to grasp the present arrangements for irrigated agriculture, interviews with representatives of the branch offices of the agency and farmers were conducted from 2003 to 2009. We obtained data about irrigation water supply from 1998 to 2008, farmland area of townships for 2004 and 2007 in Xayar County from the water resource agency.

IRRIGATION METHODS AND WATER MANAGEMENT

Irrigation water is supplied via one main canal of 50 km length from Longkou Division waterworks, and is supplied to each individual field via the canal system through five stages. In this county, only 4% of the total canal length is lined. The conveyance efficiency is about 60% and irrigation efficiency is only 40%. Irrigation is performed mainly from spring to summer, with minor winter irrigation. From spring to summer, irrigation water is used for general crop growth. Winter irrigation aims to maintain soil moisture, which would otherwise be low in the sowing period of early spring. Border and furrow irrigation occupy about 80% of farmland in Xinjiang (Zhong et al., 2009) and it is similar in this area. In addition, water-saving irrigation technology has been introduced in recent years. The water resource agency in this county is responsible for maintenance of the main canal and water distribution to each township or town, while each branch office is responsible for the management of water distribution and maintenance within each settlement. Water supply to each farm is overseen by local office staff and farmers' representatives. When irrigation water supply is adequate, the appropriate level of water is distributed for each crop and planted area. However, during shortages, irrigation for all fields is not possible. Therefore, the following rules exist when establishing priority.

Spring to summer:
- Upstream takes priority over downstream.
- Larger canals (or irrigation blocks) take priority over smaller canals, because water passing to one large-scale irrigation block suffers less seepage than that to several small-scale blocks.

Winter:
- Downriver takes priority over upriver, because water shortages are more likely downstream at sowing time.
- Wheat fields and land under 30 years contract take priority. Many farmers who plant wheat or have contract land are on a comparatively low income. Therefore, local government has decided to secure poor farmers' production.

MONTHLY IRRIGATION WATER VOLUME

Many irrigation resources in the Tarim River basin are derived from a mountain glacier, and therefore, the volume of irrigation water increases in summer but decreases in winter. Although the Kyzyl Dam constitutes the main water resource in this region, there is a very distinct seasonal bias, with inflow and outflow for irrigation being concentrated in the summer months (Yamamoto et al., 2006). The monthly irrigation water volume (average for 1998-2008) is shown in Fig. 2. The largest volume is supplied in July, followed by August, partly because of high summer temperatures. March and November also show peaks: the former being when sowing occurs and the latter when irrigation is required for wheat. Although irrigation is also required in December and February, this is winter irrigation, as explained above. There is little irrigation water supplied in January because inflow from rivers to the dam is reduced on account of the volume of water locked in by freezing. The water volume supplied from Longkou Division waterworks is more than the total combined volume of irrigation water supplied to each township and town from January to June but is only marginally more than the total to each settlement from July to December. A possible explanation for this is that some of the irrigation water returns to the main canal via groundwater, because part of the main canal is unlined and its elevation is lower than the surrounding fields.

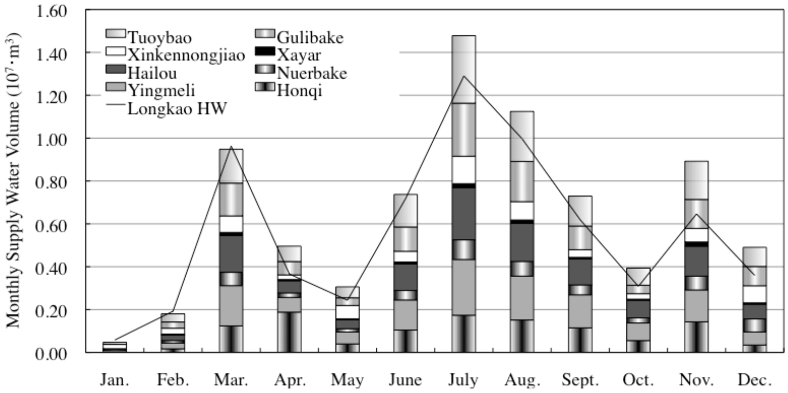

Fig. 2 Monthly supply water volume (average of 1998-2008)

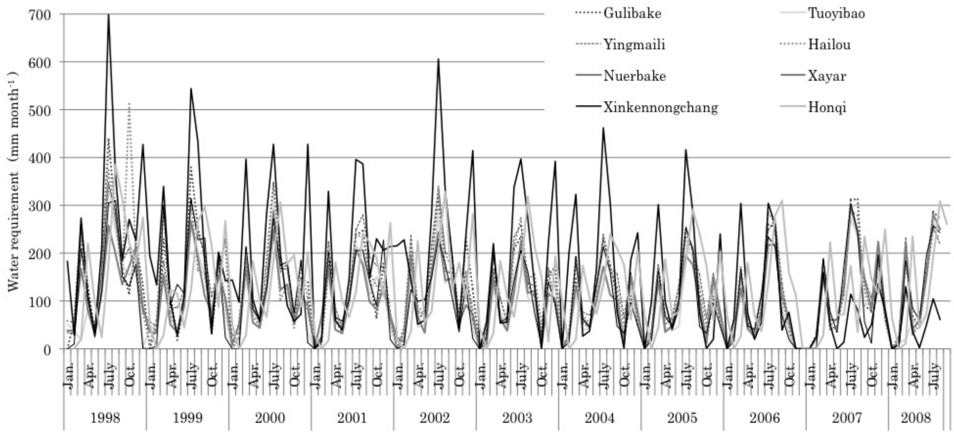

Fig. 3 Variation of monthly supply water volume

VARIATION IN MONTHLY VOLUME OF WATER SUPPLIED IN EACH TOWNSHIP

Fig. 3 shows the variation in the monthly supply of water to each town or township from 1998 to 2008. The areas of irrigation in each town or township were not obtained except for 2004 and 2007 and these values are therefore presumed from two years data. These data showed that the water supply per unit area is found to decrease in each town or township. The decrease was small for all towns and townships except for Xinkennongjiao Township. This reduction in irrigated water supplied is remarkable in Xinkennongjiao Township. One of the reasons for such a decrease may be the abandonment of farmland. However, we cannot detect any reason that the area of farmland decreased. Therefore, the reduction in irrigation water supplied is considered to be due to other factors. Maintenance levels of the irrigation canal have not maintained a high rate of conveyance efficiency in this particular township. Nor has there been any major shift in the types of crops grown locally. It is therefore assumed that irrigation water must have been supplied from other resources, and it is surmised that an increase in groundwater is the reason. Since 2004, a large area in Xinkennongjiao Township has been able to reduce requirements for irrigated water by using groundwater. Why has this not occurred in any other township? The main reasons are that the economic burden involved in construction of facilities is large and there is an inadequate technical input for water-saving irrigation.

WHY DOES A SHORTAGE OF WATER OCCUR?

Irrigation water demands (design net water requirement) and requirements in Xayar County are shown in Fig. 4. A, B, and C and represent design net water requirement, water requirement (supplied irrigation water), and presumed net water requirement (water requirement × 0.4:

irrigation efficiency in this region), respectively (Abdisalam, 2005). The total design net water requirement is calculated from cultivated area according to crops grown in the years 2004 and 2008, and to the design net water requirement for each crop. Data for each cultivated area from 2005 to 2007 that was not available was calculated from the transition in cultivated field area over the same period. C is less than A between 2004 and 2008, and the average annual shortfall volume is 0.76×10^8 m^3. It is thought there is sufficient water available (B), although many farmers argue strongly that there is a water shortage. The relationship between water volume deficit (A-C) and cultivated field area shows that the former becomes larger by expansion of the cultivated area (Fig. 5). Because expansion of cultivated area indirectly indicates the total length of the main channel, it is suggested that the water shortage has resulted from seepage from both canal and irrigation channels.

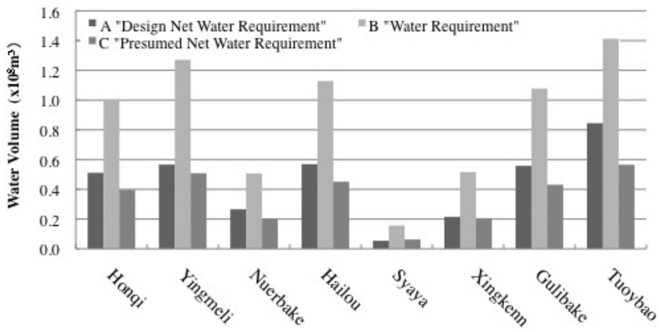

Fig. 4 Water demands and requirements (average 2004-2008)

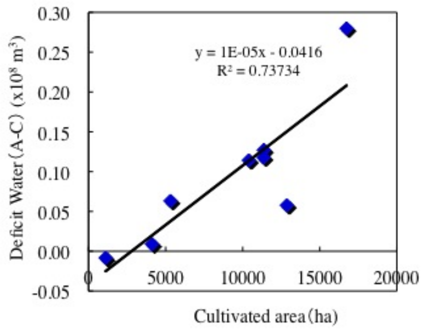

Fig. 5 Relationship between deficit water and cultivated area

CURRENT CONDITIONS AND THE PROBLEM OF REDUCING WATER IRRIGATION THROUGH GROUNDWATER

Chronic water shortages are a problem in China, and the introduction of water-saving irrigation has been proposed as a solution. Since 2007 a water-saving project has been in place for farmers in Xayar County. Water-saving irrigation facilities (drip irrigation) have provided improved irrigation for about 10,000 ha of farmland, equal to about 10% of the total cultivated area in the county. The Chinese government subsidized one-third of the total cost of construction of these works. It was decided that the farmers' liability in this respect would be one-half of the total cost, rather than two-thirds. The remaining cost is borne by the government. However, irrigation facilities cannot necessarily be constructed on all farmlands. Local construction standards recommend one pumping facility for irrigation of about 26.7 ha. Construction of this facility is difficult for the common family farmer because each farmer in this region manages about 1.3-2.0 ha. Although this is about 6.7 ha in Tarim Township, the construction of a pumping facility is not cost-efficient for one family farmer. This situation does not arise for the landowners, as their landholdings are large enough to justify the construction of facilities on their land. On the other hand, in the case of the common farmers, their representative controls each pump. In addition, even if irrigation priorities are decided, some farmers cannot understand the correct operation of the facilities provided, or there may be a lack of cooperation among farmers. Therefore, each farmer irrigates independently; as a result, the water pressure in some irrigation pipes decreases, causing shortages of irrigation water. On occasions, disruption to supply occurs because the pipes upriver are cut in order to monopolize supplies. Problems are exacerbated by the fact that farmers are only given a manual to learn about the scheme, and the manual is in Chinese, which may not be their spoken language.

PROBLEMS IN THE EFFECTIVE MANAGEMENT OF IRRIGATION SYSTEM

It has been demonstrated that seepage from canals is a major cause of water shortages for agricultural land. The solution to this problem requires improvements in water conveyance efficiency in the branch canals. However, the cost of lining of these canals is huge, and any improvement in conveyance efficiency cannot be realized in the short term. In addition, there is the cost of long-term maintenance, as damage occurs from freezing of water within the channels. Therefore, in order to avoid water shortages in the short term, maintaining conventional irrigation and the introduction of water-saving irrigation are considered to be the most effective methods. According to one landowner who uses water-saving irrigation, "The irrigation water requirement was decreased to one-third, when water saving irrigation was introduced." However, this is an example of the ideal situation under effective management of facilities; there are many administrative problems in case of individual farmers. It is therefore necessary to support individual farmers who are not landowners in order to achieve the benefits of water-saving irrigation throughout the entire region. This may be achieved through further financial support for construction of new facilities, a training system for farmers on the maintenance of these facilities, and instilling a water-saving mindset in all those involved.

CONCLUSION

It was confirmed that the main cause of water shortage is seepage from branch canals before they reach farmland, and not the volume of supplied water. It is also evident that the effects of water-saving irrigation are different for the landowner and the common farmer, even if facilities are similarly constructed. The development of water-saving irrigation will be indispensable to the preservation of water resources in this region in the future. The influence of pumping of groundwater on natural vegetation is of concern, and the environmental impact of this on large areas is not yet realized. It will be necessary to examine these environmental concerns, including the evaluation of groundwater resources.

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