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Water price policy analysis in China—An experimental approach

Proposal to China's Ministry of Water Resources

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Water price policy analysis—An experimental approach

Background and motivation

Water scarcity is one of the key problems that affect northern China, an area that covers 40 percent of the nation's cultivated area and houses almost half of the population. The water availability per capita in North China is only around 300 m^3 per capita, which is less than one seventh of the national average (Ministry of Water Resources, 2002). At the same time, expanding irrigated cultivated area, the rapidly growing industrial sector and an increasingly wealthy urban population demand rising volumes of water (Crook, 2000, Wang, et al., 2005). As a result, groundwater resources are diminishing in large areas of northern China (Wang, et al., 2005). For example, between 1958 and 1998, groundwater levels in the Hai River Basin fell by up to 50 meters in some shallow aquifers and by more than 95 meters in some deep aquifers (Ministry of Water Resource, et al., 2001).

Past water policies have not been effective in solving water scarcity problems (Lohmar, et al., 2003, Wang, 2000). China's leaders have put priorities on increasing water supply through developing more canal networks or building more reservoirs (Boxer, 2001, Ross, 1983). In 2001, the State Council started the South-to-North Water Transfer Project. However, these supply-side approaches cannot meet the increasing demand for water from all of the different sectors and cannot solve water scarcity problems in the long run.

In recent years, China's leaders have started to recognize the need for a new approach: save water by stemming demand (Boxer, 2001). For example, since the early 1990s leaders have encouraged households to adopt water saving technology (Lohmar, et al., 2003). Despite the significant progress of the research on water-saving technologies, there is little evidence of water saving technologies adoption by households (Blanke, et al., 2005, Lohmar, et al., 2003). In more recent years, water officials also promoted water management reform in hope that managers that faced better incentives might save more water (Wang, et al., 2005); measured water savings have been marginal at best. Although the methods of water application, water deliveries and pumping time have changed, no real water savings were produced (Kendy, 2003).

Why haven't these schemes worked? One obvious answer is that farmers and other water users do not have an incentive to spend their time or investment funds to save water. It is almost axiomatic to say that China's water users may not be expected to save water until they have to pay for it. It is for this reason that there is beginning to be serious discussions about the need to design and implement water pricing policies.

Water Pricing Policy

Water pricing is becoming known as one of the most important policy tools for managing the demand for water (Dinar, 2000, Tsur, et al., 2004). A water pricing policy uses higher water price to signal to users the relative scarcity of water so as to provide them with incentives to save water. When water price is increased to a level that reflects its value, farmers will reduce the level of water use in agricultural production. The higher level of water price will also give farmers an incentive to start to invest in water saving technologies and switch to less water-intensive crops. In short, with higher water price, demand for water is lower.

Unfortunately, effective water pricing schemes in developing countries are rare. Instead, the price of water is usually set based on criteria that do not necessarily lead to an efficient allocation of water resources (Rhodes and Sampath, 1988, Seagraves and Easter, 1983). For example, water officials often set water charges on a unit area basis; in many cases the price is set close to the average cost of supplying water (Dinar and Tsur, 1995, Sampath, 1992). In other countries surface water is highly subsidized (Sampath, 1992). In Egypt, for example, the government supplies irrigation water to farmers free of charge (Kuper, et al., 2003). There are almost no readily known examples of developing countries in which officials use the price of water to signal its scarcity value. Inside China, water price is also low. The price surface water is so low in the Yellow River Basin that often less than 25% of the cost of supplying surface water is recovered (Jia, 2005). In groundwater-using areas in China, farmers only need to pay for the cost of energy (electricity or diesel). The water itself is free (although it should be pointed out that in China, electricity is sold to farmers at or near world market price for electricity.

There are many reasons for the absence of effective water pricing policies in China and other countries. One of the major reasons is that decision makers do not know whether water pricing policies will work in the "real world" and how they should design the policies. Specifically, three basic issues need to be addressed before any new set of policies can be made. The first issue is the effectiveness of increasing the cost of irrigation. In many developed countries, the economic literature suggests that the derived demand for irrigation is relatively price inelastic (e.g., Moore, et al., 1994, e.g., Ogg and Gollehon, 1989), which means increases in the price of water will not lead to a significant reduction in water use. If this is the case in China, water pricing policy will not be the solution to the water scarcity problem.

Besides water saving efficacy, an equally important issue is the impact of increasing the cost of irrigation on producer welfare. China has made remarkable progress in alleviating poverty in its rural areas in the past and the leaders are definitely intent on continuing to alleviate poverty in rural China (Rozelle, et al., 2003). The government has set the target of lifting more than 20 million people out of poverty in the next five years (Xinhua News Agency, 2006). In the political-economy environment that dominates policy making in rural China today, it is absolutely imperative to assess how much producers would be hurt should pricing policies be effectively implemented and how should the government compensate water users (Feng and Zhang, 2005).

Last but not least, it is important to learn about the nature of the responsiveness when planning price interventions. One of major concerns is the potential impact of higher irrigation cost on grain production. Changes in water use may reduce grain production down to a level that threatens food security. Even if farmers are compensated for their income loss caused by higher water prices, farmers may choose not to sustain their level of production. While there is increasing consensus that reforming water pricing is necessary, very few studies have addressed these issues.

Limitations of current water policy analyses

Furthermore, current studies are limited in their use to advise China's leaders on water policies. There have been a number of studies that analyze the impacts of water pricing policies. Typically, simulations instead of "examinations of the actual data" are used to look at changes in water use under different levels of water prices. In simulations, water prices are increased by assumption. The responses of water users are then calculated from a profit maximization problem. This approach is used because the price of water often does not vary across space or over time and so there is no such data to collect. Although results from simulations can provide some insights, its credibility depends crucially how well the profit maximization profit problem represents the real-world context. This will be difficult in a world in which farmers plant multiple crops, face different types of production risks (weather, insects, price variation, etc.) and have different on-farm (different crop choices and different types of water saving technologies) and off-farm opportunities (e.g., off-farm employment).

In addition, most studies fail to take into account many factors that may affect the result of a water pricing policy. One such factor is the behavioral response of farmers. When the price of water goes up, farmers may start to adopt new water saving technologies; farmers may change their cropping pattern; and farmers may start to trade water. The behavioral responses of farmers also depend on the specific local hydro-geological, social and economic characteristics of each area. There are many unobservable characteristics that may affect farmer behavior (e.g., their risk attitude). Most studies fail to capture the effects of these factors since there are limited ways that farmer behavior can be incorporated into an analytical model.

One additional shortcoming of current methods of water policy analysis is that most studies do not address the implementation of water policy. Most studies stop with vague recommendations about using policy instruments such as tax, subsidy or quota. Few studies focused on comparing the advantages and disadvantages of these different instruments. Even rarer are studies that examine the cost and benefit analysis of implementing the policy.

Using survey data to study water use and develop water policies may cause a problem. In most cases, farmers in the same village are facing the same price of water. This makes it difficult to identify the responses to changes in prices since there is no variation in the price of water. When collecting data on different farmers from different villages, while there may be differences in prices, these differences may be due to unobserved factors. As a result, differences in water uses are not only due to price differences but also due to these unobserved factors. If these unobserved factors are not controlled for in the analysis, there will be bias in the estimates of changes in water use in response to changes in water prices. Using the terminology in economics, this problem is one type of endogeneity problem. In part, this problem can be overcome by collecting data on the same farmers over time. However, collecting data over time is expensive.

Searching for New Approaches: Field Experiments

The recent development in the methodological approach in economics may help us overcome the limitations in current studies. The use of experiments by economists can be traced back to 1930s (Thurstone, 1931). However, only in recent years have economists begun to use experiments on a regular basis (Smith, 1990). Since the 1980s, economists have increasingly begun to use laboratory experiments to observe individual choices and to test game-theoretic hypotheses and industrial organization/market structure in response to varied information content, incentives and rules in a controlled environment. Typically, high school or college students, instead of real market agents, are the experimental subjects in laboratory experiments.

Partly in response to the criticisms that laboratory experiments are not representative of real-world settings and that subjects may not be giving real world reactions to the stimuli, in recent years economists have begun to promote the use of field experiments in order to observe real world subjects in their naturally occurring environments. Instead of following the actions of agents in response to an event that occurs in an economy, in the field experimental team intervenes in a specific and measurable way and does so differently in a set of randomly assigned treatment and control sites. In this way, the endogeneity problem is eliminated. Quantitative measures can be produced. Multiple policies can be tested. Since the founding of the Poverty Action Lab at MIT in 2003, there has been an increasing attention to the use of randomized interventions in developing countries. Economists have studied education in India (Duflo et al., 2005), the adoption of deworming drugs in Kenya (Miguel and Kremer, 2004); microfinance programs for the poor in South Africa (Karlan and Zinman, 2005); the economics of charity in the US (Karlan and List, 2006) and rural consumer credit in South Africa (Karlan and Zinman, 2005).

Need for field experiments in the Study of Water Policy

The approaching of using field experiments may also be one way to overcome the problems of studying water policy. The use of field experiments can overcome of the problem of insufficient variation across villages as well as the elimination of unobserved heterogeneity. This is done by randomly choosing villages and then changing prices exogenously. The use of experiments will allow us to control for the level of water prices. Since the changes in water price are not caused by any unobserved factors, we will be able to identify the impact of the changes in water price on water use.

Because implementing water pricing field experiments would closely mirror the actions of policy markers who were trying to manage water demand by raising prices, in this case field experiments would also be useful for learning about the problems that might occur during the actual scaling up of the policy at some point in the future. Some may be expected: such as the reduction in water use. Others may not be predictable but may provide important information for those charged with implementing policies. For examples, if electricity prices were raised to try to control water use, farmers might switch to diesel pump sets. Farmers might also begin to find it worth their while to steal energy, while previously they did not believe the gain outweighed the potential cost of getting caught. The incorporation of these behavioral responses in our policy analysis will surely aid China's leader better when designing policy.

Equally important, the experiment will provide us opportunity to implement different combinations of pricing and compensation schemes which will facilitate the development of complex policies that may be needed in the complex natural, social and economic environment in China. In summary, we believe the use of the field experiments can generate policy analysis that guide China's decision makers as they deliberate over the design of water policies.

Goals and Objectives

The overall goal of this project is to assess water pricing policy as a tool for managing water demand in China. Admittedly this is an enormous undertaking and this proposed project is only a small part of what will necessarily be a much greater effort. However, as China continuously grows at a rapid rate, water is increasingly the most limiting factor in the development. A policy change on water price is unavoidable. This proposal will be a pioneer in the type of work that is needed to implement policy changes. We also realize that effective management of water demand will not happen overnight, so information about problems and solutions—though urgently needed—will be useful for many years into the future. Hence, this proposed research can best be thought of as the first step towards a broader collaborative research agenda that will entail work in many areas in China. Secondarily, but perhaps just as importantly given the general lack of effective water pricing policy in most countries, this project will generate results that will not only greatly influence the development of China, but also serve as a model for other countries as they grapple with the scarcity of water.

Therefore, without limiting the ultimate ambition of the overall goal, in this specific research project, we will focus on a small set of specific objectives. **Objectives 1, 2 and 3** (defined below)—which will be carried out in the first year of the study—will utilize our existing network set up in rural China in collaboration with researchers in the Chinese Academy of Sciences. In this new effort we will also initiate new partnerships with the China Institute of Water Resources and Hydropower Research and the Center for Water Cycle & Terrestrial Processes to better use our previously collected survey data from 2004 and to make our current survey more effective and built on a more solid scientific basis. The work associated with these three objectives will also serve as a basis of departure (or baseline) for **Objectives 4 and 5** (also defined below) which will begin to set up a "controlled pilot experiment on the effect of water pricing on the demand of farmers for irrigation water" that will begin in the third funding year.

The objectives are:

OBJECTIVES 1-3 (collecting and analyzing information about demand behavior of farmers)

Objective 1 [*collect the baseline data for the Water Price Reform Program* (WPRP)]: We will collect a set of data that covers information on water use, agricultural production activities, changes in water resources, precipitation and other relevant information. This set of data will serve two purposes. First, it will be used for the analysis that will be used to meet objectives 2 and 3; second, it will be used as the baseline to assess the success or failure of our experiment that reforms water price in rural villages [Objectives 4 and 5]. The data will cover a sample of farmers that we have been following since 2001. Some of these villages will become our experiment (or treatment) villages; others (in the original sample and others outside the original sample) will become designated control villages. The control group and treatment villages will be randomly assigned. The sample will create a baseline data set covering sample villages that will be used in the pilot experiment and the larger-scale formal experiment.

Objective 2 [*estimate the demand for water*]: Using our data previously collected from 2001 and 2004 and the new data collected under this project for 2007, we will describe how the cost of water (or the price of water) and water use vary across space in our sample areas. This will be the first step in describing the relationship between water use and the price of water. We will also measure the water-output relationship and evaluate how responsive farmers in China were in their use of water to changes in the price of water in the past. Such an analysis will provide a description of the general nature of the water economy in our sample areas. Huang et al. (2006) have created a framework to address these issues and have attempted to carry out the empirical analyses (*Available at http://www.apec.umn.edu/faculty/qhuang/research.html*).

Objective 3 [*assess the disparity between the cost of water and the value of water*]: One of the most basic pieces of knowledge needed for setting up the WPRP is to know how much we need to increase the price of water in order to begin to induce water savings. This is needed since in many cases the current price being paid for water is less than its value. If the current price of water is less than its true value, then any policy that raised the price of water—at least at the margin—would be ineffective. The gap between the price (or cost) of water and actual value of water will be the amount by which the price of water will have to be raised in order to elicit a demand response.

So how do we get this information? We can obtain the "cost of water" (the price of water farmers are paying for water) directly from the survey data collected to meet objectives 1 and 2. This has to be done carefully, however, and we will utilize three approaches: recall data; interviews with well operators; and access to the data kept by local village accountants and electric company sales agents. In order to obtain estimates of the "value of water," we will take two different approaches. In our survey questionnaires, we directly ask farmers about their "willingness to pay for water," which is the value of water to them. We also use the estimates from the work associated with objective 2 to estimate the value marginal product of water, which is the value of the output generated from using water (Huang, 2006).

OBJECTIVES 4 and 5 (experimenting with water price):

Objective 4 [*set up the WPRP pilot program*]: The objective here will be to set up a pilot program that will serve as a basis of learning about how to set up the formal experiments in the next phase of the project. To meet this objective, we will create a pilot program that will increase the price of water farmers in the randomly selected treatment villages need to pay. We will then observe how they change their water uses. We will also compensate farmers in their income loss with a payment that is de-linked to water use. As an alternative way to control the use of water, we also will experiment with alternative policy tools (e.g., quantity rationing at current prices). Since the effectiveness of the water pricing policy would depend on local hydrogeological, social and economic characteristics, the longer-run objective will be to implement a larger, controlled field experiment (in 100 villages in three different sample provinces) that will be used to assess the impact of price policy under different production and social environments (note that this will be pursued under research to be supported by future grants).

Objective 5 [*evaluate the effects of WPRP*]: After collecting the field-experimental data in our pilot project villages, we will compare the changes in water use and water resource stock to evaluate whether the program has been successful in generating water savings. We will also compare the changes in crop mix and proportion of adopting water technologies to see how farmers adjust water use. We will also document other changes (e.g., water trade among farmers) that may have implications for WPRP. One of the main objectives of this part of the current proposed research will be to try to detect any type of unexpected behavior that might occur if the project was implemented on a larger scale (e.g., shifting of farmers from electricity-driven pumps to diesel-driven pumps; or a rise in the propensity to steal electricity).

Project Execution: Methodologies and Approaches

To meet our five specific objectives, the proposed activities can be divided into five steps (or categories of activities): Collecting survey data; Analysis; Setting up the Pilot experiments in the field; Collecting field-experimental data and Program evaluation.

Step 1: <u>Collecting survey data</u> [to meet Objectives 1, 2 and 3, collect the baseline data for WPRP, estimate the demand for water and assess the disparity between the cost of water and the value of water]:

Collecting data in rural China is a huge challenge. Fortunately, significant amount of work has already been done. Partly as the preparatory work for WPRP, we have collected a set of data that can be used for the analysis of the WPRP: the *2001–2004 China Water Institution and Management Survey* (CWIM). The CWIM data was collected in collaboration with the Center for Chinese Agricultural Policy, Chinese Academy of Science. Because a lot of work went in to design the survey questionnaires; choosing the sample; training enumerators with established training procedures and manuals; and establishing relationships with local government, the current work can be done more efficiently and in shorter time.

2001–2004 China Water Institution and Management Survey (CWIM)

<u>Timing of Survey</u>: January 2002 (CWIM 2001); September 2004 and August 2005 (CWIM 2004).

<u>Geographical Coverage</u>: 3 provinces / 14 counties / 47 townships / 80 villages / 320 households
Hebei, Henan and Ningxia provinces in north China.

<u>Years of Coverage</u>: 2004; 2001 and (by recall) 1995

<u>Enumerators</u>: Ph.D. and Master students from several Chinese Universities

<u>Survey Questionnaires</u> (all respondents were randomly selected):

- 80 Community level questionnaires: village demographic characteristics, share of groundwater and surface water resource; changes in depth-to-water and perception of water scarcity; village average water use by crops; details on different water management institutions; local government water policies.
- 109 Groundwater water manager questionnaires (randomly selected 1 to 4 water managers in each groundwater-using village) and 68 surface water manager questionnaire (randomly selected 1 to 2 canal managers in surface-water using villages): Characteristics of the wells and/or the canals and their command area; Operation and Maintenance of wells and canals; etc.
- 320 household survey questionnaires (randomly selected 4 households in each village): demographic information; agricultural activities; water use, payment for water and willingness to pay for water; adoptions rate and investment in water saving technology.

More information available at <u>http://chinawater.ucdavis.edu/</u> <u>(Please ask PI for password)</u>

In the 2007 survey (a part of the new work in this proposed research), during which we will collect the baseline data for the WPRP, there are two new data collection tasks (in addition to the work we have already done). The first task is to add more sample villages to the 2001-2004 CWIM samples (up to 100 more villages). A larger sample will allow us to carry out a larger-scale experiment in the third year of the project. Because there are more villages, we will eventually be able to use a broader array of treatments (different increments in water prices, different combinations of pricing and compensating schemes). The second task is to add and refine questions in the 2001-2004 CWIM survey questionnaires to reflect new issues and the new focus of the 2007 baseline sample survey. We will extract existing questions and blocks of questions from the 2004 baseline sample survey for re-use in the 2007 baseline sample survey. It is possible some of the blocks of the original survey will not be used. When questions are included from previous years, an effort will be made to keep the questions in a format as similar as possible to their original format in order to increase their comparability.

Step 2: Analysis [to meet Objectives 2 and 3, estimating the demand for water; and assessing the disparity between the cost of water and the value of water]:

As in the data collection step, we also have accomplished part of the work to meet this objective. Because of this we can start on this work from a more established basis and work more efficiently. Specifically, in our paper (Huang et al., 2006) we have developed a methodological approach and executed a preliminary empirical analysis of the effect of water price changes on water demand. A review of the current results from our analysis is in the dialogue box below. Huang et al. (2006), however, should not be considered a final product. The work in the current paper is limited in that only the 2004 CWIM data were used. In the extension of this work under this new project we will extend the use of the methods using data from 2001, 2004 and 2007.

Hence, the major task of step 2 is to build on our previous work and to use the methods with the panel data that we have in hand after the 2007 survey. With the 2004-2007 panel data, we will be able to improve our estimates for water demand parameters. The analytical results will help us gain an even greater understanding of water demand in the sample areas. More importantly, the results will aid us in designing the experiments by providing information on the gap between the current costs of water, which will guide the increments by which we should increase water prices in the experiments. The results will also provide information on the extent of income losses that should be expected when farmers face higher irrigation costs. This will help us decide by how much to compensate farmers in the experiments.

Irrigation Water Pricing Policy in China

Qiuqiong Huang, Scott Rozelle, Richard Howitt, Jinxia Wang and Jikun Huang

This paper analyzes the effects of water pricing policies on water use, crop production and producer income in rural China. An innovative approach is used, which captures the constrained nature of water demand in some of the sample areas and produce the most accurate estimates of water demand parameters given the data availability. This approach allows us to recover the true price of water and generate more accurate measures of the price responsiveness of households.

The estimation results that are generated by the county-level models show that water is severely under priced in our sample areas in China. As a result, at the current level of water prices, water users are not likely to respond to increases in water prices. Thus policy makers must increase water price to the level of value marginal product (VMP) so that water price reflects the true value of water. Using simulation analyses, we show that increases in water prices once they are set at the level of VMP can lead to significant water savings. However, our analyses also show that higher irrigation costs will lower the production of all crops, in general, and that of grain crops, in particular. Furthermore, households will face crop income losses. The inequality level of crop income distribution is also higher with increases in water prices.

In summary, the policy analysis provides both good news and bad news to policy makers. On the one hand, water pricing policies clearly have great potential for curbing demand and helping policy makers address the emerging water crisis. On the other hand, dealing with the production and income impacts of higher irrigation costs will pose a number of challenges to policy makers.

Available at http://www.apec.umn.edu/faculty/qhuang/research.html

Step 3: <u>Setting up 2 Pilot Experiments in the field</u> [to meet objective 4]

The plan is to set up four pilot villages that will serve as prototypes for the formal experiment (to be conducted in the next phase of the research —not included under this proposal). The communities will be chosen from one of the 14 counties in our original sample. To do so, we will need local cooperation of the county water resource bureau. Fortunately, we have established close collaborations with the local officials from the county water resource bureaus and township water management stations during the 2001 and 2004 CWIM surveys. In addition, the cooperation will be secured through our other professional contacts (and the contacts of our colleagues in CCAP and IWHR).

We admit that it will be a daunting task to set up a field experiment, especially in the complex social, economic and hydrogeological environment in rural China. There are many factors that need to be taken into account when designing the experiments. For example, although all pumping in the study areas are currently being done with electricity-driven pumps, this is mainly a function of the fact that electricity is relatively cheaper than diesel, even in areas with shallow groundwater (which could use diesel). Therefore, it is possible that in some areas in which we raise the price of electricity to a fairly high level, farmers may take the compensation and then find a way to buy or lease or hire diesel-driven pumps. Another such factor to take into account is the experimenter effects (Harrison and List, 2004). That is, farmers may resist an experiment on reforming water prices because they know the results of the experiments will affect the future water prices they will face. Since both PIs are from academic institutions in the United States, it is easy to convince farmers that this project is just academic research. In addition, we will compensate farmers for all their income loss.

Despite these difficulties we believe that we are fully capable of undertaking the task of carrying out the field experiment since we have organized a team of participants that have expertise in different areas (Appendix 2). We have several scholars (including the PIs) that are experienced in the collection of survey data. We will have one of the world's best experimental economists on our team as our advisor. We have one of the best hydrologists in China that will help us deal with the hydrogeological parts of the work (e.g., investigation of the nature o the aquifers in each treatment and control village; measure changes in water level; measure precipitation; etc.). We have a strong team of economists and water policy analysts from different institutes in China that can not only help the US-side of the team undertake the economic analysis, but who will also be able to get the message of the findings to the top officials in China.

To set up such a set of experiment villages, the following activities need to be implemented:

1. Announcement: We will announce the increase in water price beforehand at the end of 2008. The price increase will take place during the irrigation seasons in 2009. Informing farmers ahead of time will give them enough time to adjust (e.g., adopting water saving technology; crop choice; level of input use).
2. Water fee collection: We will install "Intelligent Integrated Circuit (IC) technology" in order to implement a "card automatic irrigation collection" system (CAIC). Under this system, irrigators must buy prepaid IC cards. Before the pump can be used, the card must be inserted into a server before water is released. The flow stops when the card is removed from the server or when the pre-paid amount is met. After each operation, farmers receive an electronically printed receipt, stating the amount of water used, price paid per unit of water, and the total amount of money deducted from the card. All servers are Internet-connected, so control and monitoring are easy, which greatly reduce administrative costs. Each irrigation server costs 1,000 yuan (about US$130). The CAIC system is already in uses in some areas in rural China (e.g., Shandong and Liaoning province) and is produced in China.
3. Subsidy: In order to de-link the subsidy to the level of water use, we will tell farmers the compensation is given to them as payment for participating in the program. Farmers will only be paid in partial at the beginning. They will get the rest after the experiment is over if they are not caught cheating (stealing water).
4. Monitoring water use: We will install water meters in the villages to monitor water use. We will also send out team members (and our paid agents) to monitor water use during the irrigation season. In addition to installing water meters, we will also directly measure changes in the depth-to-water in wells. We will also collect data on precipitation during the irrigation season since this will directly affect water use.

Step 4: Program Evaluating [to meet Objective 5]

For most outcome variables (e.g., water use; crop mix etc.), we will have longitudinal data from before (2004; and before the experiment – 2007) and after the implementation of the WPRP (2009). Because of this, we can employ the *difference-in-differences* estimator. This evaluation approach compares the mean before-and-after changes among people living in the areas that experienced the policy (e.g., those areas in which the WPRP was implemented) with the mean before-and-after change among people living in non-project areas (e.g., those in areas in which WPRP was NOT implemented). Since the treatment and control villages were randomly assigned, the effect of the policy can be easily calculated. For example, let P_t equal one if period *t* is after the "new program" has been implemented. Then the difference-in-difference estimator can be implemented by the convenient regression (cf. e.g. Cameron and Trivedi 2005):

(1) $$y_{it} = \alpha + \beta P_t + \gamma T_i + \delta P_t T_i + \varepsilon_{it} \qquad t = 1,2.$$

where the interaction term $P_t T_i$ equals one for the treated individuals in the post-intervention period, and the coefficient δ is the difference-in-difference estimate. Or the difference-in-difference estimator can be implemented by regressing the change in outcome over time on a treatment dummy:

(2) $$\Delta y_{it} = \beta + \delta T_i + \Delta\varepsilon_{it} \qquad t = 1,2.$$

where Δ is the difference operator. The difference-in-difference estimator sweeps out the effects of time-invariant influences on outcomes, both observed and unobserved, and in effect nets out any changes that could be considered likely to have occurred anyway. One can also add covariates to equations (1) and (2) (Cameron and Trivedi, 2005), to get, for example:

(3) $$y_{it} = \alpha + \beta P_t + \gamma T_i + \delta P_t T_i + \sum_k \phi_k x_{kit} + \varepsilon_{it} \qquad t = 1,2.$$

which we refer to as the difference-in-difference estimator with covariates. Combining differencing with covariates allows us to control for heterogeneity.

One alternative method of assessing the impact of the treatment is the method of propensity score matching (PSM) developed in P. Rosenbaum and Donald Rubin (1983). This method has been used extensively in the debate over experimental and nonexperimental evaluation of treatment effects initiated by Lalonde (1986): see Rajeev Dehejia and Sadek Wahba (1999, 2002) and Jeffrey Smith and Petra Todd (2000). The goal of PSM is to make non-experimental data "look like" experimental data. The intuition behind PSM is that if the researcher can select observable factors so that any two individuals with the same value for these factors will display homogenous responses to the treatment, then the treatment effect can be measured without bias. In effect, one can use statistical methods to identify which two individuals are "more homogeneous lab rats" for the purposes of measuring the treatment effect.

Expected output

We expect to have at least six publications from the work associated with Objectives 1 to 3. We will have two publications that document in detail the current status of water resources and water management in China and the disparity between the cost of water and the value of water. We also will have three analytical papers: a). Estimating the historical water demand in rural China; b). Evaluating the impact of China's water price reform; c). A cost-benefit analysis of water price reform using the sample villages in the pilot experiments as a case study. There will almost certainly be additional evaluations to do, but emphasis will be put on those issues that are most pressing and of concern to the government.

In addition, we will also write a paper that not only documents the changes in water use, crop mix and adopting water technologies, but also documents any other changes that may not be easy to predict (e.g., water trade among farmers, shifting of farmers from electricity-driven pumps to diesel-driven pumps; or a rise in the propensity to steal electricity). Documenting and discussing any type of unexpected behavior that might occur if the project was implemented on a larger scale will provide important information for those charged with implementing policies.

The collection of the 2007-CWIM will add one more panel in the unique time series data we collect that record water resources and water management and institutional changes in rural China. In addition to the use as the baseline data in the experiments, the time series data alone will be extremely valuable to research on water issues.

Importantly, we also will have created baselines that will be used when we scale up the experiments. The baseline will consist of details on water resource stock, water use, crop pattern, current rate of adoption of water saving technology. These will be the “before data” when we do the full scale WPRP experiments in Phase 2 (funded by future projects).

Appendix 1. Activities, Timeline, Budget and Funding Prospects:

Timeline	Activities	Amount	Source of Funding [a]
First year			
	Survey work [to meet objective 1, 2 and 3] [b]		
June 2007	**The First 3-day Workshop**: § Assign responsibilities among all the participants § Discuss survey implementation § Discuss Experiment design § Develop proposals to apply for the World Bank Research Grant and the National Science Foundation Grant	10, 000	***Interdisciplinary International Research Circle Grant, University of Minnesota***
June 2007	Pretest work	15,000	ERS, USDA, Cooperative Agreement
September 2007	Implement the 2007 China Water Institution and Management (CWIM) Survey	70,000	*40,000 from Grant-in-Aid, University of Minnesota* *10, 000 from Center for International Food and Agricultural Policy Micro Grants Fund* 20,000 from ERS, USDA, Cooperative Agreement
October 2007	Enter and Clean data	5,000	ERS, USDA, Cooperative Agreement
	Analysis [to meet objective 2 and 3]		
Nov 07 – Mar 08	Research Assistant at University of Minnesota	24,000	Qiuqiong Huang (PI) start-up fund
March 2008	**The Second 3-day Workshop** § Develop experiment design § Develop grant proposals to seek funding beyond 2009 **[to meet Objective 4 and 5]**	10, 000	***Interdisciplinary International Research Circle Grant, University of Minnesota***
Second year			
June 2008	**Set up pilot program in 4 sample villages [to meet Objective 4 and 5]**	40,000	*World Bank Research Grant*
Third year			
Jan –Dec 2009	**Monitor experiment process and collect field-experimental data [to meet Objective 4 and 5]**	70,000	*National Science Foundation Grant* (*The Economics program*)
	Program evaluation [to meet Objective 5]		
Jan – Mar 2010	Research Assistant at University of Minnesota	24,000	*Grant-in-Aid, University of Minnesota*

	Total	**268,000**		

a. Sources of Funding in Italics indicate potential source of funding. b. The budget for survey work is calculated based upon the expense on the 2004 CWIM survey. The expense of new samples in addition to the samples in the 2004 CWIM is also included in the budget estimate.

Appendix 2. List of Participants and roles/responsibilities

Participant/ Affiliations	Roles/ Expertise/Responsibilities
Qiuqiong Huang Assistant Professor Department of Applied Economics University of Minnesota	PI; in the past, I have worked extensively on water issues in China. In particular, partly in preparation of this project, I managed the 2004 CWIM Survey, which will be the basis of the baseline survey for this project. Using the 2004 CWIM survey data, I have written the paper "Irrigation Water Pricing Policy in China," which will serve as the baseline analysis of this project. This project will be the research program I develop as an assistant professor at the University of Minnesota. I will be supervising the progress of the project. In particular, I will coordinate and assign responsibilities among participants; organize the field work (experiments implementation and data collection); analyze results; communicate with funding agencies and write grant proposals; write reports, papers, policy briefs and dissemination of results.
Scott Rozelle Professor & Helen F. Farnsworth Senior Fellow Shorenstein Asia Pacific Research Center Freeman Spogli Institute Stanford University	Co-PI; Dr. Rozelle is widely recognized as the best China economist. He has published more than 100 journal articles and several books on the economic, social and political issues in China. He was the Co-PI of the project for which we conducted the 2004 CWIM Survey. He worked on designing the survey forms and training enumerators. He is also the co-author of several water pricing policy papers. In this project, he will continue to collaborate with me on conducting surveys, writing papers and grant proposals.
Jinxia Wang Senior Research Fellow & Associate Professor Center for Chinese Agricultural Policy, Chinese Academy of Science	Co-PI; Dr. Wang is based in China. She has worked extensively on water issues in China. She has been doing field work and collecting data for almost ten years. She is extremely well connected with local water officials. In this project, she will be responsible for organizing survey work with local officials, recruiting enumerators and training enumerators. She will also be one of the co-authors in papers and policy briefs.
Jikun Huang Director, Senior Research Fellow & Professor Center for Chinese Agricultural Policy, Chinese Academy of Science	China policy; Dr. Huang is extremely well known in the field of agricultural economics inside China. More importantly, over the past decades, he has been advising China's national leaders (including the premiere and his policy advisors) directly. In this project, he will be responsible for supervising the policy briefs that we will write using the results of this project and communicating the policy recommendations to China's leaders.
Bryan Lohmar Economist, Market & Trade Economics Division Economic Research Service, USDA	International food policy; Dr. Lohmar has been working on the link between water and grain production in China and its impact on the US agriculture. He will be responsible for analyzing the impact of changes in water policy on crop production and effects on the international food trade (between China and the US and other countries).
Zhanyi Gao § Leader, Division of Science of Technology, Ministry of Water Resources § Head, Department of Irrigation and Drainage, China Institute of Water Resources and Hydropower Research § Director, National Center of Water Saving Engineering and Technology Research	Administrative coordination and Water saving technologies; Dr. Gao holds an administrative position in the Ministry of Water Resources. He will be responsible for communicating with the county local water resource bureau to set up a formal agreement for us to implement experiments in rural villages. Dr. Gao is also an expert on the engineering side of the water saving technologies. He will be responsible for 1). Listing the types of water saving technologies that can be used in our experiment villages; 2). Providing the technical information on the water saving technologies and providing estimates of the potential field water savings; 3). Produce the information page that will be distributed to farmers in our samples villages, which will be used in the next phase of our experiments.
Jun Xia Professor, Director of both the Center and the State Key Laboratory for Water Cycle & Terrestrial Process,	Hydrological field data collection and modeling; Dr. Xia is the best hydrologist in China. He is the national chief scientist in the field of Hydrology (an honored title for outstanding scholars) in China. He will be responsible for the hydrological component of the project. In particular, this includes: 1). Investigate the hydro-geological structure of sample villages; 2). Measure the depth-to-water in wells during the project period; 3). Measure the level precipitation during the project period and

Chinese Academy of Science	calculate the level of the effective rainfall; 4). Evaluate crop water use efficiency
Yaoming Lin Researcher Chinese Terrestrial Ecosystem Flux Research Network	Hydrological field data collection and modeling; Dr. Lin is an expert on water cycle modeling. He is responsible for collaborating with Dr. Xia on the tasks listed above. In particular, he will be responsible for developing an accurate soil-water balance model, which takes the land use and the precipitation on it into account along with comparisons of the water demand and deficits of different crops in order to evaluate the effective precipitation and irrigation utilization in the sample villages.
Dean Karlan* Assistant Professor Department of Economics Yale University	Field economic experiment design; Dr. Karlan is one of the best economists that work on field experiments. He has published on top economics journals such as Quarterly Journal of Economics and American Economic Review. More importantly, he has conducted field experiments in developing countries. His rich experience will be great inputs in helping designing our experiments in rural China.
William Easter Professor Department of Applied Economics University of Minnesota	Water management institutions; Dr. Easter has worked on water management institutions, in particular, water markets, in many developing countries for many years. He will be responsible for looking into the existing water management institutions in China and examine how water price policies would work under different institutions.

*All the participants, except for Dr. Karlan, have committed to be actively involved. We are in the process of talking to Dr. Karlan about his participation in the project and coordinating scheduling.