Economy and Environment Program
for Southeast Asia
Tanglin PO Box 101
Singapore 912404
Phone: (65) 6831-6854
Fax: (65) 6235-1849
E-mail: eepsea@idrc.org.sg
Web site: www.eepsea.org

RESEARCH REPORT

No. 2005-RR8

# Barriers to Water Markets in China's Heihe River Basin

**Junlian Zhang**
**College of Resource and Environment**
**China Agricultural University**
**No. 2 Yuanmingyuan West Road**
**Beijing 100094, PRC**
**(junlian88@sohu.com/junlian@cau.edu.cn)**

This study assesses the water use rights (WUR) system in Zhangye City, Gansu Province, Northwest China. The research was carried out to see how well the system performs, in terms of its impact on water conservation and redistribution, and to see what barriers stand in the way of its successful implementation.

Under the WUR system, every water user gets a water quota fixed by the government. WURs can be sold, temporarily or permanently. The system was set up because Zhangye City is severely short of water. It is located in one of the driest area in the world and is mainly watered by the Heihe River. Almost all the water from the Heihe is currently extracted for irrigation and this has caused widespread desertification.

The study finds that the WUR system is encountering significant problems. Farmers ignore their groundwater quotas and this is causing the region's aquifer to empty. The study also finds that water quota trades are still few and far between. There are many reasons for this failure, but a key issue is the financial insecurity of the region's farmers. There are also problems with the system itself, which encourages a "use it or lose it" attitude toward water consumption. The study concludes that water use quotas and trading in China must go hand in hand with social and administrative improvements if it is to succeed.

# BARRIERS TO WATER MARKETS

# IN CHINA'S HEIHE RIVER BASIN

**JUNLIAN ZHANG**

**June, 2005**

Comments should be sent to Junlian Zhang, College of Resource and Environment, China Agricultural University, No.2 Yuanmingyuan West Road, Beijing, 100094, China

Email: junlian88@sohu.com or junlian@cau. edu.cn

---

EEPSEA was established in May 1993 to support research and training in environmental and resource economics. Its objective is to enhance local capacity to undertake the economic analysis of environmental problems and policies. It uses a networking approach, involving courses, meetings, technical support, access to literature and opportunities for comparative research. Member countries are Thailand, Malaysia, Indonesia, the Philippines, Vietnam, Cambodia, Lao PDR, China, Papua New Guinea and Sri Lanka.

EEPSEA is supported by the International Development Research Centre (IDRC); the Swedish International Development Cooperation Agency (Sida) and the Canadian International Development Agency (CIDA).

EEPSEA publications are also available online at http://www.eepsea.org.

## ACKNOWLEDGEMENTS

This project was funded by the Economy and Environment Program for Southeast Asia (EEPSEA). I would like to express my sincere gratitude to the following institutions and people who gave me much support, help and encouragement in the pursuit of this study:

- The Economy and Environment Program for Southeast Asia (EEPSEA) for granting me the funding support to conduct this research;
- The China Agricultural University, Gansu Agricultural University, the Ministry of Water Resources, and the Water Resources Bureau of Zhangye City for giving me great field survey and logistics support;
- Dr. Theodore M. Horbulyk, Associate Professor, University of Calgary, and key resource person for this project, for his invaluable comments and instructions on the whole research;
- Dr. Herminia Francisco, Deputy Director of EEPSEA, for her advice and continuous guidance throughout the study period and for sharing her precious time in the write-up of the final report of the project;
- Dr. David Glover, Director, EEPSEA, for his kind support and help;
- Mr. Chen Xiaojun, Deputy Director of the Water Resources Division of the Ministry of Water Resources, for his great support in the field survey;
- Dr. Zhang Liqin, Associate Professor, and Ms. Hao Subo, graduate student, China Agricultural University, for their precious time in data collection and processing;
- Ms. Clare Westwood, for her wonderful and considerable editing and refining of the final report;
- and last but not least, Ms. Catherine Ndiaye, Program Assistant, EEPSEA, for her kind assistance.

## TABLE OF CONTENTS

## LIST OF TABLES



## LIST OF FIGURES

# BARRIERS TO WATER MARKETS

# IN CHINA'S HEIHE RIVER BASIN

Junlian Zhang

*ABSTRACT*

Tradable water rights systems are becoming an important way to achieve distributive efficiency for water resources. However, it is not easy for countries or regions to set up the system and water markets due to the existence of various barriers. In early 2002, the Ministry of Water Resources (MWR) of China initiated an experimental project to establish a water-saving society in Zhangye city in the Heihe river basin in north-west China – this project was the first of its kind in China. The aim of the project was to establish a new water use rights (WUR) system with tradable water quotas and to reallocate water resources reasonably and efficiently through market-based instruments. This report presents the research done on the system and water markets. It has been found that that the system is hard to implement well and that WUR trading is not popular. The barriers to implementing a WUR system are social and administrative in nature. Local farmers cannot be forced to limit their water use because they cannot endure losses caused by water shortage. Local water agencies have no incentive to restrain local farmers from using excessive water. On the other hand, WUR trading faces management, legal, administrative, and fiscal barriers. There are management risks for farmers in switching to low water-intensive crops. It is also difficult for water buyers to buy rights to land and water use from farmers with small parcels. Farmers are discouraged from selling water to the government whom they fear will reduce their water quotas, and divert irrigation water to other sectors. This report gives some policy recommendations to overcome these barriers.

## 1. INTRODUCTION

Governments control the water supply in many countries. These countries typically do not allocate water on the basis of economic efficiency but on other criteria. Fairness or equity may be a guiding principle. The price charged to agricultural users typically does not reflect the marginal costs of supplying water to them. Agricultural water is subsidized by governmental programs to support agriculture. Water use in agriculture is often inefficient and generates adverse environmental effects. Governments who have recognized these problems are slowly adjusting water prices and allowing some limited markets to operate (Hartwick and Olewiler 1998). The tradable water rights system has become a main path to market operations (Rosegrant and Binswanger 1994). Chile and the western United States are two places where water marketing is currently most advanced. The Chilean Water Law of 1981 established the

basic characteristic of property rights over water as proportional share; changes in the allocation of water within and between sectors are realized through markets in tradable water rights (Schleyer and Rosegrant 1996; Hearne and Easter 1995). To date, water marketing has largely involved transfers from relatively low-value, inefficient irrigation canals to municipal and industrial users.

However, it is not easy for countries or regions to set up water rights trading markets due to many kinds of barriers: political, legal, administrative, cultural, psychological, technical and geographical. (Bauer 1997; Thobani 1997; Frederick 2002). In the 1970's and early 1980's, several researchers noted barriers to market-determined water transfers (Tregarthen 1983). Randall (1981) identified the threat of monopoly or foreign ownership, a perceived loss of subsidies, and the eventual closure of water channels (as a result of regional market transfers) as sources likely to impede market acceptance. Gaffney (1997) identified four impediments to functioning water markets in the United States. These included (1) a lack of seller motivation and market distortions exacerbated by hoarding behavior; (2) licensees withholding entitlements for fear of creating a public perception of surplus entitlements; (3) institutional inconsistencies in the treatment of groundwater, and differential levels and transparency of subsidies; and (4) the divesting of public property to the private sector to enhance market activity and encourage rent-seeking behavior. Bauer (1997) identified four obstacles in the development of water markets in Chile: (1) geographic and infrastructure constraints; (2) legal and administrative restrictions resulting from the failure to identify and quantify unused or non-activated entitlements, and ill-defined rights; (3) cultural and psychological attitudes regarding the importance of irrigation as a symbol of national endeavor, willpower, and overcoming hardship and (4) an ingrained skepticism of market processes, prices, and value obstacles because price signals remain uncertain, ambiguous, or contradictory. Tisdell and Ward (2003) explored farmer responses to the introduction of water markets in the Goulburn-Broken Catchment of Victoria, Australia, and suggested that optimal market-based redistribution of water may not occur unless the social and cultural attitudes to trade are duly considered. Although the Chilean Water Law of 1981 has recently been touted as a model for other countries to follow, up to now, water rights sales separate from land are limited in Chile. The lesson that we can draw from the Chilean case is that while some barriers might be overcome by changes in law and policy, or by increasing water scarcity over time, others are unavoidable. The fact that empirical results are mixed (for example, price signals are confusing or contradictory) suggests that the Chilean model is something for other countries and regions to learn from rather than imitate (Bauer 1997).

Water resources are severely in short supply in China, especially in the north-west. According to the Chinese Water Laws of 1988 and 2002, all water resources are state-owned – private ownership is banned. The Government, which represents the state as owner, allocates water resources to water users through governmental orders and water quotas. In early 2002, the Ministry of Water Resources initiated an experimental project in establishing a water-saving society in Zhangye city in north-west China – the first project of its kind in the country. The aim of the project was to establish a new water use rights (WUR) system with tradable water quotas and to reallocate and use water resources reasonably and efficiently through market-based instruments. However, it was found that the system was hard to implement effectively and that WUR trading was not popular (MWR 2004). The problem is establishing what kinds of barriers caused this and how they operate.

The research presented in this article explores the barriers to water markets in the Heihe river basin in north-west China and examines ways to overcome these barriers. This research is limited to agricultural water use and its transfer to other sectors. The following section introduces the study area for the experimental project. Section 3 presents the research methodology while Section 4 identifies and analyses the barriers. The last section gives the conclusions and policy recommendations.

## 2. THE STUDY AREA

### 2.1 Zhangye City

The Heihe River, the second longest inland river in China, originates from the Qilianshan Mountain which lies mainly in the Qinhai province and ends in Juyanhai Lake in Inner Mongolia. The study area is Zhangye city of Gansu province, which is located somewhere midstream of the Heihe River. According to the Statistics Bureau of Zhangye City (SBZC 2003), the city is 42,000 $km^2$ in size and governs six counties; Ganzhou, Shandan, Minle, Gaotai, Linze and Sunan Yugur. The city currently has a population of 1.264 million, including a rural population of 911,000 and an urban population of 353,000. The urbanization rate is 27.9%. The area of farmland is 260,000 ha.

Located in one of the driest zones in the world, Zhangye city is an oasis mainly watered by the Heihe River. The precipitation in the city is 89-283mm per year, while the evaporation is 1,700mm per year. The water sources of the Heihe river basin are mainly the snow-melted water from the Qilianshan Mountain which is perpetually covered by snow. There are 26 rivers in the basin. All the rivers originate from the north side of the Qilianshan Mountain. The total water volume is 2.65 billion $m^3$, including 2.475 billion $m^3$ of surface water and 0.175 billion $m^3$ of groundwater. So far, there are 24 irrigation areas which are larger than 10,000 *mu* (667 ha), 43 small and middle-sized reservoirs, and 35 pool embankments with a total water capacity of 202 million $m^3$. There are 814 main canals and branch canals, and 4,489 irrigation wells. The available irrigation area is 257,000 ha, including 212,000 ha of farmland and 41,000 ha of forestland and grassland. (All data from SBZC 2003)

According to MWR (2004), Zhangye city is severely short in water resources even though it has used up almost all the water of the Heihe River. It has 9,937 cubic meters of water per hectare of farmland. This is only 29% of the average figure for China. Meanwhile, water use is not well managed. Firstly, water allocation is not in order. Agricultural water use accounts for about 95% of all water uses. Industrial and commercial (I&C) water demands are severely restricted and economic development is thus affected. Almost all the water of the Heihe River is extracted for irrigation use. As a result of too little water flowing into Juyanhai Lake, it dried out in 1992 and an area of 200$km^2$ around the lake became desert (MWR 2004). Currently, the desertification area is rapidly expanding and more and more families are losing their homeland. Secondly, water conflicts are severe. Arguments and fights over water use take place almost every year. In 2002, a fight for water between two villages occurred, causing four people to be killed and more than 30 wounded. Thirdly, water use efficiency is very low. Farmers continue to plant water-intensive crops and use old, inefficient irrigation methods, such as flood and furrow irrigation. Water use efficiency in the agriculture sector here is only

between 20-30 per cent, far lower than in developed countries which have an average water use efficiency of 70 percent.

In Zhangye city, water demand is increasing due to the growing population and expanding economy, with variable water demands from different users, regions, and industry sectors. As the total water supply is hard to increase, water reallocation is a difficult and sensitive issue. If not fairly distributed, severe water conflicts will break out. What the local government can do is to induce farmers to adopt water-saving irrigation measures and then to transfer the water that is saved to I&C, ecological, or other water uses.

## 2.2 The Experimental Project

In 2002, the Chinese government, through the Ministry of Water Resources, began an experiment to try to find more efficient ways, such as market mechanisms, to encourage water-saving activities and to allocate water resources. The 2002 Water Law does not refer to whether the water quotas are transferable. Similar to the land tenure reform that was initiated in 1978 (Qu et al. 1995), it appears, therefore, that China could establish a water use rights (WUR) system and allow WUR transactions through a water market while ownership transactions of water resources would still be banned. In fact, market transactions of water had emerged in some regions although no WUR systems had yet been established in China before 2002 (Wu 2003). In fact, the experimental project in Zhangye city was a pilot attempt to establish a WUR system.

The pilot project was set to save water through three main ways:

1) The government invested extensive capital to build a water-saving irrigation system because local farmers could not afford it.

2) The government invested and installed meters for water users (including irrigators), and tried to discourage farmers from wasting water by accurately metering and charging for irrigation water.

3) A WUR system with tradable water quotas was established, which tried to reallocate water more reasonably and efficiently and raise water use efficiency through water quotas trading.

The first and second measures were successful as the 2002 results showed that the amount of irrigation water used decreased to a certain extent. However, the WUR system has not yielded the expected results as WUR trading is not popular.

In the project, every water user gets a water quota that is fixed by the government. Water quotas (from the Heihe River) are allocated proportionally to all water users based on their respective historical usage. In the agriculture sector, historically, the average irrigation water amount of per hectare for all farmland in Zhangye city is allocated according to the acreage of the farmland. In the I&C sector, the water quota of every water user is individually granted by the government also according to historical water usage. In fact, the process and method of distributing the water quotas is no different from before the experimental project. But the character of the water quotas have changed. The water quotas have become a kind of long-term

property right, the WUR, which are allowed to be freely traded in water markets by water users. WUR can be sold both temporarily and permanently. Farmers can divide their WUR from their land use rights. This means that the nexus between water and land has been broken. But the WUR are not bankable unless the water users have water storage facilities, such as reservoirs.

In Zhangye city, there is a perfectly natural irrigation system. Water melts on snow-covered mountains and flows to rivers, then to reservoirs, main canals, and finally to farmlands. The process is 'self-flowing' due to the change in topography from highland to lowland. All reservoirs and main canals are state-owned or collective-owned. As many water users, such as farmers, have no reservoirs, water agencies on behalf of the government are engaged to manage the irrigation systems and water quotas. Water users can get water according to their water quotas by paying water fees to the water agencies. They must completely utilize their water quotas or sell them. Otherwise, they will forfeit them.

## 3. METHODOLOGY

In a water market, a water rights system underlying well-defined property rights must first be established and well implemented in order for water trade to work. In Zhangye city, a WUR system has been designed and promoted. Water trading would be difficult or even impossible if the WUR system is not well implemented. This study considers two different and independent processes, WUR system implementation and WUR trading, separately. The analysis on WUR trading is based on the proper implementation of the WUR system. The Hongshuihe irrigation area is one with a well-implemented WUR system while other WUR systems have not been well implemented in most other areas of Zhangye city.

In this case, the barriers to implementing a WUR system are first analyzed in the areas of Zhangye city with poorly implemented WUR systems. Then the barriers to water trading are analyzed in the Hongshuihe irrigation area based on the well-implemented WUR system found there.

### 3.1 Field Survey and Sources of Data

Both primary and secondary data were used to achieve the study's objectives. Primary data was gathered through questionnaire surveys in five selected irrigation areas. The respondents included farmer households and officials from selected villages. Based on the pre-survey from 15 May to 2 June 2004, the survey strategy and questionnaires were designed. Sixteen college students from Gansu Agricultural University who originated from Zhangye city were then hired to conduct the main questionnaire surveys through interviews with the respondents in July and August 2004. To provide the students with a firm understanding of the objectives of the study and survey instruments, a three-day training course was given. In addition, during the two-month survey period, two telephones hotlines were made available to the students.

The stratified random sampling method was used to choose respondents for data collection. The samples of respondents for the survey were drawn randomly from the

updated lists that were prepared for the stratified sampling. In Zhangye city, there are about 25 main irrigation areas and 200,000 farmer households. The Hongshuihe irrigation area was primarily selected based on the pre-survey due to its good WUR system. Four other irrigation areas were selected randomly. In the Hongshuihe irrigation area, there are about 78 villages, 1,800 farmer households, and 268 local water agency officials. Forty villages were selected and from each, 10 farmer households were selected. There was a total of 400 farmer-respondents interviewed for this study, 380 of which had completed survey forms that were used in the analysis. At the same time, 100 water agency officials were selected within the irrigation area of which 95 interviews were utilized. In each of the four other irrigation areas, 10 villages were selected, and from each, 10 farmer households. The total farmer respondents was 400 with 388, having completed forms. At the same time, 200 officials from the local water agencies within the four irrigation areas were selected of which 191 were used in the analysis.

### 3.2 Questionnaire Design and Pre-Survey

The questionnaire had three sections. Section 1 sought information on the characteristics of the irrigation areas and farmer households, such as the water quotas, actual water uses, farmland areas, crops, income, and labor of farmer households. Section 2 combined single- and multiple-response questions and open-ended questions to elicit the opinions of the farmers and local officials on the WUR system and WUR trading, such as their attitudes towards these and whether they were willing to accept the system. Section 3 used a 5-point Likert scale (1 for ‘strongly agree’ and 5 for ‘completely disagree’) to check which of the possible barriers were perceived as true barriers by local farmers and officials. The possible barriers were determined through a pre-survey.

The pre-survey was conducted through the use of in-depth, in-person interviews. The interviewees, both in local study areas and at national level, included 26 local farmers, 7 water experts, and 18 officials of various levels in the government. An interview guide was developed and used to ensure that the interviews were systematic and focused enough to cover relevant and comparable information. The questions were open-ended, focusing on the barriers identified in the literature review. By analyzing the data from the pre-survey, the possible barriers in Zhangye city were preliminarily identified.

The possible barriers to the implementation of the WUR system were identified as: (1) geographical and technical barriers: it is difficult to divide and measure water (2) historical and cultural barriers: local farmers psychologically reject the establishment of a WUR system due to their customs and culture, (3) social barriers: local farmers cannot be forced to limit their water uses and endure the loss caused by water shortage, and finally, (4) administrative barriers: local water authorities have no incentive to restrain local farmers from over-using water.

The possible barriers to the WUR trading were identified as: (1) geographical and technical barriers: it is difficult to divide and measure water (2) cultural barriers: local farmers treat water rights essentially as family property that they are by no means willing to sell (3) management barriers: there is a risk to farmers in increasing areas devoted to low water-intensive crops, (4) legal barriers: it is difficult to buy use rights to land and water from small farmers with small parcels (5) administrative barriers: the

government may reduce the farmers' water quotas and transfer irrigation water to other sectors, and finally (6) fiscal barriers: the government is not willing to buy the surplus water of farmers when farmers fail to sell their surplus water in markets.

### *3.3 Data Analysis*

Based on the 5-point Likert scale survey, the mean values were used to examine whether the possible barriers obtained in the pre-survey were supported by data obtained from the large survey of farmers and other respondents. A possible barrier was considered to have a significant role if it took a rank mean value of less than 3. The level of significance was tested at probability levels of 5% and 1% using the t-test of statistical significance. The differences in the responses of farmers and officials were assessed using the Mann-Whitney *U*-test and Kolmogorov-Smirnov test. The validity of these barriers was further assessed based on a review of literature on water trading practices elsewhere in the world.

## 4. EMPIRICAL FINDINGS

### 4.1 Barriers to WUR System Implementation

The initial approval and distribution of WUR was given and carried out by the government authorities in Zhangye city. According to the WUR system, every water user obtains his/her explicit and exclusive annual water quota. In the WUR system, surface water and groundwater are integrated for allocation to water users. Of the farmer respondents to the survey, 97.5% knew the system and their own water quotas. However, in the practical implementation of the WUR system, groundwater quotas are almost totally ignored and only surface water quotas are faithfully adhered to by irrigators (see Table 1).

Table 1. Adherence to water quotas in five irrigation areas in Zhangye City

| **Irrigation area** | **% of groundwater quota to total water quota** | **% of households whose actual water use is more than their water quota** | | |
|---|---|---|---|---|
| | | **Total water** | **Surface water** | **Groundwater** |
| Hongshuihe | 4.1 | 2.6 | 0.8 | 23.8 |
| Daman | 35.0 | 78.1 | 1.7 | 98.1 |
| Liyuanhe | 24.2 | 37.6 | 1.2 | 87.3 |
| Maying | 21.3 | 23.7 | 0.9 | 67.5 |

| | | | | |
|---|---|---|---|---|
| Luotuocheng | 83.8 | 76.4 | 1.3 | 81.7 |

Source: field survey

In the Hongshuihe irrigation area in Minle County where irrigation water mainly comes from a small-sized reservoir, Shuangshusi reservoir, and groundwater is very scarce and deep, water quotas are adhered to and the WUR system is well implemented. In the four other irrigation areas, where irrigation water comes from surface and ground water, besides adhering to surface water quotas, the users can still withdraw groundwater without considering their groundwater quota limits.

The design of the WUR system is such that the government reduces the water quotas of farmers gradually (see Table 2) in order to transfer irrigation water to I&C and ecological uses. However, the farmers do not reduce the amounts of their actual water use in order to maintain their income level and production practices. They just reduce the amount of their surface water utilization but increase their groundwater use. Figures 1 and 2 show the increase in the average number and depth of irrigation wells in the sample villages over the last few decades. Nowadays, the aquifer (an underground layer of porous rock, sand, etc. containing water into which wells can be sunk) is rapidly decreasing at a speed of 0.05-0.10m per year in Zhangye City (Chen 1999). Oases are shrinking and wells are drying up. Obviously, the WUR system will not work well and the aims of the experimental project will not be achieved unless groundwater quotas are strictly adhered to.

Table 2. Water quotas for farmlands in Zhangye City

| **Year** | **2000** | **2004** | **2010** |
|---|---|---|---|
| Average ($m^3$/mu) | 820 | 676 | 643 |
| Ganzhou District ($m^3$/mu) | 847 | 706 | 668 |
| Linze County ($m^3$/mu) | 788 | 648 | 620 |
| Gaotai County($m^3$/mu) | 809 | 651 | 621 |

Source: Water quotas of the regions in the Heihe river basin, Zhangye Municipal Government, 2004

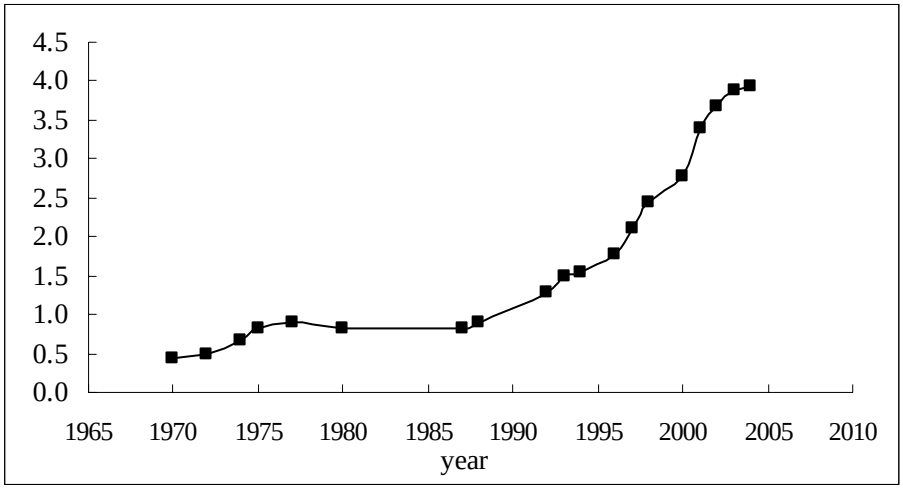

Fig 1. The average number of irrigation wells in the sample villages (1970–2004)

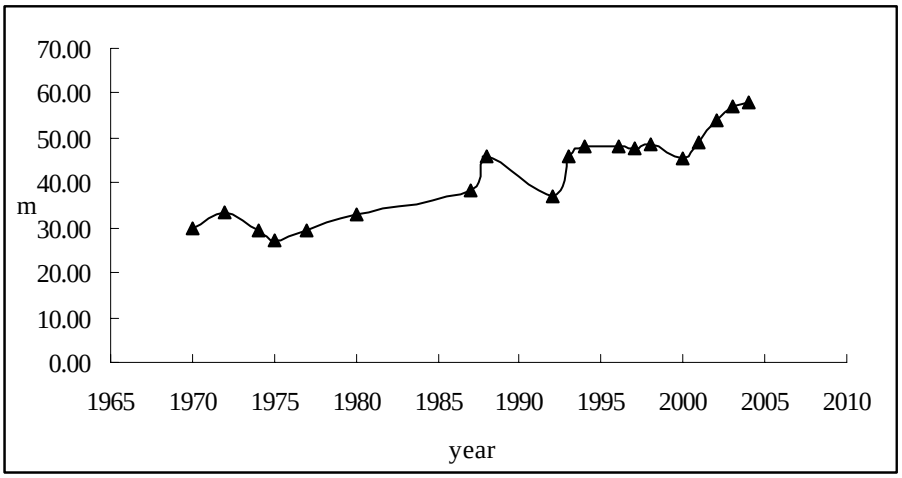


Fig 2. The average depth of irrigation wells in the sample villages (1970 –2004)

Table 3 summarizes the survey findings on which of the possible barriers are considered the major barriers in practice in Zhangye City. On the whole, the results of the survey suggest that social and administrative barriers are the main barriers rather than geographical, technical, historical or cultural barriers. Although the same results are gained from the responses of farmers and officials, there are differences between them according to the Mann-Whitney *U*-test and Kolmogorov-Smirnov test.

Table 3. Opinion of farmers and officials as to possible barriers to WUR system implementation

| **Barriers** | **Mean Rank Response** | | | **MW-U** | **KS-Z** |
|---|---|---|---|---|---|
| | **Mean** | **Farmers** | **Officials** | | |
| (1) Geographical and technical | 4.2[b,d] | 4.28 | 4.04 | 31564[d] | 1.174 |
| (2) Historical and cultural | 4.45[b,d] | 4.52 | 4.32 | 32012.5[d] | 1.349 |
| (3) Social | 1.59[a,d] | 1.68 | 1.42 | 117561.5[d] | 1.349 |
| (4) Administrative | 1.93[a,d] | 1.8 | 2.21 | 27712[d] | 2.008[d] |

Source: field survey

Notes: Scale: 1, strongly agree; 5, strongly disagree. MW-U represents the Mann-Whitney *U*-test.

KS-Z represents the Kolmogorov-Smirnov test.

[a] significantly less than 3.

[b] significantly greater than 3.

[c] significant at $p<.05$.

[d] significant at $p<.01$.

Although the mean rank responses of both officials and farmers convincingly indicate that social and administrative barriers exists, their ranking of which one is more important varies between the Mann-Whitney U-test and Kolmogorov-Smirnov test. Farmers think that administrative barriers are more serious while officials consider social barriers as the real hindrances. Based on further survey and interviews with local officials, experts, and farmers, the specific reasons as to why various barriers exist or do not exist are as follows:

1) There are no geographical and technical barriers because good water engineering and infrastructure enables the convenient redistribution of water to almost all water users. Snow-packs provide natural water storage. Snow begins to melt in spring and continues till early autumn through most of the irrigation season. To date, a reservoir has been built upstream of almost every main river. Canal systems with permanent concrete structures have been built to connect these reservoirs with water users. Through the use of natural storage and well-constructed reservoir-and-canal systems, water can easily flow to water users due to the down-slope. At the same time, there are effective and cheap metering techniques to measure water volume. For surface water, locals can meter the volumes of irrigation water according to the section size of canals and the water flow speed; as for groundwater, they can do so by taking into account conditions of the well and the amount of electricity used. (Every well has an electrical power pump connected to a meter.)

2) Historical and cultural barriers do not exist because there is a long history and culture of allocating water by quotas. A water quota system was initiated in 1726 (Shen and He 2004). Since then, water quotas have been regulated and controlled by the government and the system has worked for several hundreds of years. Of the farmer respondents in the survey, 96.8% welcome the WUR system if the government does not reduce their water quotas, and 87.2% think that the WUR system is similar to the old water quota system.

3) Social barriers exist as farmers in Zhangye City are still poor and are naturally concerned about their income from their farmlands. According to the survey, the annual average income per farmer is only CNY 2983. The income of local farmers from agriculture accounts for just 35.60% of their total income. Nowadays, many farmers do non-agricultural jobs during their spare time so much so their income from agriculture is no longer their major source of income. However, 75.2% of the farmer respondents consider their income from agriculture as still very important to them. There are two reasons. Firstly, there is no social security system for farmers in most areas in China. Farmers have no security such as pension, new job opportunities, and medicine. Secondly, the farmers' non-agricultural jobs are not fixed and lack security; by contrast, their income from agriculture is relatively secure. The farmers, therefore, think that their income from agriculture is a necessity for them to survive while non-agriculture derived income is just extra cash to be able to live better. So, most farmers panic when they fail to get sufficient irrigation water. Of the farmer

respondents, 98.7% are not willing to adhere to water quotas if they do not get enough water for their crops. In such a case, officials are concerned that monitoring and simply constraining farmers' irrigation water use will lead to many social issues, such as conflicts and disturbances. In fact, many conflicts have already occurred.

4) Administrative barriers exist due to the fact that local levels of government and their water agencies are charging for the administration and management of water use, and have no incentive to force farmers to adhere to groundwater quotas. Groundwater use has severe negative externalities. For instance, the groundwater use in areas, such as Ganzhou district and Linze county, resulted in Minle county having the fastest drop in aquifer although Minle county used the least groundwater – many wells dried out and wetlands disappeared (Chen 1999).

   According to the WUR system, water agencies should encourage farmers to save their water quotas in order to achieve water saving. On the contrary, however, these agencies usually force farmers to use up all their water quotas. From an institutional perspective, these agencies are non-profit organizations that should be financed by the government. But in practice, due to local government budget constraints, all the expenses, including salaries, of the agencies depend on the water fees charged. So the more water the farmers use, the more water fees they get.

## 4.2 Barriers to WUR Trading

Since the experimental project in 2002, WUR have become tradable. The field survey could not find WUR trading in most places except for the Hongshuihe irrigation area in Minle County. This is understandable because the WUR system has been well implemented only in this particular irrigation area and WUR trade depends on the good implementation of a WUR system. Of the farmer respondents to the survey, 82.4% know that WUR are tradable. In 2003, there were 13 WUR trades in the Hongshuihe irrigation area (see Table 4). This indicates that water trades are still few – all trades occurred between farmers within the agriculture sector. The water trades with land are greater in number and scale than those arising from surplus or saved water. Water trades with land are long-term, usually for several years, while those arising from surplus or saved water tend to be short-term trades for water quotas within the current year.

Table 4. WUR trading in the Hongshuihe irrigation area

| Types of trades | Number | Amounts ($m^3$) | Average water price | % of the total water trade | % of the total water use | Amounts per trade ($m^3$) |
|---|---|---|---|---|---|---|
| Long-term trade with land | 8 | 39000 | CNY2250 /ha* | 98.4 | 2.59 | 487.5 |
| Short-term trade | 5 | 615 | CNY0.2 /$m^3$ | 1.6 | 0.04 | 123 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Total | 13 | 39615 | | 100 | 2.63 | 3047 |

Source: field survey.

Note: The water quota per ha of land is about 6,000 $m^3$. It is hard to separate the prices of land and water. In theory, the price of water rights should be equivalent to the difference between irrigated land and non-irrigated land. In the Hongshuihe irrigation area, the output of irrigated land is about 10 to 20 times that of non-irrigated land.

Table 5 summarizes the survey findings on the possible barriers existing in the Hongshuihe irrigation area. On the whole, the results of the survey suggest that management, legal, administrative and fiscal barriers are the main barriers rather than geographical, technical, and cultural barriers. According to the Mann-Whitney *U*-test and Kolmogorov-Smirnov test, farmers consider management, legal, administrative and fiscal barriers as more serious obstacles to trading than officials regard them to be.

Table 5. Opinions of farmers and officials as to possible barriers to WUR trading

| **Barriers** | **Mean Rank Response** | | | **MW-U** | **KS-Z** |
|---|---|---|---|---|---|
| | **Mean** | **Farmers** | **Officials** | | |
| (1) Geographical and technical | 4.34[b,d] | 4.34 | 3.99 | 15802[c] | 1.193 |
| (2) Cultural | 3.99[b,d] | 3.99 | 4.02 | 17594 | 0.177 |
| (3) Management | 1.62[a,d] | 1.48 | 2.18 | 10132.5[d] | 3.51[d] |
| (4) Legal | 1.65[a,d] | 1.61 | 1.79 | 88294[c] | 0.734 |
| (5) Administrative | 1.53[a,d] | 1.41 | 2.03 | 83690[d] | 2.753[d] |
| (6) Fiscal | 1.59[a,d] | 1.49 | 1.97 | 12678[d] | 1.950[d] |

Source: field survey

Note: Scale: 1, strongly agree; 5, strongly disagree. MW-U represents Mann-Whitney *U*-test.

KS-Z represents Kolmogorov-Smirnov test.

[a] significantly less than 3.

[b] significantly greater than 3.

[c] significant at $p<.05$.

[d] significant at $p<.01$.

Based on further surveys and interviews with local officials, experts, and farmers, the reasons for the results are given as follows:

1) There are no geographical and technical barriers because good water engineering and infrastructure enables the convenient redistribution of water to almost all water users. The good conditions have been described above (see pg 10).

2) Cultural barriers also do not exist. Since the foundation of the People's Republic of China in 1949, farmers no longer have ownership of land and water. They have been eligible only for tradable use rights to land and water since 1978 and 2002, respectively. Most farmers do not think the land and water use rights are necessary and essential property rights. There are two major reasons. Firstly, they think that use rights are unstable and not legally secure, and worry that governments might withdraw them at any moment. Secondly, as the land and water owned by a farmer household is too small in size to support the farmer's whole family, most farmers have to migrate to look for non-agriculture based jobs if they want to improve their lives. Of the farmer respondents to the survey, 71.2% are willing to sell their land and water use rights and migrate, while 6.6% do not even care about the price or are willing to abandon their rights.

3) Management barriers exist. According to Dai (1999), some modern irrigation technologies, such as sprinkle and drop irrigation technologies are not economically feasible in the arid area in northwest China. The most feasible water-saving practices are substituting furrow irrigation for flood irrigation, and substituting less water-intensive cash crops for water-intensive cereal production. In fact, enlarging alfalfa farmlands, especially with furrow irrigation technology, would be a good way for farmers to save water and then sell it. Local governments are now promoting this practice. But the expansion of alfalfa is taking place very slowly. Why? Of the farmer respondents to the survey, 92.4% worry about the risk of enlarging alfalfa farmlands and prefer to plant wheat and corn while only 12.6% think that the income from planting alfalfa is lower than that of planting cereal crops. The perceived risks associated with enlarging alfalfa farmlands include the fear that there may not be enough buyers of alfalfa and that farmers may face a low price due to the absence of a floor price policy for this crop, which exists for cereals. China's central government set up a floor price policy and subsidy policy for grain production in order to encourage farmers to plant grain to ensure food security. For cash crops, including alfalfa, there is no similar policy.

4) Legal barriers have their roots in the Land Administration Law of China which states that farmlands owned by farmer organizations (collective organizations of all farmers in a village, usually in an administrative village) should be leased to every farmer household equally and fairly not only in quantity but also in quality. In order to guarantee absolute equity in quality, every parcel of land that is thought to have a different quality from another parcel must be segmented and allocated to every household at one time. For example, if a village has ten lots of land, a household would get ten little parts from them respectively instead of a big part from any one of them. In this case, farmers would have small but many farmland parcels. According to the survey, the average total area of farmland per household is 1.22ha, and the average number of farmland parcels of every household is 10.13, meaning that the average area of every parcel is only 0.12ha. In such a case, it is very difficult for a farmer who wants to buy land and water use rights to achieve scale economies because he/she has to negotiate with many farmers at the same time. Of the farmer respondents to the survey, 71.2% are

willing to sell their land and water use rights and 65.3% are willing to buy land and water use rights and achieve economies of scale. 71.2% plus 65.3% is more than 100% – this means that some farmers are open to the possibility of either buying the rights to enlarge their agricultural holdings or selling their rights and quitting agriculture altogether.

5) Administrative barriers also exist. Reducing water quotas (see Table 2) will gradually leave farmers with no surplus water to sell. Of the farmer respondents to the survey, 98.6% think that water is in shorter supply than before and that they have no surplus water to sell, making potential water buyers disappear. By reducing the farmers' water quotas, local governments can increase the water quotas of users in non-agricultural sectors who need more water. Nowadays in China, most local governments pay strong attention to how they can get more investments from the outside. A local official[1] said that the government would not let new I&C water users buy water quotas from water markets at the market price (a higher price than the water fee), in order to attract investors. He added that the government has reserved water quotas for future investors, the potential water buyers, according to its water use plan. Reducing the water quotas of farmers discourages them from saving water. Of the farmer respondents to the survey, 80.1% said that the policy of gradually reducing farmers' water quotas gives rise to the worry that the government would further reduce their water quotas if they saved water and had surplus water to sell.

6) Fiscal barriers arise when the farmers have no way to store the surplus or saved water, and it is hard for them to find buyers for surplus or saved water in the water market. Because of the lack of an efficient water market, users continue to lack motivation to save water if the "use it or lose it" doctrine is still maintained. Farmers usually just irrigate the surplus water to their farmlands. Thus, it would be a good alternative for the government to buy the surplus water of farmers. It would encourage farmers to save water which would be bought by the government and stored in reservoirs or transferred to other uses, such as new I&C or ecological uses. In the draft of the "Guidelines for Agricultural Water Trading in Zhangye City" (Zhangye Municipal Government 2003), it was proposed that the government buy the water saved by farmers at a price of 120% of the water fee.[2] But when the Guidelines were officially issued in 2003, this proposal had been taken out, the reason being that it was hard to obtain fiscal support for local authorities to buy the surplus water. So who should then pay the fee for ecological water use? This problem remains unsolved.

## 5. CONCLUSIONS AND POLICY RECOMMENDATIONS

[1] Personal communication with Mr. Luan Linmin, Director of Water Resources Office of Zhangye City Government, July 25, 2004.

[2] The water fee averages about CNY0.10 per $m^3$. If the local authorities buy water at the price of CNY0.12 per $m^3$,
this could make farmers' income increase by CNY0.02 per $m^3$.

## 5.1 Conclusions

The WUR system is not well implemented in most places in Zhangye city except for the Hongshuihe irrigation area where groundwater is scarce and deep. There is no WUR trading to be found in the irrigation areas where there are groundwater sources and the WUR system is not well implemented. Even in the Hongshuihe irrigation area where the WUR system is well implemented, WUR trading is scarce. This study analyzed the barriers of two different processes, the implementation of the WUR system, and WUR trading. It was found that the geographical, technical, historical and cultural barriers that exist in other countries (Bauer 1997; Gaffney 1997; Tisdell and Ward 2003) do not exist in Zhangye city. It was also found that there are different barriers for the two processes.

The barriers to WUR system implementation are social and administrative in nature. Local farmers cannot be forced to limit their water use as they cannot endure the loss caused by water shortage. Local water agencies have no incentive to restrain local farmers from using water, especially groundwater. As for WUR trading, the barriers faced are management, legal, administrative and fiscal related. There is a management risk for farmers in switching to low water-intensive crops. It is difficult for water buyers to buy rights to land and water use from farmers with small parcels. Farmers are discouraged from selling water to the government whom they fear will reduce their water quotas, and divert irrigation water to other sectors.

## 5.2 Policy Recommendations

The following policy recommendations are given to overcome the barriers to WUR system implementation and WUR trading:

1) Set up a rural social security system to overcome the social barriers. According to the empirical findings, many farmers value their agricultural income but not their water and land use rights. At present, farmers have a strong dependence on water and land resources due to the lack of a good social security system. They need the stable income from agriculture or natural resources such as water and land for security. If they can gain better forms of social security, most of them would no longer value the income from agriculture as much as it would only be a smaller part of their total income and they would be better able to endure the losses arising from water shortage.

2) Reform the water management institution and fix long-term farmers' water quotas to overcome administrative barriers. Make the revenue of local governments and water agencies no longer dependent on local water usage. Create a policy to fix the revenue or reduce it when the local water use increases. Raise the revenue when local water use decreases. This could also reduce the effect of the negative externality of groundwater over-use. At the same time, the government should abandon the policy on reducing farmers' water quotas gradually and transferring irrigation water to non-agricultural sectors. The farmers' water quotas should be fixed for a long term, such as 30 to 50 years to stabilize the WUR of farmers. It should also allow and encourage farmers to transfer agricultural water to other water users via market-oriented channels instead of through government intervention.

3) Draw up policies to help farmers avoid the management risk of increasing low water-intensive crops. Increasing low water-intensive crops is a good way to save water but the farmers dare not take the risk of changing their cropping system. So the government could provide subsidies or eco-compensation to farmers who plant alfalfa, or set a floor price for alfalfa just like for cereal.

4) Draw up policies to encourage farmers to enlarge the land area under their management. Since households get little parcels from all lots of land, they could be encouraged to concentrate on one parcel of land and aim to make it bigger by acquiring additional lands from other land owners. Some of them could even be encouraged to quit farming, thus releasing their water and land resources. At present and in the future, China should promote urbanization (Tian 2003). In Zhangye city, the urbanization rate is very low – many farmers will migrate from rural to urban areas if urbanization is further promoted (Zhangye City Municipal Government 2000). This would lead to many farmers surrendering their water and land resources and improve scale economies for remaining farmers, but how to make such a policy work needs further study.

5) Establish a floor price policy for farmers' surplus water to overcome the fiscal barriers. The government should no longer force farmers to use their surplus water. On the contrary, it should set aside a budget to buy farmers' surplus or saved water at a floor price[3] when the farmers fail to sell it in the market, just as what was originally proposed in the draft of the "Guidelines for Agricultural Water Trading in Zhangye City". Through this policy, the doctrine of "use it or lose it" could be eventually dropped and farmers would be encouraged to save water.

[3] It could be CNY0.12/$m^3$ as mentioned earlier. It should be affordable for the government. Assuming that all the farmlands in the Hongshuihe irrigation area switch to planting alfalfa, it could save 28 million $m^3$ of water, worth CNY3,361,680. This is just 0.3% to the GDP of Minle county in 2003 (according to the 2003 Statistics of Minle County).

## REFERENCES


Bauer, C. J. 1997. Bringing water markets down to earth: the political economy of water rights in Chile, 1976-95. World Development. Vol. 25, No. 5. pp. 639-656.

Chen, G.D.; B.Y. Chang; and Y.G. Qu. 1999. Study on water resources use and social development in Heihe river basin. Report on the national key research project. Chinese Academy of Science. (In Chinese.)

Dai, J. 1999. Economic assessment of agricultural water-saving technologies. Agriculture Tech-economy. Vol. 6. pp. 43-46. (In Chinese.)

Frederick, K. 2002. Handling the serious and growing threats to our renewable resource — water. Resources for the Future. Issue brief 02-11.

Gaffney, M. 1997. What price water marketing? California's new frontier. Australia Journal of Agricultural Economics. Vol. 56. pp. 475-521.

Hartwick, J.M. and N.D. Olewiler. 1998. The economics of nature resource use (second edition). Harper and Row Press. New York. p. 85.

Hearne R.R. and K.W. Easter. 1995. Water allocation and water markets: an analysis of gains-from-trade in Chile. World Bank Technical Paper No. 315, Washington, DC, World Bank.

MWR (Ministry of Water Resources). 2004. Pilot experiences of establishing a water-saving society in China. China Water Press. Beijing City, China. (In Chinese.)

Qu, F.; N. Heerink; and W.M. Wang. 1995. Land administration reform in China. Land Use Policy. Vol. 12, No. 3. pp. 193-203.

Randall, A. 1981. Property entitlements and pricing policies for a mature water economy. Australia Journal of Agricultural Economics. Vol. 25. pp. 195-220.

Rosegrant M.W. and H. P. Binswanger. 1994. Markets in tradable water rights: potential for efficiency gains in developing country water resource allocation. World development. Vol. 22. pp. 1613-1625.

SBZC (Statistics Bureau of Zhangye City). 2003. Statistics Yearbook of Zhangye City. Zhangye Press. Zhangye City, China. (In Chinese.)

Schleyer, G.R. and M. W. Rosegrant. 1996. Chilean water policy: the role of water rights, institutions and markets. International Journal of Water Resources Development. Vol. 12. pp. 33-48.

Shen, M. and L. He. 2004. Comparison of the past and the current water rights systems. Yellow River. Vol. 26, No. 2.

Thobani, M. 1997. Water markets: why, when, and how to introduce tradable water rights. World Bank Research Observer. Vol. 12, No. 2. pp. 161-179.

Tian, X. 2003. Issues on the future population of China. Population Journal. Vol. 5. pp. 13-15.

Tisdell, J. and R. Ward. 2003. Attitudes toward water markets: an Australian case study. Society and Natural Resources.Vol. 16. pp. 61-75.

Tregarthen, T. 1983. Water in Colorado: Fear and loathing of the marketplace. Anderson, T., *In* Water Rights. Pacific Institute for Public Policy, San Francisco. pp. 119-136.

Wu, J. 2003. Pricing mechanism on water resources. Website: http://www.mwr.gov.cn/ (Website of the Ministry of Water Resources). July. (In Chinese.)

Zhangye Municipal Government (ZMG). 2000. Long-term social-economy planning in Zhangye city. Governmental report No. 5. (In Chinese.)

Zhangye Municipal Government (ZMG). 2003. The Guidelines for Agricultural Water Trading in Zhangye City. Governmental report No. 19. (In Chinese.)