Tarim River Water Allocation and Community-Based Management

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BACKGROUND

The Tarim Basin is an important base for implementing the strategy of utilizing China's abundant resources in the twenty-first century, including the large petrochemical reserves, and the important cotton and other agricultural products' production area in Xinjiang. However, the ecology in this region is rather fragile. The extremely dry climate, desert ecology, excessive cultivation of land and the irrational utilization of water resources all accelerate the deterioration of the basin's environment. The river and the lake are dried up, the water quality is worse, the natural vegetation is withered over large areas, the "green corridor" along the lower reaches is disappearing, desertification is increasing, natural disasters occur more frequently with increasing destruction, and many species have disappeared while the population of other species have decreased significantly. The environment now restricts the sustainable development of the local economy.

The Tarim Basin ecology, is drawing more and more worldwide attention from experts, scholars and international aid organizations, especially the issues of preventing desertification and managing the water resources being the most important among all the current problems that await immediate solutions. IDRC funded and organized this project to make a thorough study on the Tarim Basin.

Western China Development strategy is an important strategic decision made by the Chinese government to bridge the economic gap between the western and eastern regions, to coordinate the economic, industrial and social development among the different regions and to assure sustainable and healthy growth of the national economy. The objective of the western China development plan is to improve the local environment and the local economy. The Tarim Basin plays a major role in the municipal economy and the social development of Xinjiang, which is an important autonomous region in the west. This project is thus very significant with the need for new management strategies and technical solutions. Efficient management and rational utilization of water resources, the two key issues in this project, are needed to coordinate environmental improvement and economic development.

Exacerbation of the environment problems in the Tarim River Basin has hindered local and regional economic development, threatened human existence in the region and retarded social development. In January 1999, at the second session of the ninth National People's Congress of the PRC, the Xinjiang delegation submitted a motion for funding a project to dredge the Tarim watercourse and to improve regional ecology as a national program. This

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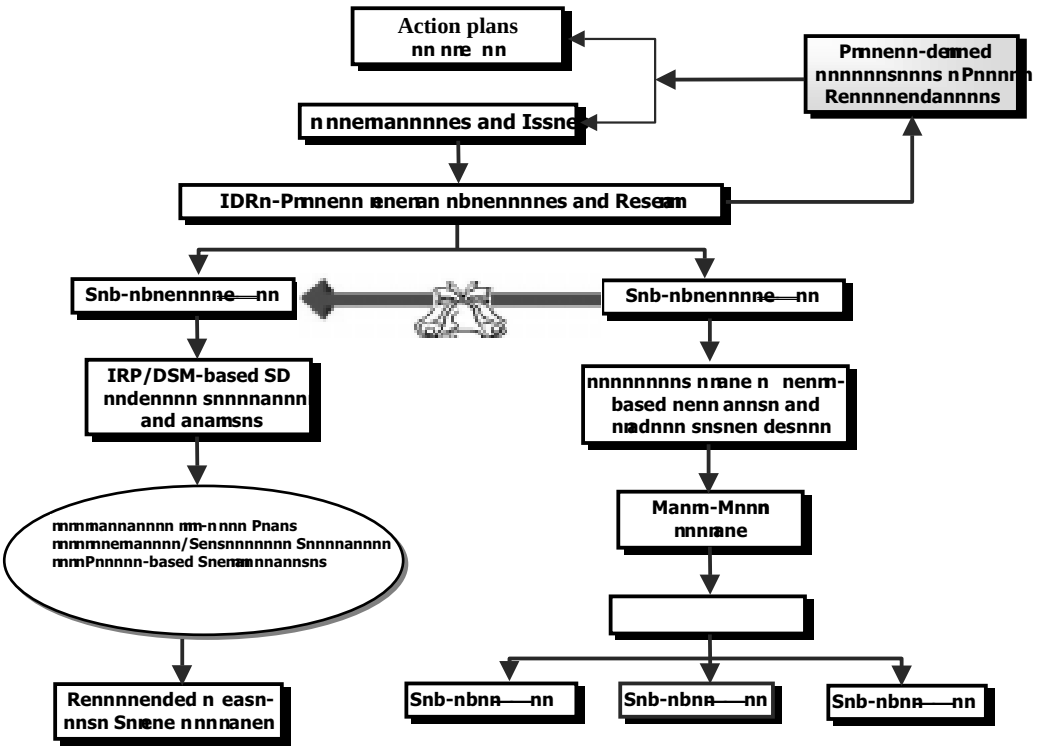
Note: Only one paper is included in the China section. The other papers could not be included as they were not available at the time of publication.

motion drew attention from the State. This project, approved by the State Council, has been listed as one of the ten national river environmental improvement projects, with the first phase of the work already begun. In accordance with these, the research group adjusted the research content to facilitate implementation of the Tarim River project. The thorough research at both the macro and micro levels has provided wide-ranging policies and suggestions to maintain sustainable economic development of the Tarim Basin, which is of practical and far-reaching significance.

Figure 1. The research framework of the project study.



RESEARCH METHODOLOGY

The socioeconomic system, the water use and the ecosystem are all interconnected through complex interactions, interdependence and interlinks. At the same time, by virtue of the internal intrinsic mechanisms and dynamic feedbacks, the whole system would display a non-linear and counterintuitive characteristic. These issues are obviously typical of complex large-scale system natures, and need to be carefully analyzed using proper system engineering approaches.

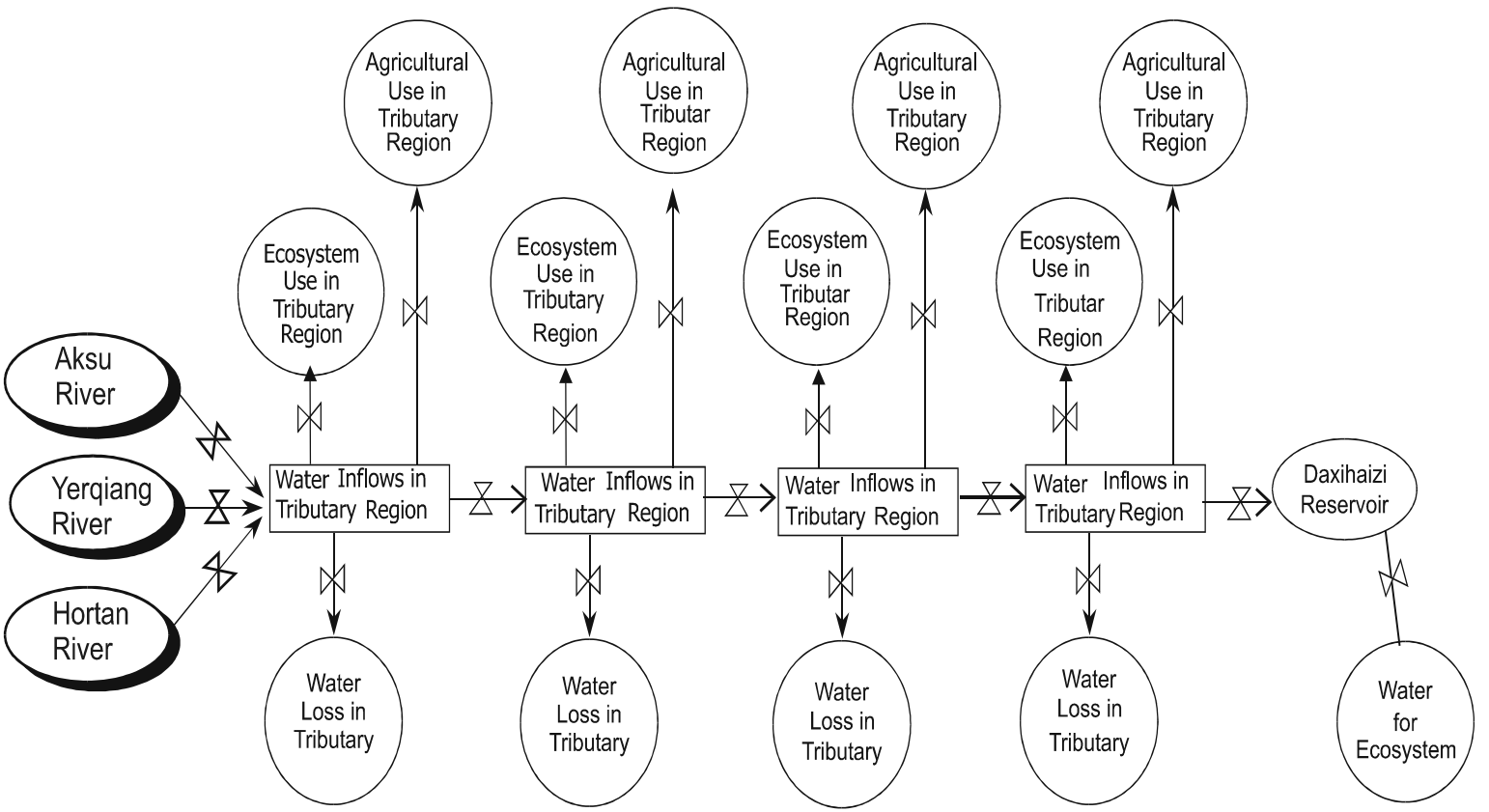
The system dynamics(SD) method which can analyze both quantitative and qualitative effects was coupled with the Integrated Resource Planning(IRP) and Demand Side Management(DSM), to systematically analyze the status of the water supply and demand throughout the Tarim River basin, as well as the impacts of socioeconomic growth on the water demand, and the effect of variable flow on the water supply and demand.

The purpose of building this SD+IRP/DSM model is to explore how to successfully implement the government-sponsored remedial program for the still-degrading Tarim ecosystem and how to achieve the planned socioeconomic growth and development. The model should simulate the possible scenarios of imbalance between water supply and demand, and then develop cost-effective response measures involving a set of the mixed water supply/ demand technologies available to meet the variable water demand.

- The model includes three functional modules described below:
- Surface water allocation module reflecting the natural interconnections in the entire Tarim River system.
- Total water demand module related to the crop structures and agricultural scales
- IRP/DSM-based water supply module driven by the gap between water supply and demand

Design framework and modeling exercises: With the annual estimates of water demand equation derived from the water demand module, the gap between water supply and demand can be mathematically expressed in the PD computer language using the variable surface water inflows given by the surface water allocation module. More importantly, the imbalance between the water supply and demand will be used as the primary motivation of the IRP/DSM-based water supply module to drive the selection process by identifying a cost-effective group of both supply-side and demand-side technologies. The selection will start from the lowest unit cost water supply technology among the available candidate options and increase in ascending order of unit cost until supply and demand are balanced. It should be noted that the SD sub-model has been coupled with the IRP/DSM sub-model to form a powerful functional modeling tool which apparently overcomes the deficiencies of the single IRP/ DSM model once employed in the first phase of the project study. The addition of the SD sub-model allows simulation of the interdependent and interactive nature of the large-scale complex system. The IRP/DSM method will determine the water supply options to satisfy the target demand for a given scenario. The successful and efficient coupling of the SD sub-model with the IRP/DSM sub-model using only the Professional Dynamics(PD) plus computer language is an important innovation in this second phase of the project study to facilitate analysis of various scenarios. Additionally, the data used for the model inputs and outputs is organized in a database, to enable efficient management and retrieval of the data. The model structure is described by the block diagrams as shown below.

Figure 2. Cause-effect relationship for Tarim River.



As described above, the dynamical selection of the mixed water supply technologies to balance the aggregate demand in the model simulation is driven by the imbalance between the water supply and demand, which is affected not only by the natural annual flows in the three tributaries, but also by the demand related to the socioeconomic growth rate at that time. For instance, with low economic growth, the water supplies may not necessarily fall short of the total demand in the event of *low flows* during dry years, and by the same token, the water supplies wouldn't necessarily exceed the overall demand in the case of *plenty flows* when it happens to be a wet year. That is to say that the balance status is at last finalized by the actual gaps between them. In reality, the surface water flows(**S**) from the three tributaries may occur as one of the following scenarios:

- Multi-year average flows
- Dry-year low flows
- Wet-year high flows
- Multi-year statistically variable flows

The water demand is primarily related to the agricultural scale, that is, total area of irrigated farmland, and the overall water use efficiencies, which include both the canal efficiency and field irrigation efficiency. The irrigation areas are more dependant on several parameters such as local population increases, agricultural productivity(crop yields per unit area), the target growth rate of the local economy, and so forth. These relationships can be described functionally as:

Water demand(i)=WD_i=F($Area_i$, Eff_i), $Area_i$ =G(Pop_i, Uyd_i, Gr_i)

Here, Eff=Efficiency, Uyd= Crop yields per unit area, and Gr=Agricultural growth rate

i={tributary, upstream, midstream, downstream}

Therefore, all these possible changes which is related to the socioeconomic development in the Tarim Basin should be properly considered in the model simulation. The following key factors and their combinations are supposed to be the most important elements affecting the overall water demand in the foreseeable future.

- ✓ $\frac{\partial \mathbf{F}}{\partial \mathbf{Eff_i}} > \mathbf{0}$, When the overall efficiencies of water use remain variable
- ✓ $\frac{\partial \mathbf{G}}{\partial \mathbf{POP_i}} = (>)\mathbf{0}$, when the local population remains constant or variable
- ✓ $\frac{\partial \mathbf{G}}{\partial \mathbf{Uyd_i}} = (>)\mathbf{0}$, when the crop yields per unit area remains constant or variable
- ✓ $\frac{\partial \mathbf{G}}{\partial \mathbf{Gr_i}} = (>)\mathbf{0}$, when the local agro-economy scale remains constant or variable

In accordance with the basic theory of the System Dynamics(SD), there always exist some sensitive parameters or critical “loops and sub-structures” in the complex systems, which affect the overall properties or performances of the whole system. So in an attempt to identify and then simulate such important and crucial elements that could impact the water supply and demand, as well as the possible gaps between them, a set of scenario combinations of water supply cases with water-demand situations have been designed to reflect all the possibilities that may occur in the time horizon of 50 years. The scenario-based analysis will reveal the possible conflicts or challenges that may arise from the future implementation of the water allocation scheme outlined in the government remedial package, and also provide the corresponding response measures to help resolve the problems in the event of imbalance. For the details about the scenario combinations, please refer to the attached table.

In reality, there only exist the following three situations of the water supply and demand in the event of imbalance:

$$S_i(\text{surface water})\text{-}D_i(\text{demand}) \begin{cases} <0, \text{ +Policies (Policies 1)} \\ =0, \text{ Business as Usual (BAU)} \\ >0, \text{ +Policies (Policies 2)} \end{cases}$$

In which, S_i represents the water supply D_i denotes the water demand{i=tributary, upstream, midstream, downstream}. When there is a gap between the water supply and demand as illustrated above, the following policies will also be taken for the water use priorities.

Policies={ Policies-1, Policies-2}

Policies-1:

Top priority is given to the use of scarce water for the ecosystem

Top priority is given to the use of scarce water for the agricultural production

Encouragement of the implementation of **IRP/DSM**

Policies-2:

Emphasis of the ecosystem

Emphasis of the agricultural production

Emphasis of both the ecosystem and the agricultural production

Continuation of the implementation of **IRP/DSM**

MODEL-BASED RECOMMENDATIONS AND CONCLUSIONS

The population increase would undoubtedly result in the growing need of the agricultural products which could be apparently satisfied by the expansion of the farmland scale,

or other means like the restructuring of the crop patterns or the improvement of productivity. The study shows that the increase of the yields per unit area could largely offset the additional requirement of the agricultural products. It is very important to both readjust the crop mixes and develop some locally advantageous economic sectors, with the aim to improve the living standard of the local ethnic groups.

The simulation also shows that the improvement of the water use efficiency could reflect the local capacity for future economic development. But the potentials from the efficiency enhancement would depend on the water flows available. When the surface water is relatively plenty, this potential would be more obvious. So the upstream regions should deliver more water flows to the middle and lower reaches.

MANAGEMENT MECHANISM FOR ENSURING THE IMPLEMENTATION OF WATER ALLOCATION SCHEME IN TARIM WATERSHED

Defects of Current Water Management Mode—Lack of Benefit Allocation and Adjustment Mechanism

Under the traditional planned economy, water resources were allocated among different users through administrative orders. The Department of Water Conservation as the administrative organization of the basin was responsible for making water allocation plans. The department relied on administrative orders to ensure water resource allocation, which often did not reach the expected target. The various mechanism concerned with water allocation in the Tarim Watershed are illustrated in figure 3.

Figure 3. Simplified relationships for water allocation in the Tarim Watershed.

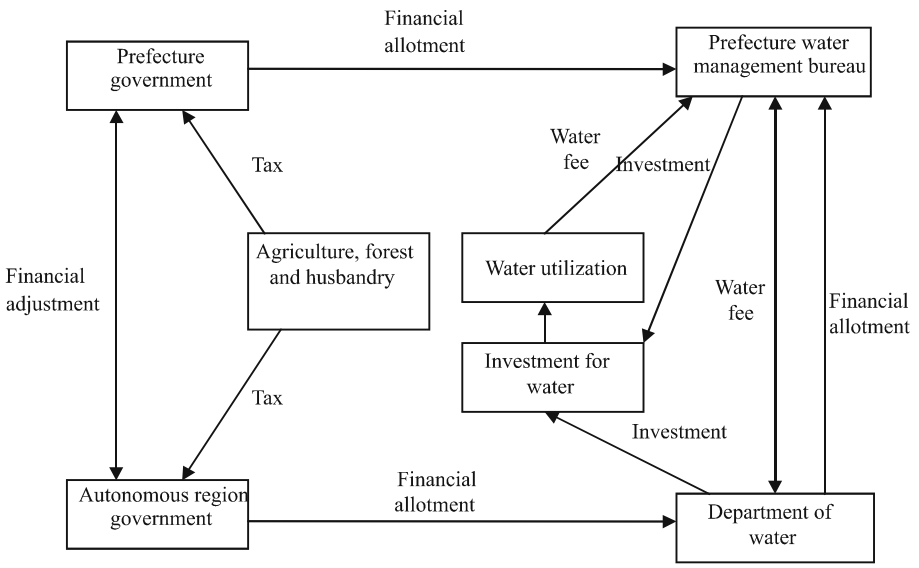


Figure 3 shows that the management organizations directly involved in water resource allocation including the Department of Water Conservation, the Autonomous Regional Government, local water management department, local governments and the Tarim River Administrative Bureau.

The decisions on water resource goals were made by the Autonomous Regional Government basically by itself after considering the central government's constraints. The main preference of the government is economic development, through a much higher rate of economic growth. The most important preference is the maximization of production for Tarim Watershed. Environmental preservation was only given minimal consideration. Therefore, when the Autonomous Regional Government established economic development goals, the constraints of water resources on agricultural production were neglected, which greatly influenced the reasonable allocation of water resource among the whole watershed. As with the Autonomous Regional Government, local governments focused on economic development of their territories, i.e., the maximization of local production, without considering the interests of the whole watershed. The main objective of the Department of Water Conservation of Autonomous Region was to ensure the investment and normal operation of the water conservation projects. Thus, the Department of Water Conservation had limited influence on the local water management departments through allocation of investment funds from the central government and the Autonomous Region, with no authority to restrict local water departments, especially those responsible for water allocation. The responsibility of the Prefecture Water Department is to ensure the allocation and utilization of water in its own territory, investment into water conservation projects and to collect and use water fees. Therefore, the local water administrative departments aim to ensure regular operation of the water system in the local prefecture and satisfy the agricultural irrigation needs, to achieve the economic goals established by the local government because the local government overseas the local water department. So, there is no administrative department with clear and definite responsibility to coordinate the reasonable allocation and utilization of water resource throughout the whole watershed. The Autonomous Regional Government and its Department of Water Conservation represent the country's ownership of the Tarim River water resource. Local prefectures only possess the right to use water. Self- interest would drive all of them to select the most favorable decisions for their own benefits. Their decisions and countermeasures, as a consequence, more or less oppose the goal of reasonable allocation and utilization of water resources throughout the river basin. This is the real reason for irrational allocation of water resources among the local prefectures. Behavior analysis of the administrative departments showed that only the Autonomous Regional Government can regard the rational allocation of water resources as one of its key goals. The allocation and management of water resources is supervised by the Department of Water Conservation, which mainly relies on the local water management departments to control the Tarim Watershed. Thus, the local water management departments directly affect the allocation of water resources. The Tarim River Administrative Bureau, as part of the Department of Water Resource Management, is just a peripheral organization. Although in 1997 it was promoted to the vice-bureau status, the Tarim water situation has not changed much with the promotion. The Tarim River Administrative Bureau lacks actual authority to control the whole watershed, so it cannot coordinate the water allocation conflicts. From the complicated administrative relationships among these management departments, it is clear that only the Autonomous

Regional Government has enough authority to coordinate the conflicts between different interest groups to make them achieve the goal of reasonable water resource allocation throughout the whole watershed.

Therefore, the Department of Water Conservation of the Autonomous Region should be responsible for management of the river resources. The Department of Water Conservation should adopt effective steps to ensure rational allocation of water resources among the five regions. However, the biggest problem is that orders from the Department of Water Conservation cannot get support from the Prefecture water management sector, so there is no effective control. The Department of Water Conservation must have more power over the water resources for the whole watershed to guarantee that its orders are executed effectively and must be able to control the water extracted by the local prefectures. To achieve the target, the government investment must be increased to set up enough control systems so that the Department of Water Conservation can completely control the river to properly allocate the water resources throughout the water conservation. At the present level of financial investment, the intervention cost is too great for the Department of Water Conservation or the Government. The current investment level can only provide some administration so the Department of Water Conservation cannot control the local prefectures.

However, other methods can be used to provoke water conservation. After several years of field surveys to study the management of the Tarim River Basin and its policy mechanisms, we think that market economics would provide better investment. From the viewpoint of economic benefit, it is better to set up an effective management mechanism based on incentives than to intervene by means of administrative orders. The best systems for the Department of Water Conservation is to reform the pattern of water resource use rights, introduce market reforms and to bring out the use of their own interests to promote reasonable utilization of the water resources among the local prefectures. Therefore, the problem of the irrational water resource management mechanism is not the water price or the government organizational structure. The problem lies in the lack of incentive mechanism throughout the whole watershed. Therefore, the water resource management regime must be improved to promote an interest allocation mechanism, which can realize reasonable allocation of water resources throughout the whole river basin at the lowest investment cost with the benefit-driven methods to encourage investment from different benefit groups. Therefore, further study on the innovative water management system is needed.

Water Rights Allocation and Transaction System

1. Water rights allocation among the five prefectures:

   The allocation of water rights firstly depends on identifying the differences between the societies, economies, environment, resources, capabilities, etc. of the prefectures; then developing a reasonable model for water rights allocation.

2. The principles of water rights allocation:

   The principles for water rights allocation differ greatly due to people’s different conditions and understanding. There are often debates and opposite viewpoints

on the principle of allocation, because every person always thinks about the questions relative to their own benefit. Generally speaking, the principle of water rights allocation between prefectures should consider the benefits of the most areas.

The goals that must be considered in the analysis are efficiency, fairness, environmental protection, sustainable development, etc.

Balance between efficiency and fairness

In the Tarim River basin, the water use efficiency is very low and conflicts over water resource allocations occur, so neither efficiency nor fairness is achieved within the present water resource management system. The government seeks efficient and fair use of water resources, so the policies must balance economic efficiency and fairness. The principle of fairness requires that every individual, interest group and region should have equal rights to obtain water resources, rather than each prefecture using water based on its abundance of water resources. For efficiency, the water resources should be allocated to maximize the output per unit water. Therefore, the water resources should be allocated between prefectures with consideration of their GNP and the influence of the water utilization on the output.

Environmental protection

Maintenance of the environment must be a fundamental aspect of the water resource allocation plan. The decrease in water flow to the lower reaches of the Tarim River, has seriously damaged the ecology of the desert and the oasis causing much worse desertification. In the past 40 years, forest area in the basin has decreased by over 500,000 ha. All of the managed artificial forests, the grasslands and the desert oasis vegetation should be allocated a certain amount of water to maintain the ecology. This ecological water should be allocated fairly and rationally, with the woodland and grassland areas chosen as the basis to allocate water for environmental protection between prefectures.

Keep sustainable development

Water resource allocation should also aim at sustainable development in the whole basin. The principle of water rights allocation between prefectures should include consideration for social improvement, economic development, environmental protection, sustainable resource exploitation and use, population increase, improvement of local residents' living standards, etc.

Balance between historical and present development

For historical reasons, the different prefectures in the Tarim River basin are in different stages of water resource exploitation and utilization with deficient factors influencing their water use such as population, resources, economy and so on. Therefore, specific initial allocation of water rights should be determined according to the actual specific conditions and considering the historical development. The main indices for water rights allocation, such as population, GDP, arable land area, etc., must be based on current data (for example, the 1995 data) with the influence of the development in each prefecture. For example, the influence of the average increase since the hydrological stations were established in 1950s would be considered.

Therefore, the water rights allocation principles can be generalized as follows: "Allocation should consider the actual condition and the historical development, promoting a combination of fair economic development, which is sustainable and protects the environment."

Allocation model for water rights

The water in the Tarim River basin is mainly used for agricultural irrigation, animal husbandry, ecological needs of the desert oases, and people's daily needs, as well as for industries, petroleum development and other sectors. The water rights of each prefecture should include the following parts: residential water consumption, water consumption, environment protection water consumption.

Water rights = residential water consumption
+ industrial and agricultural production water consumption
+ ecological protection water consumption

The allocation of water rights for industry and agriculture should first meet the requirement that every prefecture has a fair opportunity for development with consideration of the influence of economic efficiency, so as to promote increased benefit from the water resources in the whole basin. Water for agricultural irrigation should be allocated according to the gross farmland area with consideration of the agricultural output per unit water to efficiently use the water resources. The industrial water rights should be allocated according to the industrial production, for example, using the water consumption per 10000 yuan of industrial production as a weighting factor. According to the current water resource utilization in the Tarim River basin 25-30 percent of the water has been used for ecological maintenance for many years.

Data for water consumption is not normally given per capita but is correlated with income per capita. However, the population must be confident simultaneously with an influencing weight relative to the income per capita, which could be the ratio of the income per capita in the prefecture versus the average income per capita in the whole basin.

These principles were used to develop a model to allocate water rights with the aim of sustainable development The water rights allocation model was used to calculate the initial water rights allocation for the Tarim River basin.

Water Rights Transaction System

Once the allocation of basic water rights for each region and each user is fixed, there must be some imbalance between supply and demand. Consequently, a system is needed for trading water rights. The allocation of water rights by governmental orders would result in conflicts and unlawful exchanges such as “black market.” The allocation of water rights at the regional level has established a basis for the transaction system. As soon as the original water right is allocated, the transaction system and the transaction regulations (and the transaction price) must be established to offer guidelines for transactions.

1. *Trade principle for water rights among prefectures:*

The trading of water rights among prefectures should be consistent with the basic principles.

The total profit of the whole basin is to be maximized to optimize the allocation of resources. The maximum total economic efficiency, which means the efficient allocation of water resources, should be promoted.

The principle of trade compensation and shared interest states that the seller of the water right should receive compensation with the amount depending on the profit that the buyer and seller gain through the transaction. Because the water right transaction is a win-win interaction, the profits should be allocated by negotiation or an exchange price system.

The principle of maximal tradable water rights states that the water sold in each region must not exceed that stipulated by the management of the Tarim River basin. For example, water rights for the ecology cannot be sold.

The principle of progressive forfeit for surpassing quota states that a region may not exceed the quota plus any transactions. When the flow at the hydrological station exceeds its quota, the region must progressively forfeit some of its quota.

2. *Rules and implementation of water rights transactions among prefectures*

a. Water rights transaction rules

The core of the transaction system is a set of explicit rules to guide the transaction rules.

Suggested specific rules and processes are:

Each prefecture forecasts the possible necessity of transactions according to their water consumption plan in the beginning of the year and the unpredictable runoff, then applies to the water right transaction management institute for a transaction.

As the organizer of the water rights market, the management institute of the Tarim River basin publicizes the transaction request and facilitates the transaction by considering both the demands (of the buyer) and the supplies (of the seller).

The management institute of the Tarim River basin used the transaction sheets and the actual water usage to ascertain the seasonal (or annual) transaction of water rights at the end of the year.

The management institute together with the prefectures measures the water consumption, and the amount exceeding the quota, then settles the transaction accounts based on the exchange price (to be discussed later in this report).

b. Transaction of water rights among sectors

The analysis indicates two kinds of tasks that must be done by the management institute of the Tarim River basin to guarantee the transaction process:

A service institute for the water right transaction market that would supervise the water right exchanges among prefectures throughout the basin. At present, the Department of Water Conservancy could serve as the institute. Its budget should come from governmental financial allotment for administrative enterprises to avoid additional economic burdens on the users for the water rights transactions.

To ensure the balance of supply and demand, a trade fund for water rights transactions should come into existence through which the government can intervene directly into the market (like the open market function).

Unregulated transactions, i.e., trades without the permission of management institute of the Tarim River, would be permitted to allow prefectures to get enough water from other locations according to a price agreeable to both sides. But these transactions should be reported to the institute for the records. The management institute ought to examine the legitimacy of the transaction to ensure that it does not affect the environment nor a third party by permanent transfer of water rights. The institute could veto such transactions.

The permanent transfer of water rights among sectors would request the consent of a third party and the management institute of the Tarim River. The transaction must not harm downstream users or the environment.

When the water cannot be allocated proportionately, the management institute must be able to implement compulsory measures. When a prefecture has not obtained extra water through transaction and the quantity of water used exceeds its legal water right, the penalty should be levied based on the price set by the river management agency.

If a prefecture has not arranged transactions and the actual quantity of water used is less than its legal water right, it should receive compensation for the rest of the water right from the management agency at an agreed upon price.

Because the water resources are unpredictable since the runoff may be affected by the weather, the water right of each prefecture and user each year cannot be definitely guaranteed. The effect on production of the unsteady water volume can be minimized through “futures” to regulate water rights bargaining. The water right futures market bargaining may be improved through regulation of a “futures broker.”

c. Problems in the water rights transaction system

Return-flow problem

Water right transactions may sometimes affect the water rights of third parties, such as in agricultural irrigation. If a farmer transfers his whole irrigation water right to a farmer living out side the basin, then the downstream users cannot get the benefit of the return flow of

the irrigation water used by the upstream user. The downstream user should be protected from such loss. This is the so-called return flow problem. The solution is to have any changes of diversion points or else water rights transactions must apply to the basin management authority or the related water user group for their approval to protect the downstream user's benefits through supervision of the water rights market. If the water rights transaction changes the return flow, for example, transferring irrigation water to the oil sector, the basin management authority should approve only part of the actual water right (calculated by the average utilization rate of the water resources).

Groundwater problem

Though the water right allocation does not include allocation of groundwater resources, the influence of groundwater reserves in each prefecture has been considered in the allocation model. Since the cost of groundwater use is much more than that of surface water, groundwater use in the Tarim River basin has not yet resulted in obvious conflicts. However, groundwater use will be developed in the future and groundwater use affects the surface water allocation, so a license system should be established for groundwater use. The basin management authority should be in charge of issuing licenses, supervising and protecting water resources, and evaluating the influence of the water resources. Before a landowner can use groundwater, he must apply to the related water user group or groundwater management authority. The management authority should punish illegal users by reducing his/her surface water right or his/her right to directly use groundwater.

Water for the ecological system and environmental protection

Currently in the Tarim River Valley, the faction of water used for the ecology is about 25-30 percent. Therefore, the water allocation scheme assumes that 28 percent of the water in each prefecture must be used for the environment to ensure water for forestry development Gobidesert irrigation, etc. This portion of the water cannot enter into the trading market and be used in any other way. The basin management authority should supervise the use of water for ecology in coordination with the autonomous regional forestry departments, the prefecture forestry bureaus, etc.

If the total runoff is more than the total water allocated to all the water rights and no prefecture water consumption exceeds its rights, a proportion of the excess water can be used to improve the downstream ecology environment. However, when there is no excess, the water rights transactions may transfer more water to the upper reaches of the river so as to indirectly influence water for ecological use downstream. The basin management authority must properly supervise water use and transactions to ensure that sufficient water is available for environmental protection in each section and prefecture so that water rights transactions do not cause further desertification in the lower reaches of the Tarim River Basin. Therefore, when each prefecture increases its consumption, the basin management authority should invest the income by trading excess water rights to the downstream areas to improve their ecology.

Furthermore, the environmental problem caused by poor water quality such as the discharge of salty wastewater after irrigation will require water quality regulations.

Price Regulation of Water Rights Bargaining

The establishment of reasonable bargaining price regulation will determine whether the water rights bargaining is successful. The water rights bargaining system will require a water rights price a regulation system that is appropriate for the water rights bargaining.

1. Water rights price and water rights tax

2. Basic principles for water rights transaction:

- Basic water right exchange price
- Market-based water rights exchange price
- Initial water rights are free
- Combining penalties with compensation
- Progressive penalties
- Setting up seasonal prices for water right transaction

3. Inter-prefecture water rights transaction pricing system:

- Basic water rights exchange price
- Water rights exchange price determined by the market
- Water right pricing mechanism to penalize activities that are not part of the transactions
- Intra-prefecture water rights transaction pricing system

Water Price Reform

Price is one of the most important and effective incentives for allocating resources in the market economy. However, the water supply price in China is very low historically, even lower than the water supply cost, so the water price cannot correctly reflect the supply and demand of water resources, indirectly resulting in the inappropriate use of water. A reasonable pricing system will play an important role in promoting effective management of water resources in a basin.

As is well-known, all economic activities in the traditional economics are based on price and the economic relationships in the society are a kind of pure price (currency)

relationship. Price can't represent all economic relationships, and price system can't solve all economic problems in the society.

Similarly, without the support from some kind of non-price system, water property right regime can't be put into practice effectively and water right allocation will be defeated.

A representative of non-price systems is the outstanding social trend to depend on laws and regulation. In this section, non-price system related to water right transaction will be discussed. The main contents will focus on the following three fields legislation, institutions and the Government's responsibility.

(1) Legislation for keeping market in order

Before the introduction of law systems, people had to depend on customs or ethics to allocate water resources. Along with the social development, the whole system of commodity transaction became more and more complex, people realized that the tortious cost is far less than the exchange cost. However, it is very difficult to value tortious activities, so that the law system becomes the best way to keep market in order. Law is often a governmental action, and clearly regulates the cost for taking tortious activities. The implementation of property rights needs to establish a complete legislation system to make market mechanism work, and reasonable property right legislation becomes one of the most important tools to ensure market operation.

Another, the existence of risk in the transaction is also an important reason for a legislation system. If there is no legislation to keep a contract or an agreement effective, they will lose their roles. Legislation becomes the basis of contract implementation and a basic institutional guarantee to remove factitious risks.

Anyway, the legislation system has set up rules and criteria for social members to go after benefits so as to promote the progress of the whole society. The establishment of rules by legislation plays a role to normalize market.

(2) Water rights and legislation

"Property right systems" are a collective term of systems about definition of property right, management, transfer or transaction, benefit and responsibility of property right, and these systems are authorized and enforced by legislation. If our society has no property right system, the individuals will take various tortious measures to meet their desires. Just like water resource in the Tarim river basin, the whole basin currently encounters continuous conflicts on water use because of lack of clear property rights. There is no legislation to define prefectures' and users' water property right. There is also no regulation or law to clearly regulate the transfer or transaction of water property right. The inevitable result is that all prefectures will take their countermeasure to use water, even some tortious actions.

Legislation on resource allocation is the chief way to control organizational actions, and the institutional guarantee to implement water rights transaction. When we try to set up a water property right transaction system, it is also an urgent task to establish relevant laws or regulations that cover the whole system.

Institutional arrangement and function adjustment

As described above, in order to completely solve the water conflicts in the basin, water rights allocation and transaction system under the market economy should be introduced to establish effective water management mechanism. To guarantee the successful implementation of this mechanism, it should study and reform the existing water administration system and establish a suitable organizational structure for water rights transaction. Separating administrative functions of the government agencies from operational functions of enterprises is the key to ensure successful implementation of the water rights allocation and transaction system. Water rights allocation and transaction requires setting up of corresponding institutional framework that should manage water rights transaction, and making clear definition about the functions of water management agencies and water enterprises.

ENFORCEMENT OF THE MACRO-SCHEMES AND MANAGEMENT OF COMMUNITY WATER RESOURCES

Basis for the enforcement of macro-strategies and macro-schemes: Management of community water resource

The management of resources and the effect of the communities are analyzed in this section to improve the practicality of the macro-schemes and to understand the effects of the water resource management schemes and the macro-schemes for allocating water. The water resource management patterns of the Tarim Basin were studied by analyzing the effects of water prices, the influences of non-technology factors on the water conservation techniques, and the effects of farmer households on the macro decision making and the conservation techniques.

Community surveys

According to the research project objectives, the project group choose 3 testing locations for community studies, which represent the upper reaches, the middle reaches and the lower reaches of the Tarim River to analyze the effect of water prices on the water conservation and desertification techniques and on various communities. The locations are Tuoyibaoledi Township in Shaya county in the upper reaches of the Tarim River, Akesupu Township in Bazhouweili county in the middle reaches of the Tarim River, and Thirty-third Regiment of the Second Agricultural Division in the lower reaches of the Tarim River.

Influence of water price on agricultural water conservation techniques

(1) Relation between water price and agricultural water conservation techniques

According to basic economics, only when the economic benefit of a technology is larger than the cost will the technology be adopted throughout the economy. For agricultural water conservation technologies, the benefit that a technology brings must be larger than the annuity cost of the application. A larger difference between the benefit of water conservation and the annuity cost will increase the motivation to implement the technology, so the technique will be more widely accepted. The spread of agricultural water conservation technologies is directly related to the water price. So increasing the water price will increase the benefit of water conservation and facilitate the spread of he technology. Otherwise, the technologies will not be widely used. The following formula explains their relationship.

$$C_j = PQ_{ij} \qquad \text{…….. (A)}$$

Where:

C = Annuity cost for application of a water conservation technology
P = Adjusted per cubic-meter water rate
Q = Amount of water saved relative to flood irrigation
i = Crop index
j = Technique index

When $PQ_{ij} > C_j$, the application of a water conservation technology j can produce the beneficial returns. Q_{ij} is fixed, so only when P is high enough , PQ_{ij} will be lager than C_j.

$$P = C_j / Q_{ij} \qquad \text{……..(B)}$$

Only when the water price is higher than the average per cubic-meter annuity cost will the technology j satisfy the essential requirement for spreading of technology so that the use of the technology j will provide the benefit expected. Therefore, the influence of water price on the spread of water conservation technologies is based on the cost and benefit analysis of the water conservation technologies $Q_{ij.}$

2. Influence of water price on the application of the water conversation techniques

We analyzed the cost and the benefit of various water conservation techniques for water transport and field irrigation systems in the first phase of the study. The specific water conservation techniques can be used with certain crops. For example, wheat can only be irrigated with *check irrigation, small check irrigation* and *moving nozzle-line irrigation.* But cotton can use all kinds of water conservation techniques. The water price for which the

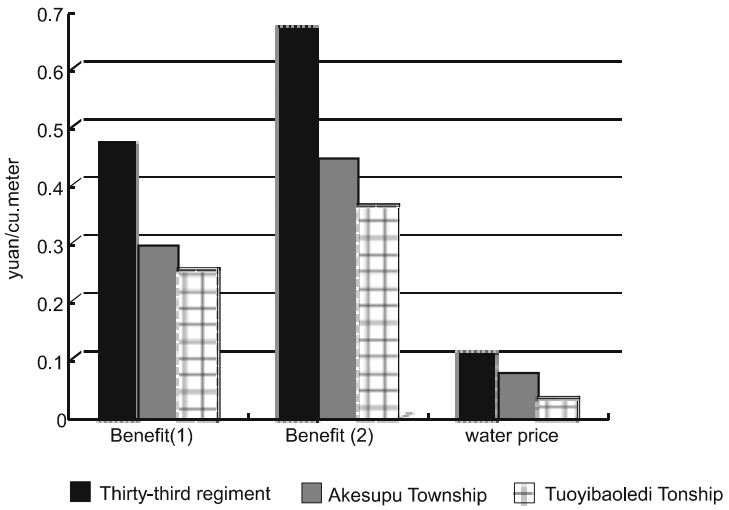
communities will apply water conservation technique for wheat and cotton is analyzed in this section. Annuity cost data do not include the plastic-sheet cost. Some data have been adjusted in the following study.

- Cotton

Table 1. Water price for application of various conservation techniques.

Technique	Furrow irrigation	Small check irrigation	Check irrigation	Irrigation above	Moving nozzle-line plastic-film	Trickle irrigation irrigation
Water price						
Yuan/ m^3	0.06	0.05	0.033	0.05	0.194	0.389

Figure 4. Comparison benefit of planting cotton and the water price.



The water price for the Thirty-third Regiment and Akesupu Township were 0.12 yuan/ m^3 and 0.08 yuan/m^3 in 1998 which satisfy the essential condition for the application of furrow irrigation, small check irrigation, and check irrigation. In fact, these water conservation techniques have been widely applied for cotton production in the two communities. However, because the water price in Tuoyibaoledi Township is only 0.038 yuan/m^3 since it has abundant water resources, flood irrigation is still the main irrigation method here.

- **Wheat**

Table 2.Water price for application of water conservation techniques.

Technique	Small check irrigation	Check irrigation	Moving nozzle-line irrigation
Water price (yuan/m^3)	0.067	0.044	0.215

The Thirty-third Regiment has never planted wheat. The Akesupu Township water price is now 0.08 yuan/m^3 that satisfies the essential condition for application of small check irrigation and check irrigation, so these water conservation techniques have been widely applied for the wheat production in this community.

The cost/benefit analysis shows that in these three communities, moving nozzle-line irrigation and trickle irrigation are still too expensive.

Maximum agricultural water price

(1) *Maximum agricultural water price*

The water price is determined not only by the cost of supplying water, but also by the demand. Economics principles show that the consumption and the desire to pay for a commodity are decided by the marginal utility provided by the final unit of the commodity. The average benefit of using water in agriculture is the practical ability of the farmers to buy water. The desire of the farmers to pay the water fee is decided by the marginal utility that the water provides. Therefore, the net income that the water provides is the upper limit that the farmers will pay. The benefit provided by per cubic-meter water used in agriculture is regarded as the maximum water price. When the water price exceeds the benefit that the per cubic meter of water provides, farmers will not buy the water.

(2) *Determination of the maximum agricultural water price*

a. *Per cubic meter of water benefit and crop value*

- Cotton

The benefit sharing and the cost discount methods were used with the data gathered in 1998 to calculate the benefit and the crop value per cubic meter of water for cotton. The results are listed in table 3.

Table 3. Benefit and crop value per cubic-meter of water for cotton

Communiy	Benefit(1) (yuan/ m^3)	Benefit (2) (yuan/ m^3)	Water price (yuan/ m^3)	Crop production (kg/m^3)	Crop value (yuan/m^3)
Thirty-third Regiment	0.48	0.67	0.12	0.36	1.52
Akesupu Township	0.30	0.45	0.08	0.23	0.84
Tuoyibaoli Township	0.26	0.37	0.038	0.22	0.80

Note: 1. Benefit(1) is calculated by the benefit sharing method.

Benefit(1) = (0.65*(net production + water fee))/ the amount of saved used,

where: 0.65 is the coefficient of the benefit sharing for irrigation as stipulated by the Water Conservancy Department of Xinjiang Autonomous Region.

2. Benefit (2) is calculated by the cost discount method.
Benefit (2) = (total output - other cost - other cost*0.07)/ the amount of water used,
where: 7% is the coefficient of other cost discount.

- Wheat

The benefit sharing and cost discount methods were used with the 1998 data to calculate the benefit and the crop value per cubic-meter of water for wheat in Akesupu Township. The results are listed in table 4.

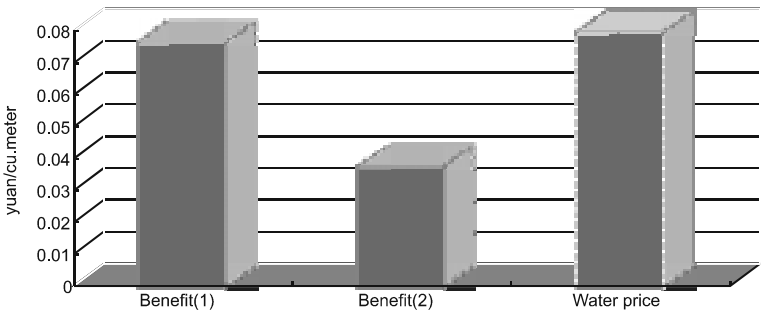
Table 4. Benefit and crop value per cubic meter of water for wheat.

Community	Benefit (yuan/ m^3)	Benefit (yuan/ m^3)	Water price (yuan/ m^3)	Production (kg/m^3)	Crop value (yuan/m^3)
Akesupu Township	0.077	0.038	0.08	0.29	0.56

b. Maximum water price

The results in tables 1 and 2 show that the benefit and the crop value per cubic meter of water for cotton are more than the water price in 1998 in each community, but the benefit per cubic meter of water for wheat is less than the water price in Akesupu Township in 1998. As a results, cotton accounted for 70 percent of the planting area in Akesupu Township and 100 percent in the Thirty-third Regiment. The maximum water price may equal the greatest benefit which was 0.48 yuan in the Thirty-third Regiment, 0.30 yuan in Akesupu Township and 0.26 yuan in Tuoyibaoledi Township.

Figure 5. Comparison of benefit of planting wheat and the water price in Akesupu Township.



The feasible management pattern of water resources in the future

In order to scientifically manage and reasonably use the water resources in the Tarim Basin, we must vigorously reform the outdated and irrational system and pattern of managing water. The community is the most basic unit of using water, which concretely puts the strategy and the measures of macro management in practice. Only the community can finally weigh the rationality of a measure of managing water. Because the peasants are the concrete users and the final beneficiaries, they should also become the genuine managers of water resources.

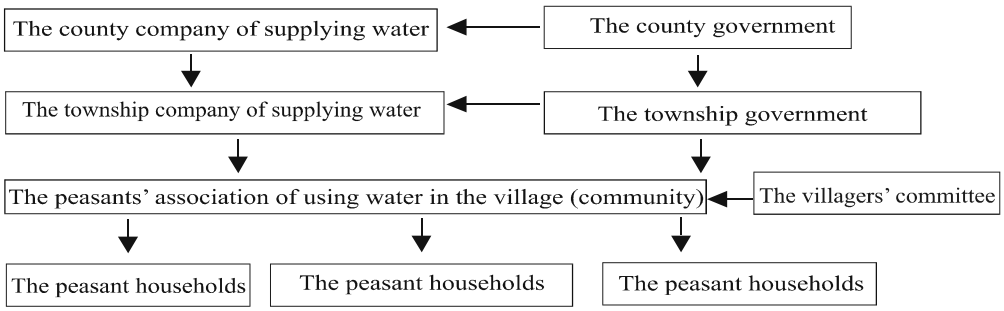
According to our investigation, on the basis of analyzing the advantages and the disadvantages of the now pattern of managing water, using the experience of other countries for reference, we propose that the following two patterns of managing water should be applied in the communities in the future.

(1) *The pattern of the administrative guidance plus the peasants' participation*

The pattern of the administrative guidance plus the peasants' participation are conceived according to the operational system of the social market economy. After the departments of managing water at all levels implement the same management methods with the private enterprises, the country or the divisional departments of managing water will be translated into the parent companies of supplying water. The township or regiment institutes of managing water will become the branches of the parent companies supplying water. Water is a necessitous and special commodity. The conditions that water is bought and sold fully according to the supply and the demand are not still mature. Therefore, in the process of the water management, the economic benefit, the social benefit and the ecological environment are equally important. In order to protect the benefit of the local masses and improve the ecological environment, it is necessary for the government departments to superintend the

water management. The companies of supplying water or their branches are managed by their own superior companies on the business, but are guided and superintended by the government departments at all levels on the policies and the rules.

Figure 6. The pattern of the administrative guidance plus the peasants' participation.



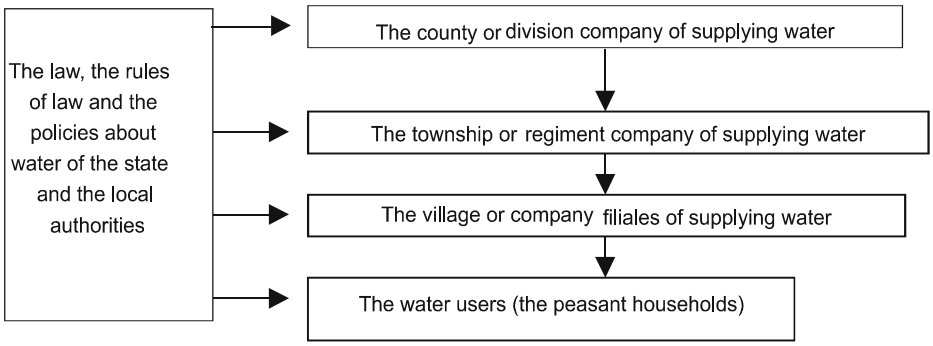
The township or regiment companies of supplying water set up the peasants' associates of using water in the villages or the companies. The peasants' associates of using water are the mass organizations of managing water in the communities, the corporate organizations. The peasants' associates of using water mainly represent the whole interests of the water users, take charge of all the work of managing water in the communities. The peasants' associates of using water take charge of working out the plans of using water in the communities and reporting the plans to the *filiales* of supplying water. The *filiales* of supplying water allocate the water resources in the whole township or the whole regiment according to the plans that every community reports. The peasants' associates of using water are in charge of allocating the water resources in the communities, charging the peasant households the water fee, building and maintaining the water conservancy facilities in the communities. A part of the funds that it needs to build and maintain the water conservancy facilities comes from the water fee charged by the peasants' associates of using water, the other from the companies of supplying water and the higher governmental financial department. The peasants' associates of using water are responsible for stipulating the community bylaw, improving the system of the rewards and the punishment to supplement the community bylaw, and advocating the peasant self-management, self-mastery and to superintend each other. The peasants' associates of using water also post up the rolls to promulgate the water amount that the peasant households use, the water fee that the peasant households should hand in, and the present water price etc. so that the peasant households can superintend.

The above management pattern integrates the enterprise behavior, the governmental behavior and the peasants' benefit. The companies, the governmental departments and the peasants are independent of each other as well as restrictive to each other under the management pattern. Undoubtedly, the management pattern strengthens the management functions of the skeleton communities by a long way, makes for the fulfillment and embodiment of macro management policies in the communities. The pattern is more suitable

for the districts that water is seriously short such as at the middle reaches and the lower reaches of the Tarim River.

The management pattern of the peasant households' superintendence under the market mechanism

Figure 7. The management pattern of the peasant households' superintendence.



The above water management pattern is the operational pattern under the market mechanism. The companies supplying water independently deal in the water resources. The local administrative departments cannot intervene in their management activities that are fully independent. But their management activities must be restricted by the law, the rules of the law and the policies about water of the state and the local administrative departments. The companies of supplying water comply with the peasant households' demand to send the water to the peasants' fields through the *filiales* of supplying water or the water managers in the communities. The peasants superintend the *filiales* of supplying water or the water managers, and report their opinions upon the *filiales* of supplying water or the water managers to the companies of supplying water in time. The *filiales* are in charge of solving the problems that the peasants lodge.

The management pattern is favorable to the scientific management of the water resources in the whole valley, the operation and the management of the companies of supplying water. But the management pattern very easily leads to the industrial monopoly. Only when the system of managing water is fully innovated, the superintendence system of the law and the rules is effectively implemented, the water conservancy establishments are very consummate, and the management pattern is feasible. Therefore, the management pattern cannot be put in practice in the local communities in the near future, and can only be regarded as reform objective. Thirsty-third Regiment may try the management pattern.

MAJOR CONCLUSIONS AND POLICY CONTRIBUTIONS

1. Water is a critical resource to maintain the watershed ecosystem, so the overall water use efficiency must be improved to make the best use of already scarce water resources by upgrading water conservation facilities and the basin-wide water management system.

2. Market-driven mechanism of water allocating and trading schemes would lead to the most efficient use of the Tarim Basin water resources and effective implementation of the planned restoration program for the Tarim watershed.

3. The Tarim Basin water resources must be managed at the micro level by introducing the ideas of CBNRM relevant to the local sociocultural conditions.

4. The pace of pricing reform must be improved and more innovation is needed in management mechanism in a bid to achieve efficient and effective use of Tarim Water resources.

5. The water conservation potential and methodology needs further research to promote wider application of water-efficient technologies.

6. Tarim water resources should be allocated in an equitable and enforceable way to ensure a reasonable balance between the economy and the ecosystem.

7. New ideas and methodologies in this project study will greatly improve the scientific and practical results.

REPORT ON WORKSHOP DISCUSSIONS

INAUGURAL AND TECHNICAL SESSION

The Chinese national workshop for project on "Pro-Poor Intervention Strategies in Irrigated Agriculture in Asia: China" was jointly held by the Center for Chinese Agricultural Policy (CCAP), the Chinese Academy of Sciences (CAS), and the International Water Management Institute (IWMI) in Beijing on 16 May 2001. The workshop was chaired by Dr. Linxiu Zhang, professor and Deputy Director General of CCAP. The workshop was attended by approximately 30 water and poverty experts and officials from IWMI, CCAP, the Asian Development Bank (ADB), and various Chinese research academies and universities.

The first presentation was given by Dr. Intizar Hussain, introducing the overall background highlighting its background, objective and scope of the research activities. This was followed by the presentation on Chinese workplan by Dr. Jinxia Wang. She introduced the CCAP's seven research programs and the relationship between the pro-poor project and these programs. She stated that rural poverty issues are related with all programs, such as production and technology, resource and environment, household food and poverty, consumption and nutrition, and other programs.

Then she discussed the significant progress in the reduction of rural poverty in China that occurred from 1978 to 1999. Despite drastic reductions in the rate of poverty incidence and increases in rural incomes, there remain great disparities among the different regions of China. For example, for 1998 the average rural net income in Shanghai province was more than 5000 yuan, while rural net income in many provinces such as Tibet, Ningxia, and Henan remained less than 2000 Yuan. In addition, distribution of the poor in China is not even. China's eastern regions[1] share of total poor population has decreased significantly over the past several decades, while the proportion of the poor population in the western regions[2] has increased from less than 40 percent in 1989 to more than 50 percent in 1998. The share of the total poor population from the central regions[3] has also shown a declining trend from 37.4 percent in 1989 to 34.5 percent in 1998.

Previous research on poverty reduction in China indicates that the marginal contribution of irrigation to poverty reduction is less than from technological improvements, agricultural

[1]Eastern regions include Beijing, Tianjin, Hebei, Liaoning,Shanghai, Jiangsu, Zhejinag, Fujian, Shandong, Guangdong, Guangxi and Hainna Provinces.

[2]Western regions include Chongqing, Sicuan,Guizhou,Yunnan,Tibet,Shananxi,Gansu,Qinghai,Ningxia and Xinjiang Provinces.

[3]Central regions include Shanxi,Inner Mongolian, Jilin, HeilongJiang, Anhui,Jiangxi,Henan,Hubei and Hunan provinces.

institutional reforms, and other public investments, such as education and communications. This raises the question "Why is the contribution of irrigation less than other factors in China?" Currently, there is limited potential to expand irrigated areas in the future, so the expansion of irrigated areas is unlikely to play an important role in reducing poverty and promoting development of China. Alternatively, improving irrigation management, policies, and institutional arrangements do have the potential to impact further reductions in poverty.

In order to realize the research objectives, two surface water irrigation systems in Ningxia and Henan Province would be selected to carry out the surveys for the project. These two irrigation systems have the following characteristics: 1) relatively poor areas, 2) low water productivity, 3) increasing water shortages, and 4) the importance of irrigation for pro-poor interventions.

The next presentation was given by Professor Jun Xia's on "Water Issues and Characteristics in the Arid and Wet Regions of China." Professor Jun Xia pointed out that water is a source of life; water also presents hazards at both ends of the water-availability spectrum in the form of floods and droughts.

He gave the example of floods that occurred on the Yangtze River in July and August of 1998. These floods caused an estimated US$2.2 billion worth of damage. Between 2,000 and 4,000 people lost lives and the floods affected more than 223 million people. Additionally, 17 million homes were destroyed and 22 million acres of farmland flooded. Major flood events can seriously harm agriculture, socieconomic development, and property. Likewise, droughts cause serious problems including water shortages and ecosystem degradation. Impacts from drought include inadequate drinking water supplies, reduction in crop production, ecosystem degradation, and reduced or non-existent river flows in the downstream.

Dr. Jun Xia suggested that the seven challenges to achieve water security in the twenty-first century proposed by the Second World Water Forum and Ministerial Conference are also important for China. These seven challenges include: meeting basic needs, protecting ecosystems, securing the food supply, sharing water resources, dealing with hazards, valuing water and governing water wisely. In conclusion, it was pointed out that, in China, socioeconomic development is closely related with changes in the water cycle. Understanding the characteristics and regulations of the water cycle is helpful for improving the socioeconomic conditions of rural and urban populations.

The next presentation was given by Professor Suhua Yu, who presented research results from the project on "Desertification Control and Water Management of the Tarim River Basin." This project was conducted under the support of the International Development Research Center (IDRC). Major issues included: 1) water pricing reform and water management; 2) assessment of water saving technologies and analysis of water saving potential; 3) desertification control and strategies and 4) rational water allocation scenarios. Based on an analysis of water supply costs for different regions in the Tarim River Basin, various water-pricing reforms have been proposed. These are self-maintenance of operating cost, self-recovering of supplying cost, and self-development by market regulation. Currently, water management systems suffer from a lack of integrated river basin management approach, poor implementation of laws and regulations, and a mixture of political and enterprise issues. Research results suggest that water saving planning should be gradually shifted from normal technologies to technologies that are more efficient.

In China, desertification has become increasingly serious and downstream "green corridors" are disappearing. They analyzed the situation, evolution, and regeneration of desertification and two kinds of desertification control measures (engineering and biotechnology measures). Ecological benefits induced by each kind of desertification were measured through a quantitative assessment of environmental influences. They proposed desertification control measures integrating economic and ecological benefits.

Phase 2 research activities include: 1) an assessment and policy influence analysis of water allocation scenarios of the Tarim River Basin, 2) research on reform mechanisms for water management, and 3) implementation of macro scenario and community water management. They established the integrated model of IRP/DSM and SD, which is based on "Water Project and Ecological Environmental Construction Program", proposed by the Planning Commission of Xinjiang Province. Using this model, they simulated the supply and demand for water and corresponding policy alternatives for a normal year, a dry year, and a wet year.

In the study, they introduced water rights concepts, specified the original water allocation model, analyzed regulation and system of water rights transfer, determined water pricing system and non-pricing system, proposed and designed water right transfer price as a basis for a water market. They suggested conducting integrated management system comprised of government macro-control, water supply company operation, and water user participation. For community water management at the micro-level, they selected three experimentation areas to conduct PRA and household surveys. Through the surveys, they understood farmers' responses to local water management and water saving technologies. Research activities included analysis of price elasticity of demand for agriculture, capacity of farmers to bear water pricing, and the highest potential of water pricing. Additionally, they examined the influence of water price adjustments on application and extension of various water saving technologies, the degree of influence of community non-technical factors on water saving technologies, and proposed water management patterns for farmers' participation and monitoring.

According to their research, Professor Suhua Yu suggested strengthening water management and water project construction, establishing market mechanisms for water rights allocation and transfer, emphasizing water saving approaches and micro-water management, making scientific and rational water allocation scenarios for the Tarim river basin, and ensuring economic development and eco-environmental protection.

The next presentation was given by Professor Xurong Mei on "China's Water Shortage and Conservation to Promote Rural Economy Growth." He began by explaining that water scarcity in Chinese agriculture is due to the following issues: shortage of available water for agriculture, uneven spatial and temporal distribution of water resources, incapable increment of agricultural water, and low water use ratio and efficiency. He showed the picture of gross grain production and effective irrigated area of China from 1949 to 1996. Since 1949, gross grain production increased continuously while effective irrigated area declined since the 1980s. According to their forecasts, agricultural water use after 2000 would stabilize.

Professor Xurong Mei stated that the real water saving is to improve the output of water use in production. The real water conservation in agriculture is to maximize water use efficiency, it not only concerned with water use ratio. Priority objectives of water-conserving

agriculture should be to promote the rural economy and improve farmer incomes. Major executor of water-conserved agriculture is farmer, not government. The water use ratio and water use efficiency can be improved by extending suitable technologies. In order to promote water-conserved agriculture, investment mechanisms and the property rights system should be reformed.

Professor Xurong Mei showed his research on productivity and its limits of rain-fed corn in Shouyang from 1992 to 1998. He suggested that the following measures could improve the rural economic growth by water conservation: models to improve farmer incomes through water-saving technologies; adjusting economic structure to save water; reforming possession right system of water conservancy facilities already existing; investing and managing mechanism of water conservation facilities; increasing investment intensity to develop modern irrigation for profit; promoting science and technological improvements, and strengthening human capacity building measures.

BRAINSTORMING SESSIONS

In response to a general concern that there is no poverty in irrigated agriculture according to the official definition of poverty in China, it was explained that this research project will not only consider absolute poverty as defined by the national or local governments, it will also focus on relative poverty issues. In China, farmers who depend on irrigated agriculture are generally not considered as poor. Since irrigation plays an important role in increasing farmers' incomes and welfare, farmers in irrigated agriculture generally have incomes that are higher than the national or local absolute poverty lines. However, rural development is not balanced and the distribution of benefits among farmers benefits is not equal. Of all factors contributing to unequal rural development, poor water management is one of the most important reasons to be explored.

The following issues were suggested to be included in the project

- Understand the major causes of poverty in irrigated areas.
- Match irrigation supplies with demand.
- Issues related to reliability of irrigation water supply.
- Issues related to water rights, water allocation and equity in distribution of water (How to improve equity of water use?), assessment of efficiency of water use and distribution.
- Issues related to irrigation management (role of irrigation managers) and institutions, issues related to farmer participation in irrigation systems, implication of the current irrigation management practices and institutions for the poor, legal and regulatory issues.
- Performance of irrigation systems.

- Water pricing (impact on poor farmers), irrigation financing: investment, maintenance, operation-cost recovery, sharing the cost of irrigation management.
- Water saving technologies (identification of pro-poor irrigation technologies in the study areas?)
- Identifying factors that may have impact on poverty through changes in sources of income generation.
- Issues related to farmers' capacity for managing irrigation systems.

It was pointed out that water conflicts in Hei River Basin are very serious, and that Hei River Basin would be a good candidate for this research project.

The second session began with an explanation by Dr. Intizar Hussain of his idea of a framework for this research. He suggested that this research would be conducted at four levels: macro-level, meso-level, system-level, and farm-level. For macro and meso-level research, national water policies, management, and institutions would be analyzed. System-level analyses will focus on issues related to performance of irrigation systems, water use efficiency, equity of water allocation, operation and maintenance cost, water pricing, productivity and other issues. Micro-level research will focus on understanding poverty situation at the household level. Team members for China expressed concern over the implementation of the project, especially on how to integrate research among four levels and find quantitative relationships between water management and poverty. However, it was recognized that determining the relationships between water management and poverty is a key point of the project.

In order to find a relationship between water management and poverty, Prof. Jikun Huang proposed potential regression models based on field surveys. During the discussion, most team members debated about the sample selection issues. It was felt that if one or two irrigation systems were selected, water management patterns would lack sufficient variation to do quantitative analysis. Therefore, more fieldwork would need to be done regarding site selection. Suggested criteria for selecting research sites included: 1) degree of water price reform; 2) degree of water management reform; 3) development degree of water users associations; 4) degree of water scarcity; 5) regulation differences on water allocation among industry, domestic and agricultural water use; 6) differences of crop water demand.