# An Institutional Approach to the Yellow River Basin Ecological Services for Human Use: A Historical Case Study of a Common Property Resource System

Dan Liu

(4267812)

Major paper presented to the

Department of Economics of the University of Ottawa

in partial fulfillment of the requirements of the M.A. Degree

Supervisor: Professor Philippe J. Crabbé

ECO 7997

Ottawa, Ontario

December 2007

# Contents

# An Institutional Approach to the Yellow River Basin Ecological Services for Human Use: A Historical Case Study of a Common Property Resource System[1]

## Introduction

The Yellow River is China's second longest river "flowing 5,464 km" (George Leung 1996c) from the west to the east of the country. The Yellow River is located in the northern part of China. It is divided into three sections: upper reaches, middle reaches, and lower reaches. It takes its source the Bayankela Mountain in the west and it empties into Bohai Sea on the eastern part of the Chinese mainland. (see figure 1 on p. 2, figure 2 on p. 3) The river serves "752 thousand square kilometers" (*Yellow River* 2007) of agricultural land and provides a livelihood for "120 million people" (George Leung 1996c), but its importance throughout China's 5,000 year-old history is such that it has been called "the cradle of Chinese civilization" (*Yellow River* 2007). Despite its undoubted benefits to the Chinese people, the Yellow River has always posed problems in terms of river management. One of the reasons for this is the natural processes of the river basin, and the other is human activity. Greer (1979, p. 3) points out that

> certain hydrologic and geomorphic processes were present in the basin which created conditions that were less than favorable for dense human settlement. These natural processes give rise to drought and flood conditions, as well as to siltation of the river canal—the roots of Yellow River management difficulties.

The landform dictates the flow of the river. "The topography of China is characterized by high west part and low east part, gradually descending in elevation from the west towards the east to form three steps." (Ministry of Water Resource

[1] I wish to thank Mr. Chang for providing me with information about <Shui Bushi>; water property rights in Qing Dynasty and the evolutions of water property rights in China.

(MWR) P.R. China 2004) China has a strong monsoon climate, therefore the climate for northwestern China is dry. "The average annual precipitation in China is 648 mm, 19% less than the world level." (Ministry of Water Resource (MWR) P.R. China 2004) From the annual precipitation of the Yellow River basin (see figure 3 on p. 3), we can see abundant water resources around the upper reaches, water scarcity at top of the river in the middle reaches and moderate abundant water resources for the lower reaches. The problems of water scarcity, water consumption and competition and human pollution around the lower reaches are becoming a serious headache for both local and central Chinese government officials.

Historically speaking, water management has not had a positive effect on the Yellow River basin. In ancient China, some cases of successful river management existed; however, river management problems have become increasingly prominent in modern China. In the lower reaches, the whole ecological system is being undermined by water scarcity and human pollution. As a result, many plants and animals are on the verge of extinction. Since the Yellow River directly or indirectly affects half of China's economy, all levels of governments are trying to find a scientific way to sustainably manage this precious water resource. Successfully solving this problem would bring balance to the whole society and the ecological system.

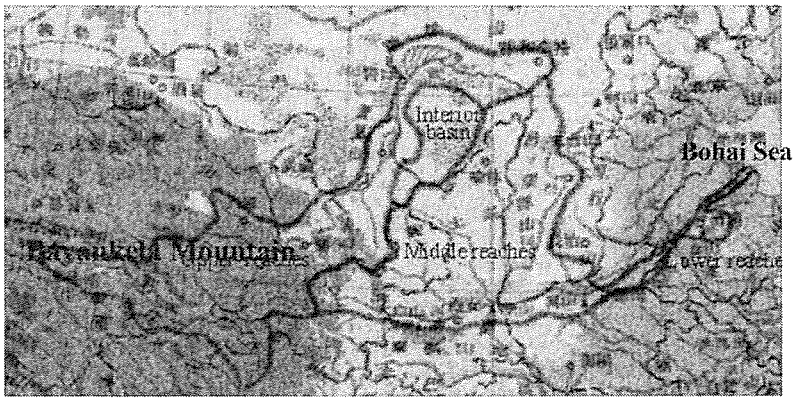



**Figure 1. Three regions of Yellow River**[2]

(source: from George Leung 1996b)

[2] Interior basin: it is a desert region surrounding the Yellow River. In this area, rivers do not form tributaries of Yellow River, but drain underground.

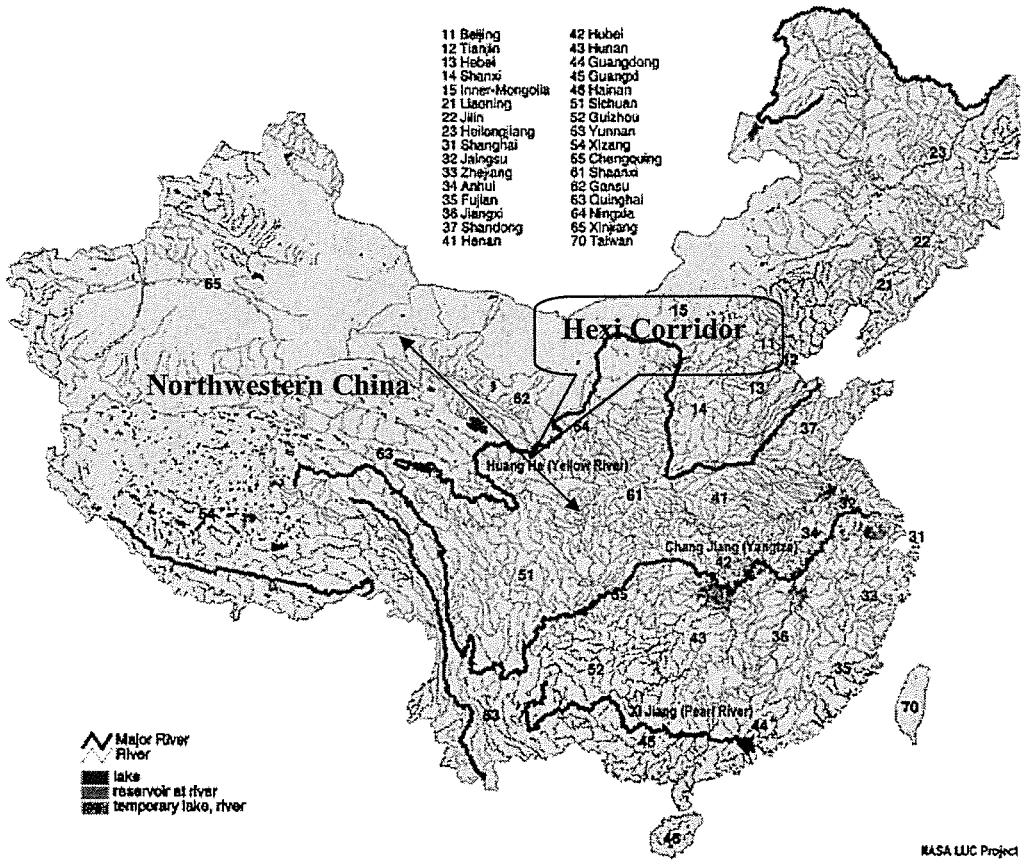



**Figure 2. Map of the main rivers of China**

(Source : from Heilig, G.K.1999 )

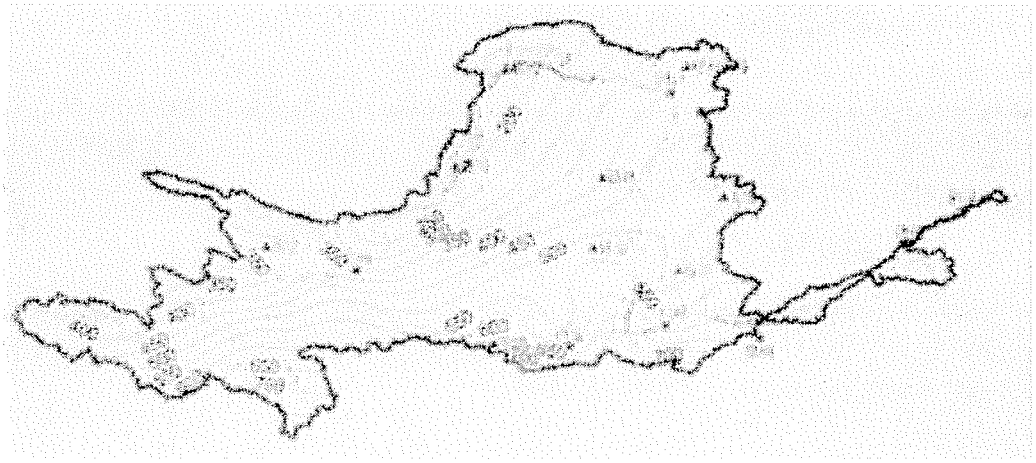


**Figure 3.**

**Spatial distribution of annual precipitation in the Yellow River basin**

( source: from Xu Zongxue; Zhang Nan 2006)

During Chinese history, the Yellow River management problem changed from an open access problem to a central government monitoring the common property problem. The "third stipulation of China's current Water Law clearly states that water resources belong to all Chinese citizens" (Chang Yunkun, Wang Shoukun 2006, p. 12). The water resources for agriculture and industry use are typical common property resource for people. Even in ancient times, property rights for human beings were set on river resource.

Certain institutions for governing and optimizing the use of water resources were established throughout Chinese history. Each of these institutions possessed unique attributes. As such, studying the historical record provides excellent context for understanding the current problems affecting the Yellow River basin. For example, 3,000 years ago, people had open access to the river's water resources. As property rights did not exist at that time, human beings could use this resource on "a first come first served basis" (T.Tietenberg 1992, p. 45). Water resources in many areas got deteriorated. As Chinese civilization evolved, there arose the concept of common property resource to restrict people using water. With water resources under common property rights, there were still management problems during history. Hence, the proper governance of the Yellow River and the management problems arising from water resource usage became important issues for the local government. Nowadays, institutions for governing water resource use tend to be similar throughout the world. As such, I prefer to focus my analysis on ancient history in order to come up with fresh ideas for future river management.

This paper focuses on a historical case study of the Yellow River as a type of common pool resource (CPR). The paper analyzes the historical relationship between river management and social problems stemming from disputes over water property rights. First of all, I introduce Ostrom's approach on how to successfully manage CPR throughout history, and explain her eight principles for successful CPR management institutions.

Next I compare her approach to other modern theories on common property

resources.

Then, in the following part, I summarize the social problems that arose in ancient China as farmers drew water from Yellow River. I describe ancient water statutes that, at least for a time, proved efficient in solving these problems. In describing the river's management history, I also apply Ostrom's theory of common property resources (CPRs) to the Yellow River case. Ostrom's work on CPRs, such as her case studies on the effects of irrigation on water resource management in Spain (Ostrom 1990 p. 69-88) and the Philippines (Ostrom 1990 p. 82-88), provides clear management success criteria for typical common resource problems. She focused her studies on small scale CPRs with 150-15,000 residents, and with people heavily dependent on the CPRs for economic returns. Such small scale CPRs included ground water basin and irrigation systems, which are applicable to the Yellow River case study. Although the Yellow River runs nearly the length of the country, water management problems usually occurred in specific areas due to a complex environment or landforms. Therefore, each specific area along river sections can be considered as a small scale CPR, which is similar to Ostrom's research criteria. As such, using Ostrom's approach to the Yellow River case is both suitable and useful. In Ostrom's work on CPRs, she illustrates how institutions, especially robust local institutions for self-governance, help governments to successfully manage a common property resource. Compared with the current problems of the Yellow river basin, one can learn useful management principles and hope the Chinese government is able to provide a solution to Yellow river management problems from her approach.

After analyzing the historical case study of the Yellow river, I will express my opinions on the current management of the river in the conclusion.

# Part I

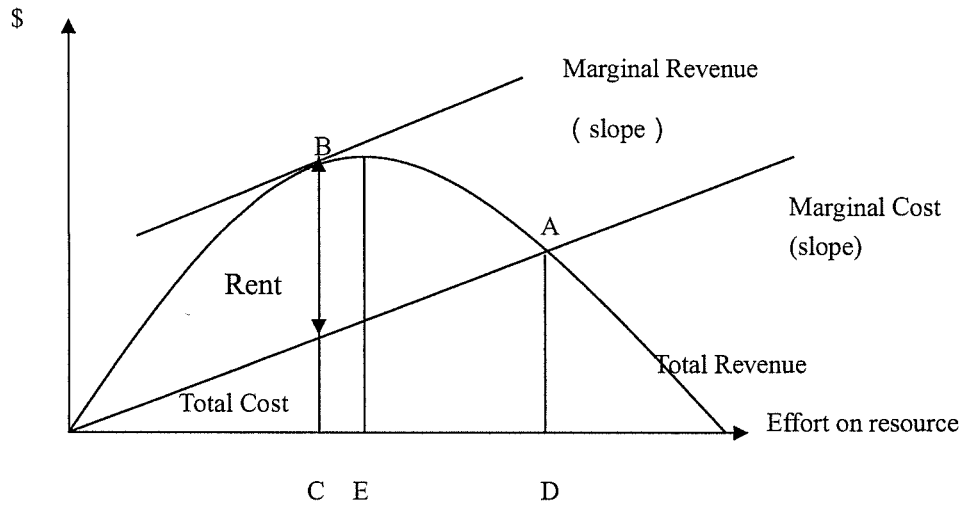
## 1. Elinor Ostrom's Theory of Common Property Resources Management

When analyzing a type of natural resource, property rights are an important issue for economists. Property rights are especially important for the long-term development of a resource. Tietenberg (1992, p. 45) points out "property right refers to a bundle of entitlements defining the owner's rights privileges, and limitations for use of the resource." He defined that an efficient property rights structure must have four main characteristics, which are universality, exclusivity, transferability and enforceability. He also defined the major category of resources ownership called common property resources as resources that are not exclusively controlled by a single agent or source. Without the property rights, resources are in an open access situation, which can be described as access to use the resource by anybody and "resource can be exploited on a first come, first served basis" (T.Tietenberg 1992, p. 45) Comparing open access resources with common property resources, we can find that open access resources are much more difficult to manage, than common property resources. In a working paper, Daniel W. Bromley (1994) discusses that an open access regime encourages overexploitation because there are no property rights restricting access to the resource. The overexploitation means a level of withdrawal of resources in excess of the economically optimal level of exploitation and not the diminution of the resource itself. From the figure (see p. 7), we know this level of overexploitation could be any points above C. Bromley also talked about the common property regime. It

> represents private property for the group of co-owners. Individuals have rights and duties in a common property regime...property owning groups vary in nature, size...they are social units with definite membership and boundaries and with certain common interests. They have at least some interaction among members, some common cultural norm, and often their own internal authority system. (Bromley and Cochrane. 1994)

Bromley called any regime related to property rights the authority system. A common property regime is therefore an authority system bound by common human interests. Resources under this regime are better protected than in an open access regime. Since open access confers a status whereby it's "anybody's access and nobody's property", (Bromley 1992) valuable resources may be gradually exhausted through overexploitation. Individuals under open access regime are chasing their own private benefits and it's hard to have collective action share the resource. Open access may also occur when enforcement of property rights is non-existent. In a common property regime on the other hand, collective action results in efficient local management of the resource.

In order to better illustrate the differences in human behavior between open access and common property resources, Tietenberg (1992, p. 306) plotted the efficient sustained yield on a graph (see figure 4, p. 7).




C=Common property effort D=Open access effort

E=Maximum sustainable yield

**Figure 4 . Common Property vs. Open Access Equilibrium**

Similar to his figure, I draw the graph to illustrate those differences and the efficient sustained yield. In the figure, the maximum sustained level of effort is at point E, any further effort can reduce the sustainable use of resource. The vertical distances between revenue and cost are net benefits. Therefore, the efficient level of effort is at point C. At this point, efficient sustained yield is achieved, where marginal revenue equals marginal cost. Therefore, any effort higher than point C is inefficient. Total revenue decreases as efforts increases. The reason is that the more individual efforts involved in exploiting a type of resource, the less marginal revenue may be left for next individuals, or, in other words, the less benefit may be left for the rest of individuals who may join in the resource system in future. In an open access resource situation, people are seeking current profits from the resources; therefore, the equilibrium quantity of human use is at point D, where the rent is dissipated. Before this point, people keep entering the resource system until there is no profit left (point D), then there are no further human entries beyond that point. In open access system, the more entries come into the natural resource system, the easier to create overexploitation problem. However, the common resource system set up a user's fee to restrict the quantity of human entry into the system. The graph shows that common property use achieves a state of equilibrium at point B. The harvest quantity of resources is smaller in an open access situation than at efficient level C. The resource is better managed and resource overexploitation is mitigated under common property rights. By issuing property titles over a natural resource, the government also imposed maintenance costs in the form of fees, whereas there are no such costs in an open access system. This comparison reveals that natural resource management thrives in a common property system rather than in an open access system, and that prudent governments would be well advised to protect this system to husband their resources. Resource is protected by setting restricted access rights and government management is involved to help people sharing common property resource within the system as well. At this moment, institutions will be important for regulating human behavior. Either government could enforce the regulations, or local self-organization can

manage water resource by their own. Therefore, for the long-term development of a natural resource, a common property rights regime is a better regime for society, and indeed for the whole ecosystem than is open access. Also, as Bromley mentioned, "open access controls the activities of participants but not their number, but the controlled access regulation can explicitly or implicitly control the number of participants and its activities." (Bromley 1995)

Depending on the nature of the problems associated with open access regime and the advantages of setting up a common property regime, Elinor Ostrom fully explained and gives advice on how to successfully govern common property resources. Here, I summarized property rights in five categories in a table with modification due to Ostrom's paper (Ostrom *et al* 1999).

| Property Rights | Characteristics |
|---|---|
| Open access[3] | Absence of enforce property rights |
| Common property | Resource rights held by a group of users who can exclude others |
| Private property | Resource rights held by individuals (or firms) who can exclude others |
| Public property | Resource rights held by a government which can exclude others |
| Government Jurisdiction | Function of government to sanction and regulate property rights and tax the resource base |

**Table1. Types of Property Rights**

Ostrom's theory claims that local organizations take collective action to successfully manage common-pool resources, often making their own rules. She

3 **Open access**: Natural resource where nobody has defined rights and resources are available for anybody to use. Open access regimes usually lead to overexploitation and degradation of natural resources1. (CBNRM, Processual terms) For an open access, it is easy to bring free-rider problem.

**Common property**: Rights are exercised by a defined group with rules defining rights to access, use and management. Sanctions ensure compliance. Common property resource is a kind of resource used in common by a group or collective.1 (CBNRM, Processual terms)

defines common pool resources as follows: "the term 'common-pool resources' (CPRs) refers to a natural or man-made resource system that is sufficiently large as to make it costly to exclude potential beneficiaries from obtaining benefits from its use."(Ostrom 1990, p. 30) Individuals, organizations and governments place constant demands on these common resources. Although common resources required the protection of property rights, these constant demands will nonetheless affect the nature of the resources. Corresponding rules and regulations then become necessary to restrict and correct human activity, especially for common property resources.

In her study on groundwater issues in southern California, Ostrom analyzed the factors associated with the successful evolution of new institutions and with the efficiency and impartiality of those institutions. Her research focused on how to create proper institutions to sustainably manage common-pool resources. She points out that effective governance of common-pool resources is impossible without robust institutions. Using empirical case studies she analyzes how institutions help users cope with CPR problems and how individuals can change these institutions. She refers to the robustness of self-governing organization over CPRs since people who share the same common pool resource create rules to regulate each other's behavior. Her theory is suitable for most common pool resource systems, including the Yellow River basin, which is a typical large common pool resource system.

Ostrom also discussed working rules and formal laws, institutional tools designed to help manage common property resources. In the "reflections on the commons" at the very beginning of her book, she referred to a fishery case to illustrate the question of "how best to limit the use of natural resources so as to ensure their long-term economic viability" (Ostrom 1990, p. 1) She concluded that, "neither the state nor the market is uniformly successful to sustain long-term, productive use of natural resource systems."

Ostrom mentioned the models of "tragedy of commons", "the prisoner's dilemma game", and "the logic of collective action" to show these are the models supporting the state and market solutions, however there are other solutions that can better solve

governing problems, such that communities of individuals using own ways to govern the commons. The model, "the tragedy of commons", is exemplified by the grazing problem. Herders share a piece of common pasture; receive their own benefits from their own animals and then only suffer a delayed cost from the deterioration of the commons where anyone can overgraze. (Ostrom 1990, p. 2) Since each herder gets benefits on this pasture, the herder would like to increase benefits by adding more animals to the pasture. Eventually, herders' behavior will cause overgrazing problem and the overgrazing problem cause the degradation of the pasture. Ostrom concluded, "much of the world is dependent on resources that are subject to the possibility of a tragedy of the commons" (Ostrom 1990, p. 3) The "prisoner's dilemma game" is similar to Hardin's "tragedy of commons". It illustrates the same results of using common resource. For the model of "logic of collective action", group members share a piece of common resource and would follow the logic that all the group members tend to collectively achieve group interests if they are rational and self-interested. But as Olson points out, "unless the number of individuals is quite small, or unless there is coercion or some other special device to make individuals act in their common interest, they will not act to achieve their group interest." (Cited in Ostrom 1990, p. 6) Based on these models, Ostrom suggests using an extensive self-governance approach rather than just government jurisdiction. In a self-governance approach, regulations are collectively enforced by the users based on their common interest in the resource. Users share the same rules and manage the resource on behalf of the common good, monitoring each other and punishing violators. But an effective and robust institution is still needed to help users manage common resources and inspect themselves. Ostrom's work provides us with the building blocks of such an institution.

Based on specifically selected cases studies, Ostrom identified eight design principles of institutions that successfully manage CPRs over the long-term. These eight principles are as follows (Ostrom 1990, p. 90):

1) Clearly defined boundaries: Clearly define the individuals who have rights to

access and withdraw the resource. The boundaries are not simply geographical, but refer to the type of individual eligible to access the resource.

2) Congruence between appropriation and provision rules and local conditions: this means using tailored rules for each local common property resource condition. Unchanged rules dealing with problems in different situations are not recommended.
3) Collective-choice arrangements: this principle reveals an important factor necessary to an institution's long-term survival, namely the ability of individuals to participate in modifying rules. In other words, this principle ensures that rules can be custom fit to local situations.
4) Monitoring
5) Graduated sanctions: participants who violate the rules will be punished through fines or other penalties. Graduated sanctions ensure order in using common resources. Therefore, a long-enduring management CPR requires both monitoring and sanctioning activities. This is also an important feature in Ostrom's theory. She claims that monitoring and sanctioning may be effectively carried out by common resource users to punish people who break the rules. Encouraging common resource users to participate in these two processes makes resource management more efficient than only relying on government enforcement, which is considered as an external authority in Ostrom's analysis. Therefore, a long-enduring sustainable CPR requires cooperation between common resource participants.
6) Conflict-resolution mechanisms: let participants have rapid access to mechanisms to solve conflicts between each other.
7) Minimal recognition of rights to organize: participants have minimal rights to correct or set their own rules to manage resources. Participants can devise their own rules without creating formal governmental jurisdictions.
8) Nested enterprises. This is for CPRs that are parts of larger systems. "All of the more complex, enduring CPRs meet this last design principle." (Ostrom 1990 p.

101) In a large common resource system, all governance activities should be in multiple and nested layers. Ostrom also applied this principle in her irrigation systems case studies on Spain and the Philippines.

Rules and regulations are very important when governments manage a type of common resource. Ostrom categorizes rules into three different levels. The most basic and indeed the key level of management rules are operational rules. This level includes the process of appropriation, provision, monitoring and enforcement on a type of resource. Taking the irrigation case as an example, operational rules can refer to the amount of water resources withdrawn from each irrigation canal, when the irrigation rotation begins, and how to punish violators if they break the rotation order and take illegal water for self-interest purposes. The second management level is called collective choice. It involves processes of policy-making, management, and adjudication of policy decisions. This level of enforcement has a linking function, connecting between resource users, local officials and central government to establish jurisdictions and draft legislation. This level indirectly affects operational choices. The third level is called constitutional level. It contains the process of formulation, governance, adjudication, and modification of constitutional decisions. This level determines "who is eligible and determining the specific rules to be used in crafting the set of collective-choice rules that in turn affect the set of operational rules." (Ostrom 1990 p. 52) The three levels are nested on top of each other and self-governing resource users often switch back and forth between them.

Ostrom's management theory of common resources could provide new approaches to the management of the Yellow River basin, especially in reviewing current water management legislation and achieving sustainable development of this water resource. The eight design principles demonstrate how an effective institution helps users engage in self-governing their resources. Ostrom emphasized that "an analysis of the underlying similarities of enduring CPR institutions, though based on limited number of cases, many have broader applications". As such, I will apply

Ostrom's theory of the eight principles of long-enduring institutions to analyze the history of institutional change in the Yellow River basin.

## 2. Recent Institutional Theories on Common Property Resources:

I will briefly summarize some recent works on common property resources governance before introducing the Yellow River case:

1) Bish (1992) found Ostrom's theory could help him to understand "one success (oysters) and two failures (abalone and clams) in Canadian fisheries." He also commented that Ostrom's,

> theoretical framework helped me to examine solutions, as well as to understand why a highly professionalized and scientifically strong national bureaucracy could not successfully manage very simple fishery resources. These applications, to me at least, are true tests of the usefulness of Professor Ostrom's work. (Bish 1992, p. 520)

According to Bish, Ostrom's major contribution is to provide a framework to solve common pool resource governance problems by using self-governance institutions to "...develop better intellectual tools to understand the capabilities and limitations of self-governing institutions for common-pool resource". (Bish 1992, p. 520)

2) Casari and Plott, (2003) argue that a common resource system with monitoring devices, users' participation and interactive inspecting would result in an efficient management of the resource. The objective of their study is a contract developed by some Italian villagers and approved by the regional government, called the *Carte di Regola*. This contract is described as a system for monitoring and sanctioning violators. In the *Carte di Regola* case, "people could inspect one another, inflict punishments and be rewarded for doing so according to well-defined legal proceedings" (Casari and Plott 2003, p. 243). Sanctions were used for dealing with violators. This village used a decentralized management system and an effective

sanctioning device to achieve successful common resource management. In evaluating the monitoring and sanctioning approach, Casari and Plott applied three different types of data to the game theory model to determine the effectiveness of decentralized sanction and monitoring institutions.

3) In 1999, Ostrom and other four authors wrote another paper reviewing common resource problems. In this paper, they discussed about local and global issues influencing common resource problems. Once again, they emphasized that self-organized people effectively manage common pool resource using their own devised long term and sustainable institutions. They also pointed out that central government management on CPR may not be more effective than a traditional, self-organized group property regime. (E. Ostrom *et. al* 2004) The paper argues that governing and managing common-pool resources is best done by restricting access and creating incentives. Incentives are proper norms, regulations or laws that can adjust the problem between users and the common resource. Not every type of property rights can help in solving the CPR problem (see table1 on P9). While institutions can systematically overcome serious problems such as the overexploitation of resources they are not a panacea for every situation.

4) Although some academics appreciate Ostrom's work, there exist some critiques of her theory as well. In criticizing her eight design principles of institutions, Agrawal pointed out that

> the design principles are expressed as general features of long-lived, successful commons management rather than as relationships between characteristics of the constituent analytical units or as factors that depend for their efficacy on the presence (or absence) of other variables. Thus, principle seven suggests that users are more likely to manage their commons sustainably when their rights to devise institutions are not challenged by external government authorities. This is a general principle that is supposed to characterize all commons situations. In contrast, principle two suggests that restrictions on harvests of resource units should be related to local conditions. Thus, it is possible to imagine certain resource and user group

> characteristics for which withdrawal levels can be high, and setting them at a low level may lead to difficulties in management. Where supplements to resource stock are regular and high, and user group members depend on resources significantly, setting harvest levels low will likely lead to unnecessary rule infractions. (Agrawal 2001, p. 1652)

Agrawal also criticizes Ostrom's work using the concept of stationarity and storage. He points out that "some resources, such as wildlife, shellfish and grazing lands are not subject to the concepts of stationary or storage, although groundwater basins and lakes can satisfy both". (Agrawal 2001, p. 1652) In the latter cases, water resource can be considered as stationary because of its regeneration character; a water resource pool possesses the capacity to store certain volume of water resources. In a water resource area, withdrawing ground water efficiently at sustainable yield will automatically guarantee its renewable status. Agrawal also points out that "Ostrom's literature pays limited attention to external factors, whether social, institutional or environmental". (Agrawal 2001, p. 1652) Agrawal took demographic issues as an example, and pointed out that "if the population changed, or a migration situation occurred, it would affect users' ability to create rules to manage their resources" (Agrawal 2001, p. 1652) He explained the limitation by saying it's just "aimed at showing the importance of local groups, institutions and resource system related factors, but ignore some other external factors". (Agrawal 2001, p. 1652)

5) As an institutional economist, Daniel W. Bromley has his theory on common property resources. He clearly delineated four regimes (Bromley 1992) for managing natural resources: the state property regime, the individual property regime, the common property regime, and the open access regime. In the literature, he points out successful common property regime operate well throughout the world. This regime protects resources by defining property to each interested party, and allowing corresponding institutions to take an effective effect in the management process. Resource users collectively use and manage the resource. The authority system takes an important role in managing process. Bromley provides us with a classic case of

common property regime—the irrigation system, wherein users,

> certainly compete for scarce water and in this sense cooperation may seem irrelevant. But on closer inspection the idea of cooperation can be seen as similar to compliance in that each irrigator cooperates by complying with the internal rules of water allocation among competing interests. (Bromley 1992, p. 3)

He also mentions that population pressure will affect the feasibility of a regime. In a reviewed article Bromley (1993, p. 282) argues that,

> although the global atmosphere is indeed an open-access resource, many natural resources are managed under a regime of common property. The size of the group of legitimate users—and the level of use by each claimant on the resource—are proscribed. These two conditions are necessary and sufficient to distinguish open access from common property.

He points out that, "Ostrom's book is important in moving us beyond the myths of conventional wisdom...reminding us that each resource management situation must be evaluated on its own terms....She incorporates transaction costs into a model of institutional choice..." He affirmed her theory and confirmed that her idea to "increase the chances of self-organizing" and "enhance institutional sustainability" provides the solution to the question of "how to ... govern resources... and obtain long-run benefits in the face of nontrivial incentives to defect." (Bromley 1993, p. 283)

In the last part of his review, Bromley adds that,

> Ostrom's book makes an important contribution to the emerging literature on analytical institutional economics. Her work reminds us that analysis of institutions and institutional change is an important aspect of a broader political economy that underlies meaningful economic policy advice. (Bromley 1993, p. 283)

# Part II

## Yellow River Basin Case Study

After 1949, When the People's Republic of China was established in 1949 a Water Law was drafted. "The third item of this statute states the water from the Yellow River basin is a valuable common property resource" (Chen and Zhang 2002, p. 12) due to today's water scarcity problem and that all Chinese citizens have the right to use the water. Traditionally, the Yellow River symbolized economic wealth. In modern times, this wealth has developed a technological face, through the construction of hydroelectric power dams and infrastructure such as bridges and dams.

The Yellow River waters were considered a common property resource for irrigation, fishing, transportation, and other economic activities thousands years ago since B.C.500. If the nature of the river's course, the basin's variable climate and high siltation proved to be obstacles for developing fisheries, the river nonetheless makes a significant contribution to irrigating the northern part of China. Although some parts of the water resource system are deteriorating due to inefficient management by users, other sections are well-managed. I chose Yellow River as a case study to apply Ostrom's eight principles, because I wanted to understand how people can make better use of this mighty river.

In terms of Ostrom's aforementioned eight principles, the Yellow River system fits for the nested enterprises principle. The large scope of the river basin makes it a complex structure for river management. As a large common property resource system, each part of the river should be connected and managed in a proper way in order to be sustainable. For every single river branch, there exists a multi-level management structure, from local governance to national government supervision. Each management level is regulated by corresponding institutions and what water resource use is transferable between cities. The management institutions in each area

of river basin must also communicate with others when setting management policies. Before discussing the current institutional management issue affecting the Yellow River basin, I shall elucidate the historical context.

## Management Strategies in Different History Periods

China's earliest and most integrated irrigation system and water property rights system was originally from the Yellow River basin. Chinese feudal governments contributed significantly to water resource management for long periods of Chinese history. Historical methods of river management included: extending the time for using water for the canal system between villages, implementing irrigation rotation policies among farmers within one county, improving irrigation technology, and building proper equipment for water preservation.

First of all, let's look at the contributions to Yellow River management during the ancient period. These river management activities occurred on the basis of the river being a property of the state.

- Early projects such as early levees and canals had been built even before the sixth century B.C. "Small levees were constructed to control tributary streams." (Greer 1979, p. 24) While levees were for flood protection canals served for transportation needs. At that time, management duties were carried out by officials under the direction of the central government.
- "Dike construction began at a later period, after levees and canals" (Greer 1979, p. 25). Just like levees, dikes were also used for flood control.
- Historical records indicate that levees were frequently breached, although water management for flood protection and constructive projects were carried out by central government in every Chinese historical period. Levees on different river branches were "breached over 1,500 times and some parts of the river's course changed 26 times. After 1194 A.D., when a major course change occurred" (Leung, 1996), the central government had to act to protect the river's course and to control floods every subsequent year.

- The Chinese government's attempts to engage in river management can be traced back to 20th century B.C. At that time, management of the river not only facilitated economic development, but also helped unify the country. For example, "during the late Chou Dynasty, levees came to be used as implements of war between various low-lying feudal states." (Greer 1979, p. 25)
- In ancient times, some famous Chinese historical figures led villagers in their defense against the floods. For example, Yu became a hero through his Yellow River management practices around four thousand years ago. (Hooker 1996)

Beside these early river management attempts China has a long history of water management activities based on the development of water institutions and the common property regime. Based on the current research, I will summarize the three stages of institutional development for water property rights in Yellow River basin during ancient times.

*Pre-stage1:* Before B.C.1100, Open Access Period.

After B.C. 500, Common property Resource.

Before 1100 B.C., people lived on nomadic agriculture. No government existed and no property rights existed on water resources. Water resources from the Yellow River were a type of open access resource for the nomads. During this time period, water was only for the purpose of nomadic agricultural activities and people could use as much water as they wanted. It took approximately six hundred years until an irrigation agriculture system around the Yellow River basin developed during the Dongzhou Dynasty (around 500 B.C). At the beginning, farmers used well water for irrigation purposes. Later, they learned to extract water from the river for irrigation.

During a period stretching from 475 B.C to 221 B.C., local people in different regions along the river began to compete for water by diverting it using irrigation canals. In this period, when the Yellow River basin was considered an open access

resource, water disputes were a frequent occurrence. Since everybody had access to the water no one sought to save water or use it efficiently. As such throughout this open access period the water resource system had hardly seen any development.

*Stage1:* From the Qin Dynasty (221 B.C.) to the Han Dynasty (220 A.D.) Included: Absence of formal and integrated water statutes. ( *Chinese Dynasties* n.d.)

During the 202 B.C. – 2 A.D. period, the central government initiated a series of large-scale irrigation projects along both the upper and lower reaches of the river, such as Wei River, Luo River, Fen River, and the Hexi corridor (Chang and Qin 2005a). The existing feudal government began formulating water property rights and set up an institution system for water resources. As a result of these activities, water resources from Yellow River have been defined as a common property resource since the Han Dynasty. However, due to technical limitations and minimal water management experience, the river management system that was created during this period was not fully functional. Villagers in local counties often could not solve water competition and litigation problems that arose from sharing water from the same canal or well. Furthermore, there was no specific management legislation to deal with the water resource problem. Although rules existed to regulate each county's rights to access water from the Yellow River, there was little monitoring and enforcement. Water stealing between counties and water competition between users within the same county presented constant headaches to ruling governors.

While local people had difficulties with water allocation issues, they worked in unison on construction projects related to water. Numerous irrigation projects were carried out along each branch of the river basin. These projects were organized by the central government and managed by a local or county leader, also assigned by the central government. Although directly concerned by these projects, villagers had no say in the selection of a leader. Nonetheless, these irrigation projects made a positive contribution to the development of Chinese society by increasing agricultural productivity.

The institutions related to the management of the common pool water resource in this first stage of Chinese history were:

1. The water institute, which defined the proper order for using water resources in that time period. Specifically, water was first used to satisfy the special needs for ruling class, such as for daily personal water usage and for transportation canals. Irrigation needs were a distant second.
2. In the Han Dynasty, irrigation areas had rules for allocating irrigation water and for the daily usage of water. In a village in Nan Yang County, a manager caved those rules on steles situated inside each irrigation area to prevent disputes. (Chang and Qin 2005a, p. 5)
3. Water management during this period depended on the formal statute governing the country. The management behavior was considered as macroscopic behavior. All of water diversion projects were operated by government, which was controlled by the king. King Wu of the Han Dynasty, for example, used huge amounts of the nation's funds on irrigation projects. Unfortunately none of the detailed local water management activities in irrigation areas and related institutions were recorded during that time. That is also the reason why management of water resources was considered a central government prerogative.
4. If water management institutions during the Han Dynasty saw greater improvement than in previous dynasties, it was due to the hierarchical structure of the water department, a structure that flowed from the top levels of central government to local institutions. The central government itself was divided into two levels of management. Its main function was to draft national rules for governing water issues. It was a top down management structure, wherein the unified management for the whole basin area and each local level of the institutions participated.

Yellow River basin area management improved after the Qin Dynasty. Before this time, people used water arbitrarily, resulting in free riding problems. Under the Han

Dynasty, the economy became more prosperous than ever, the population boomed and the value of land increased steadily. Water resources became more valuable due to their close connection with agricultural land. In order to extract more value from water resources and to satisfy increasing water demands, old institutions for water management needed to be changed. At this stage, we cannot see any local self-governance organization managing Yellow River resources. Although the river's resources became a common property resource, users relied on central government policies.

*Stage2:* From the Tang Dynasty (618 A.D.), to the Yuan Dynasty (1368 A.D.) Included: *Shui Bushi*-- the first formal water statute

This is a prosperous age for Chinese feudal society. Yellow River management reached its integrated stage and was enhanced by the development of new legislation. During the Tang Dynasty, the first integrated water statute was developed. It was called *Shui Bushi*. It's the first formal statute of water resource management in China's history and was recorded 1300 years ago. It contains "29 sections and 26000 words" (De and Niu 1995, p. 45). Volumes containing the statute still exist and can be found on display in China's national museum. This statute records local management rules for the Yellow River in the north and the Yangzi River in the south and is considered invaluable for understanding the management of shared water resources by local groups.

In ancient China, all natural resources, including water resources, belonged to the feudal government headed by the king. Common people only had rights to use water resources under the feudal state's ownership. In the Tang Dynasty, there existed two water departments. Officials in the first department were called *Langzhong*. Their duties were to create laws for using and managing water resources. (Zhang Meijuan and Zhang Meihua 2007, p.2) They managed and corrected existing regulations but didn't deal with detailed local affairs or disputes. Officials in the second department were called *Du Shuijian*. (Zhang Meijuan and Zhang Meihua 2007, p.2) They were

responsible for detailed local management affairs. These two departments held equal positions within the central government structure.

In the Tang Dynasty, the feudal law system can be divided into four different categories: "Lu, Ling, Ge, Shi" (De and Niu 1995, p. 45). *Shui Bushi* is one of the four categories. According to *Shui Bushi*, management rules were for "canal irrigations and water conservancy, local stone mill settings, daily water consumption and rules for canals, fords, navigation lock, and bridge management and maintenance" (De and Niu 1995, p. 45). Due to *Shui Bushi*, water management activities were recorded more than in any previous dynasties. The statute emphasized that the water allocation principle was for water use equalization. Each canal and irrigation area had to follow this principle. "The orders of using water in this period were first for irrigation, then for shipping purposes, and finally for common peoples water mills" (Zhou 1981, p. 51) All villagers who relied on this river for irrigation had to follow the orders of using water. Users at upper level of the river area had to give priority to lower level users. When sharing the same canal the furthest irrigation areas needed to be satisfied first, before water could be retained by areas near the river canals.

Each village leader and government official also acted in a monitoring capacity to ensure that the law was being properly followed. Cheaters were punished, often through the village court. Officials also evaluated and monitored each other, with violator officials laid off by central water departments. Finally, officials from the central water departments performed annual checks in each irrigation area of each county.

The statute also sets out rules for daily water users and water mill owners in each village. One such rule, called "Dou Man" (*The First National Water Conservancy* n.d), was a mechanism for conserving water resources. Users within a village managed their own mechanism and with villagers doing the maintenance work. The statute identified that users within a village had equal rights to access water resources for irrigation, water mill, and daily use. All people, whether rich or poor had rights to use water according this statute, but only the ruling class had the power to create water

property rights

Applying Ostrom's approach to management issues in the Tang Dynasty, we can see that some of her design principles are missing. On the positive side, *Shui Bushi* clearly established boundaries for using the Yellow River's resources and property rights for shared irrigation canals. Villagers could participate in canal maintenance. Local groups and the central government collectively monitored water use and punished violators. But the conflict-resolution mechanism and the minimal recognition of rights to self-organize were not present. Water users' conflicts and disputes were settled by the central government or the higher institute of a village. Water users normally had no rights to correct rules for using common canals or wells. Government authorities still made all the decisions at that time.

Some of the more detailed characteristics of this water conservancy statute for local irrigation areas can be summarized as follows:

**1) The Requirements of a Farmland Irrigation System**

The main idea behind *Shui Bushi* was to establish a rational system for irrigation areas, which demonstrated a relatively fair and efficient irrigation system during that time. The main irrigation areas were located on the lower part of the Yellow River. Irrigation water property rights were assigned to users along with their land ownership. Common water resources included the branch, or the common canals. The users of the water resource were the villagers of one village or one county. All of the participants involved in using water resources had to follow the rules. For example, regulations governing water gate constructions in villages were as follows: "the White Canal and other large irrigation areas must be installed with the canal sluice gate, called 'dou men'." (Zhou 1981, p. 52) The sluice gate had to be made of stones at the base, and wood for the gates, and the entire installation device had to be solid and firm. The gate's dimensions were also specified in the rules, and enforced by special officers assigned to inspect them.

Villagers in the irrigation area depended upon these sluice gates to adjust the water levels of canals and the proportion of water diversion. Sluice gates also

controlled water volume for irrigation usage according to the size of the irrigation area, the different types of crops cultivated, as well as the different growth seasons.

The construction of these floodgates during the Tang Dynasty can be considered as a remarkable symbol of water resource management and follows Ostrom's principle of "congruence between appropriation and provision rules and local conditions" (Ostrom 1990, p. 90). Sluice gates were particularly useful for water control management around the lower reaches of the river. *Shui Bushi* also stated that the priority for irrigation depended on the kinds of crops being cultivated. For example, in each irrigation area local counties ensured that irrigation was reserved for main grain crops first, and then for other types of crops. Along the Yellow River basin, the main crop was wheat, thus wheat was the first irrigation priority.

Another important irrigation requirement was "irrigation by rotation" (Zhou 1981, p. 52). As each irrigation canal supplied a prescribed amount of farmland, it was necessary for farmers to measure the size of their irrigation area carefully in advance, and then take their share of the water as part of the irrigation rotation. When the irrigation work was done, the floodgate was to be immediately closed. Irrigation rotation sought to equalize water use in an irrigation area, to supply accurate amounts of water according to irrigation acreage, and to prevent the arbitrary use of water resources. The rule ensured that each participant received a full and fair share of the resource. Irrigation rotation was also an efficient and scientific method of sharing the resource. It reduced losses from leakage and kept the water volume of a canal at a fixed level. Finally, rotations were helpful in alleviating the problem of canal siltation. The many benefits of irrigation rotation ensured that the practice continues to the present day.

Rules of irrigation rotation in China were similar to Ostrom's case study of Spain irrigation systems. The Yellow River and Spanish cases both set out rules for allocating common water resources under different situations. For an abundant water resource situation, farmers can take as much as they want. For a seasonal low water resource situation, farmers must use rotation schemes. In extraordinary drought

situations, farmers whose crops needed water the most were given priority over others. Another similarity between the two cases refers to water rights. Both for the Yellow River and Spanish case, water property rights of each river branch area were tied to the land. Applying to Ostrom's second principle of long-enduring CPR institutions, we know these irrigation rules restricted the quantity of water used depending on local conditions.

2) **Administrative Requirements in the Irrigation Area**

The central government sent officials to local irrigation area to manage water affairs. The detailed administration of an irrigation area could be found in the second section of *Shui Bushi*. Officials were responsible for managing and inspecting the main irrigation canals, while local leaders were responsible for canal floodgates. The central government administrator, a representative of the ruling class, managed the overall water resource problems and then reported them to top water institutions. Lower level leaders such as village chiefs were responsible for detailed local work. The management structure used at that time was hierarchical. According to the water code, only officials and floodgate leaders had the right to distribute water volume to each canal during each specific irrigation period.

*Shui Bushi* also described how to select administrative officials. For each irrigation area, officials were selected by the central government. They were trained and sent to irrigation area and worked on behalf of the water department of the central government. Opinions on the process of water volume distribution varied between canal managers or between floodgate managers. Conflicts often occurred when local managers dealt with water allocation issues. Central government appointed officials had the power to settle those conflicts because of their superior authority. This hierarchical structure that used the authority of the central government to guide the behavior of local users' is an essential aim of *Shui Bushi*.

Government appointed officials acted as an intermediary between the central government and local participants. Administrative officials were also responsible for instructing water resource project maintenance. If the irrigation project suffered

damages and the local irrigation area could not afford to repair the project, then these officials would be responsible for reporting the problem and requesting assistance from a higher institution at the county or state level.

The administrative features of this statute meet Ostrom's the fourth monitoring principle. Central government officials monitored local managers' behavior to resolve water resource allocation problems and local users monitored each other as well as users from other counties. Unfortunately, local management of water resources could not satisfy the requirement of Ostrom's sixth principle, that of a conflict-resolution mechanism. Only central government officials could solve conflicts between local leaders and users. This violates Ostrom's requirement for self-governance. In Ostrom's case studies conflict-resolution mechanisms are successful in surviving CPRs that depend on local governance rather than external authorities. In the Spanish case, villagers selected their own syndics, which held similar in powers to the central government officials in the Yellow River case, to manage water issues. These syndics are executive officers of individual irrigation units and have the power to allocate water resources, solve water disputes and levy fines. These powers are almost identical to the powers held by Yellow river water management officials in the Tang Dynasty, with the one difference that the latter were appointed by an external authority.

### 3) Requirements for Solving Agricultural Water Use Problems and Other Water Use Conflicts.

During the Yellow River's dry season, the major water competition problems were found in hydraulic mill devices, irrigation water use, and river/canal shipping. *Shui Bushi* contains a series of strict rules for using hydraulic mill wheel in irrigation areas. For example, "water resource stakeholders were prohibited from using the mill wheel and had to give priority to irrigation purposes for a period stretching from the first day of the lunar month to Ausgust30" (Zhou 1981, p. 53). During the non-irrigation season or when there were abundant rainfalls in an irrigation area,

people were allowed to use mill wheels for hydraulic or other purposes. It was necessary to set up the strict limits on mill wheel use because operating mill wheels required significant amounts of water and failed to recycle the water.

When villagers used mill wheels, they needed to raise the water gap to drive the wheels. After the water began to push the rollers of the wheels, it was discharged outside the canals. By wasting large amounts of water mill wheels reduced downstream irrigation water volume. The problems of mill wheels were such that in some irrigation areas the central government periodically sent officials to remove illegal mill wheels. For example "during the year 778 A.D., more than 80 mill wheels were removed at one time, since they were located in one canal, and completely hampered the river resource." (Zhou 1981, p. 53)

The conflict between shipping and irrigation was another widespread problem of this shared water resource. The rules governing this problem were listed "in the section 22 of *Shui Bushi*. Section 22 required that if shipping and irrigation cannot coexist, the first priority belonged to navigation purposes"(Zhou 1981, p. 53). The reason for this was one of scope: shipping was a national transportation method and conferred benefits to the whole country that vastly exceeded the benefits of a local irrigation area.

Prior to *Shui Bushi*, the earliest recorded water code was the "flood prevention laws and regulations of 651 B.C" (De and Niu 2004, p. 45). Unfortunately, most of those laws have not survived to the present day. The Tang Dynasty inherited this previous water management experience and used it as the basis for the most comprehensive water statute ever, *Shui Bushi*. *Shui Bushi* was a remarkable water conservation statute. It recorded local management cases regarding irrigation areas. Local water users employed its rules to protect common water resources. For example, powerful landlords, during that period, often misappropriated farmers' water resources though canal diversions and private floodgates. *Shui Bushi* banned the practice of

building a weir inside a canal and setting up a private floodgate. Landlords who violated the rule were punished accordingly.

Government also sent officials to inspect local management of water resource. This administrative feature suits Ostrom's fourth and fifth design principles. Monitoring has a positive effect in managing water resources, especially when violators are fined. However, institutions in the Tang Dynasty did not follow the principle of a right to self-organize. Water users within a village did not have rights to devise their own rules and had to rely on central government authorities.

In the Tang Dynasty, the regulations governing the use of water resources were relatively fair to the public. Common people and the royal family had equal rights to access water. The rights to use water resources applied to individuals or to collective units. In the Yuan Dynasty, the civil right of using water could be separated from the individual and sold. Buying and selling water resources was normally combined with buying and selling land, because regulations stated water rights must be tied to land. For example, when a family was divided among inheritors, the lands given to each family member came along with corresponding water property rights (Chang and Qin 2005a, p. 7).

*Stage3:* From the Ming Dynasty to the Qing Dynasty (1368 -1949 A.D.)

This is a period marked by the economic decline of feudal society and the budding of a capitalist system. The water management system changed as more local organizations took major responsibilities in managing the river. It was a significant shift from the policy-making powers of the central government in the Tang Dynasty. In the Qing and Ming dynasties, the priority for using water resources was for irrigation rather than shipping. The structure of water resource management departments changed from strictly hierarchical to partially democratic. For example, local groups could participate in water management and could vote for the local leader that managed water affairs. Self-governance and local management was encouraged. Later on, I will analyze the Hexi Corridor case to illustrate local group management of

shared water resources.

During this period, the central government began to allow water transactions and the creation of a water market soon followed. I believe the water market phenomenon was a feature of the budding capitalist system. However, the evolution of the government's water resource policy also helped to create the water market, increased the value of water and encouraged economic development. Why did government institutions encourage water transactions? Historians provide the following three reasons:

1) "The commodity economy began to dominate society and water transaction is a necessary outcome of this type of economy" (Chang and Qin 2005b, p.2-3).

2) "Population was increasing during Qing dynasty and with it came increased water demands and appreciation in the value of water resources" (Chang and Qin 2005b, p.2-3). Previous water institutions did not allow the water transactions and therefore exacerbated the problem of water scarcity. Now, people who owned land but faced water scarcity problems could negotiate with people who had access to abundant water resources but needed more land. After water transactions became legalized, all parties in the water market could maximize their welfare, and society as a whole became more economically efficient. As such, the water institutions of the Qing Dynasty fit the eight principles of Ostrom's prescription for a long-enduring successful CPR institution.

## A Case Study of the Hexi Corridor

The Hexi Corridor was considered a very important part of the Yellow River throughout history. (see figure2 on p. 3) Located in Ningxia Gansu Province it forms part of the Silk Road running northwest from the banks of the Yellow River.

As the water resources along the Hexi Corridor provide benefits to the whole western part of China, the "water disputes that arose along the corridor were the main problem of the Qing Dynasty." (Wang Peihua 2004, p. 91) Due to low annual

precipitations, water scarcity in the Hexi Corridor was a common occurrence. Disputes over water resource were most serious along the Black River, located at the upper reaches of the Yellow River. Black River course blockages at the upper level resulted in downstream water users fighting to obtain their share of water resources. Sometimes local government had to use force to settle these violent disputes. In order to resolve water dispute problems, the central government's water department built three different levels of watershed systems to equally distribute water resources. The first watershed level distributed water between the upper and lower reaches; the second level distributed water within a county between watercourses or canals; the third level distributed water within a single watercourse or a canal between individual users. Local groups of resource users were organized to share this common resource.

Regulations were recorded on the steles in each county. For example, sometime around 1743, Gulang County set out rules for water allocations and printed booklets for water rights users (Wang Peihua 2004, p. 92). In the county, villagers selected a conservator to keep the booklets and monitor dams, canal siltation, and emergency situations due to climate changes. If an event that could affect villagers' use of water from the common canals occurred, he had to report it immediately and, if necessary, dispatch laborers to repair the canals. Unsurprisingly, the conservator was held in high regard among the villagers.

The local institutions regulated that each user had to contribute to the maintenance work of canals or canals. Families who had a strong labor force had to perform the maintenance work needed to protect the water resource. Any violators or cheaters were reported by the conservator to the village court. Each village had courts for judging disputes or punishing violators. Beside the conservators and the village courts, resource users also had ditch-riders and guards to help conservators carry out their daily water allocation duties. This kind of management approach is strongly similar to Ostrom's Spanish case study, and the rules of water management in each Chinese county along the Hexi Corridor can be recognized as operational rules in Ostrom's approach. Ostrom mentioned that in irrigation cases, operational rules

decide how much water resource is withdrawn from each canal, when irrigation rotation begins, and how to punish violators if they break the rotation order and take illegal water for self-interest purposes. These specific operational rules guide users day-to-day decisions on the use of a canal.

Water allocation in the Hexi Corridor was not an easy job for local government. They had to design rules that took into account multiple factors, such as the environment, climate change, water conservancy projects, agricultural needs and ever changing social mores. In order to ensure social harmony, local governments in the Qing Dynasty used the technique of water distribution. This technique measured and counted water periods in order to determine a user's time and quota for using the water.

The main principles underlying water distribution were: (Wang Peihua 2004, p. 94)

1) The principle of fairness. This principle used geographic distance to determine distribution, by giving priority to the furthest reaches of a canal.

2) The principle of efficiency. This included three different aspects.

→ water distribution according to the labor force maintaining the canals.

→ water distribution according to the amount of harvest grain contributed to the central government each year.

→ water distribution according to the acreage amount in the irrigation area.

These principles alleviated water disputes to some extent and encouraged local users to play an important role in ensuring equal water usage.

Adapting water resource allocations to local situations is also mentioned in Ostrom's Philippines case study (Ostrom 1990, p. 82). For example, the technology used in the Zangjera River construction of common irrigation works is also labor-intensive. Consequently, the Philippines 1978 Water Code permitted only individuals or juridical persons to obtain water rights (Ostrom 1990, p. 85).

In the Hexi Corridor, the nature of the climate continues to pose water resource problems even to the present day. Precipitation in Hexi Corridor decreases with every passing year, while evaporation rates are increasing. Nevertheless, discounting climatic factors, the water management rules of the Qing Dynasty are still notable for successfully solving the water use problems for a span of over fifty years.

## Conclusion

In China, the water property rights problem has been widely discussed by scholars (e.g. Chang and Qin 2005 and 2006; Zhou 1981, Wang 2994). China has a long experience with agriculture, and formed a unique civilization and agricultural style. Chinese agriculture requires abundant water resources. How to efficiently use existing water resources is a hot topic in academia (e.g. Chang and Qin 2005a, 2005b; Chen and Zhang 2002; He and Chen 2004; Wu *et al* 2003). In recent years, as water scarcity has become severe, the rush is on to build a water-efficient society. Early Chinese history of managing common property resources does not reveal any clues on achieving such a society. Serious efforts to manage the water rights problem only commenced in the Ming and Qing dynasties.

*Shui Bushi* is the only reliable resource worth studying for water institutional management in ancient China. As China's first water management statute, *Shui Bushi* reflected both the central government's effort to resolve water resource problems and the local village users management of shared canals or irrigation areas. Partially as a result of this statue, the Tang Dynasty saw the development of advanced agricultural technologies, new farming systems and feasible management strategies.

*Shui Bushi* fits the approach of managing CPRs using local institutions, part of Ostrom's eight principles of long-enduring CPR institutions. The Yellow River case also bears certain similarities with Ostrom's case studies of Spain and the Philippines. All three cases reflect her eight design principles, such as the principle that institutions set rules for monitoring, sanctioning, and resource user participation. The

allocation principle in the Spanish case is similar to the Yellow River water allocation principles in the Qing Dynasty. The Spanish case mentioned inspectors for irrigation while in the Yellow River case *Shui Bushi* also mentioned the village leaders as inspectors for local management. Rules of irrigation by rotation order were also found in the three cases, all of which used this method when water was scarce. Water allocation criteria are the same for both the Yellow River case during the Qing Dynasty and the Philippines case. They all use methods "roughly proportional to the contributions of labor and materials and to hectare shares."

Water management problems on the Yellow River persist even today. The nature of the problem has changed little over the centuries: water scarcity, unclear boundaries of water property rights, low efficiency and incompetent management is as pressing issue today as during the dynastic period. For example, water resource management now belongs to the water conservancy department, water allocation belongs to the city construction department, and sewage disposal belongs to the environmental department. Each department has it own job to do, but they don't have clear idea about their responsibilities and rights to manage the water resource, and they do not work in concert. The water conservancy department will not consider sewage disposal problem whereas the environmental department will not consider the water conservancy problem, only caring about sewage disposal. Since these various departments do not share information on managing common property water resources the nested system is poorly connected. Isolated departmental behavior also creates opportunities for speculators to overuse or pollute precious water resources.

The current management of the Yellow River basin in each specific area poses problems and the question arises as to why the Chinese government has proven unable to scientifically and successfully manage the Yellow River basin. While the answer is complex, I believe that one possible solution lies in adopting Ostrom's eight principle approach towards managing a common property resource. It is still possible to expect Chinese central government carry out full decentralization strategy along the main

river braches in big cities, then gradually consummate to each village and union to enhance the Yellow river ecological system.

# Bibliography


1. Agrawal Arun, (2001) Common Property Institutions and Sustainable Governance of Resources, *World Development* Vol.29, No.10, p. 1649-1672.

2. Anderies John M., Marco A. Janssen and Ostrom Elinor, (2004) A Framework to Analyze the Robustness of Social-ecological Systems from an Institutional Perspective, *Ecology and Society* 9(1 June):18 .

3. Bish Robert L. (1992) Review: Common Pool Administration. *Public Administration* Review, Vol.52, No.5. (Sep.-Oct.), p.519-520.

4. Bromley Daniel W., (1993) Reviewed Work(s): Governing the Commons: The Evolution of Institutions for Collective Action, *Journal of Economic Literature.* Vol. 31, No. 1 (March), p. 282-283.

5. Bromley Daniel W. and Jeffrey A. Cochrane (1994) *Understanding the Global Commons.* Working Paper No.13, 18 pages (July).

6. Bromley Daniel W., (1989) *The Management of Common Property Natural Resources: Some Conceptual and Operational Fallacies*, World Bank Discussion Papers, #57

7. Bromley Daniel W., (1995) *Handbook of Environmental Economics,* Basil Blackwell Ltd. USA.

8. Bromley Daniel W., (1992) The Commons, Common Property, and Environmental Policy, *Environmental and Resource Economics* Volume 2, Number 1, p.1-17.

9. Bromley Daniel W., (1998) *Property Regimes in Economic Development: Lessons and Policy Implications*, Agriculture and the Environment, A World Bank Symposium p. 83-91.

10. Casari M and CR Plott, (2003) Decentralized Management of Common Property Resources: Experiments with a Centuries-old Institution. *Journal of Economic Behavior & Organization,* Vol. 51, Issue 2, p. 217-247.

11. CBNRM Networking, Norway, *CBNRM,* n.d. *Processual terms,* Available from http://www.cbnrm.net/resources/terminology/terms_processual.html [Accessed on 28 September 2007]

12. Chang Yunkun and Shoukun Wang (2006) The Evolution of water property rights trade-off in China and Position of Government in Water Market. *(Chinese Version) Inquiry into Economic Issues,* No.3. (March), pp. 12-15.

13. Chang Yunkun and Si-yang Qin, (2005a) Evolution of Water Right System of Yellow River Basin in Ancient China (Vol.1) *Journal of Economics of Water Resources* [online], Vol.23, No. 5 (September), p. 4-8.

14. Chang Yunkun and Si-yang Qin, (2005b) Evolution of Water Right System of Yellow River Basin in Ancient China (Vol . 2) *Journal of Economics of Water Resources* [online], Vol.23, No.6 (November), p.1-5.

15. Chen Shouyi and Daojun Zhang, (2002) China Water Resource Property Rights and Water Management, *Water Resources Development Research* [online] Vol.2, No.1, p. 11-14.

16. *Chinese Dynasties,* English version, Retrieved from http://images.google.ca/imgres?imgurl=http://acc6.its.brooklyn.cuny.edu/~phalsall/images/riv-vall.gif&imgrefurl=http://ancienthistory.about.com/od/china/a/ancchinamaps.htm&h=393&w=683&sz=36&hl=zh-CN&start=167&um=1&tbnid=1aodAnsF0HJi3M:&tbnh=80&tbnw=139&prev=/images%3Fq%3Dyellow%2Briver%26start%3D160%26ndsp%3D20%26svnum%3D10%26um%3D1%26hl%3Dzh-CN%26sa%3DN [Accessed on 25 September 2007]

17. De Hui and Lingfang Niu, (1995) The Earliest Water Statute in China—*Shui Bushi, Jilin Water resources,* Vol.11, p.45.

18. Greer Charles, (1979) *Water management in the Yellow River Basin of China.* University of Texas Press.

19. He Dawei and Jingsheng Chen (2004) Institutional Management of Yellow River Basin and Its Surrounding Environment, *Resource & Environment* Vol.3, p. 11-14.

20. Heilig, G.K., (1999) *Main Rivers in China - Low Resolution Map*, retrieved from http://www.iiasa.ac.at/Research/LUC/ChinaFood/data/maps/rivers/riv1_s.htm [Accessed on 12 September 2007]

21. Leung George, (1996a) Reclamation and Sediment Control in the Middle Yellow River Valley, *Water International*, Vol. 21( March), No 1, p. 12-19.

22. Leung George, (1996b) *Land and People,* Retrieved from website: http://www.cis.umassd.edu/~gleung/peopfo/pas01.htm

[Accessed on 2nd September 2007]

23. Leung George, (1996c) *Yellow River: Geographic and Historical Setting*, Retrieved from website: http://www.cis.umassd.edu/~gleung/geofo/geogren.html [Accessed on 2nd September 2007]

24. Ministry of Water Resources (MWR) P.R. China, (2004) *Water Resources in China*. Retrieved from http://www.mwr.gov.cn/english1/20040802/38161.asp [Accessed on 16 November 2007]

25. Ostrom Elinor, (1990) *Governing the Commons: The Evolution of Institutions for Collective Action,* Cambridge Univ. Press, New York.

26. Ostrom Elinor, (1999) Institutional Rational Choice: An Assessment of the IAD Framework, in P. A. Sabatier (ed.), *Theories of the Policy Process*, Boulder (CO), Westview Press.

27. Ostrom Elinor; Joanna Burger; Christopher B. Field; Richard B. Norgaard and David Policansky (1999) *Science*, New Series, Vol.284, No. 5142. (Apr.19), p. 278-282.

28. Richard Hooker (1996) *The Yellow River Valley*, Retrieved from http://www.wsu.edu:8080/~dee/ANCCHINA/YELLOW.HTM [Accessed on 3rd October 2007]

29. *The First National Water Conservancy Shui Bushi,* n.d. Available from http://www.cws.net.cn/gpwyh/ggyfhs/ArticleView.asp?ArticleID=22203 [Accessed on 25 September 2007]

30. Tietenberg, Thomas H. (1992) *Environmental and Natural Resource Economics* , 3rd. HarperCollins Publishers Inc.

31. Wang Peihua, (2004) The Disputes on Water Utilization and Distribution System in Hexi Corridor of the Qing Dynasty, *Ancient and Modern Agriculture* [online], No.3, p. 91-98.

32. Wu Lina, Hongrui Wang, Xiaobing Chen, Fanghua Hao and Changming Liu, (2003) Issues In Water Resources Management of The Yellow River Basin and Countermeasures, *Resources Science* Vol.25, No.4 (July), p.56-61.

33. Xu Zongxue and Nan Zhang, (2006) Long-term trend of precipitation in the Yellow River basin during the past 50 years. *Geographical Research,* Vol.25, No.1(Jan), p.28-34.

34. *Yellow River*, (2007) n.d. Retrieved from website: http://en.wikipedia.org/wiki/Yellow_River [Accessed on 16 August]

35. Zhang Meijuan and Meihua Zhang, (2007) Problem on the Water Rights of Tang Dynasty, *History Teaching,* [online] Vol.3 (March), p.22-25.

36. Zhou Kuiyi (1981) The Earliest Water Conservancy Code—*Shui Bushi*, *China Water Resources*, [online] No.4 (April), p.51-54.