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Institutional Frameworks in Successful Water Markets

Brazil, Spain, and Colorado, USA

Edited by
Manuel Mariño
Karin E. Kemper

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Manuel Mariño is senior environmental specialist in the World Bank's Transportation, Water, and Urban Development Department. Karin E. Kemper is an economist in the Bank's Environmentally and Socially Sustainable Development Unit, Latin America and the Caribbean Regional Office.

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FOREWORD

Water is increasingly recognized as a scarce resource that must be managed more efficiently than in the past. In addition to physical scarcity, the cost of accessing these resources is climbing. New reservoirs, water transfers among river basins and water supply systems force each new user to access more distant water resources at increasingly greater costs.

The debate surrounding these issues is increasingly focused on water markets as possible instruments for more efficient water resources allocation and use. Well functioning water markets provide economic incentives to water users, inducing allocation, use and conservation according to value. Markets are also more flexible than the traditionally used administrative allocation mechanisms. Providing users the ability to decide if they will buy or sell water rights ensures that they do so voluntarily and financial compensation is received. This is often not the case when water is reallocated or expropriated by a central authority. Thus, the market mechanism can be used to reduce conflicts.

While the benefits are clear, sufficient attention has yet to be paid to the institutional framework necessary for well functioning water markets. The principal reason for this is lack of experience. The number of functioning water markets with sufficiently long and documented experience is very limited.

This publication explores institutional frameworks in three case studies of long standing and successful water markets. The papers are written for practitioners interested in how water markets operate, for decision makers faced with the challenge of selecting a water resources allocation system, and for academics interested in analytical-descriptive case studies that provide information on how to conceptualize the functioning of water markets from an institutional perspective. These cases demonstrate the common features and essential elements of water markets, as well as how to design markets taking into account the local institutional, social, and political conditions and their integration into existing water resources management arrangements.

John Briscoe
Senior Water Advisor
The World Bank

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ABSTRACT

For the use of water markets to introduce improve water resources management, the existence of adequate institutional arrangements is one of the key elements of success. The papers compiled in this publication describe and analyze three cases from very different settings. The papers point out similarities and differences and show that various options exist for effective water resources management through use of the market mechanism. Similar features that are found in all three cases and are deemed necessary for the adequate functioning of water markets are: the existence of a user-based management approach, with structures providing transparency and accountability among members; well-defined measurable and enforceable water use rights, including those concerning return flows; and adequate knowledge of the resource available for trading, either from a known and controlled source or from supplemental resources transferred from other basins.

The implementation of a water market still implies both government involvement and active water user participation, an administrative system that registers and enforces timely water deliveries, a transparent and accepted measurement system, and a well-maintained water delivery infrastructure. For these reasons, the difference between the implementation of an administrative approach and a market system may not be as large as one might expect.

While the introduction of water rights might encounter ideological opposition because water in most countries traditionally has been regarded as a public good, a market could be developed for usufructuary rights while the water itself remains public property. For this reason, the most challenging institutional feature might not be the institution of water user rights *per se*, but rather the implementation of adequate information and transaction mechanisms that provide all water users with equal possibilities of participating in the market. These mechanisms would have to include access to price information, to registration, enforcement, and monitoring of rights.

These examples also show that the introduction of water trading might be simpler and beneficial especially in the case of supplemental water supplies. In these cases, the new institutional set-up can be developed rather independently from existing institutional arrangements, such as historical property rights, administrative allocation mechanisms, etc. Therefore, in countries that, based on a first analysis, seem to broadly feature the basic institutional requirements, water trading could be introduced in connection with new water projects and the creation of user-based management approaches. This step would be less radical than large-scale attempts to introduce water markets and the experience thus gained would provide insights in how to adapt them more broadly over time.

The examples also illustrate that a water market can be adapted to local economic, social and cultural conditions without serious repercussions on its functioning. Although the general application of case studies is always limited, the examples provide considerable insight in the institutional aspects of water markets. They also show that water markets can improve the efficient allocation and use of water and provide flexibility in the management of water during periods of shortage. However, the adequate institutional framework has to be in place before the markets can function effectively. Whether this framework exists or how it can be developed will depend on the local conditions and culture and this issue must be carefully addressed before a decision can be made with regard to the possible adoption or introduction of a water market system.

EXECUTIVE SUMMARY

In both developed and developing countries it is increasingly recognized that water is a scarce resource that has to be managed more efficiently than has historically been the case. Not only are semi-arid and arid areas subject to physical scarcity, but also financial scarcity is introduced when the construction and maintenance of more dams, water transfers among river basins and water supply systems is chosen as the alternative to optimum management.

It has been argued for a long time that water markets provide a possible instrument to contribute to more efficient water resources allocation and use. The principal argument is that markets provide economic incentives for water users, inducing the use and allocation of water according to its real value and its conservation. A further argument is made that markets are more flexible than administrative allocation mechanisms, which have been the rule in most countries until today. Also, when users themselves can decide if they want to buy or sell, those who sell their water do so voluntarily and get a financial compensation. This is often not the case when water is reallocated or expropriated by a central authority. Thus, the market mechanism can be used to reduce conflict.

Due to the potential advantages of water markets, they are, at present, being promoted in a number of developed and developing countries, e.g. in Mexico, Brazil, and Peru. However, little knowledge exists concerning the institutional framework that water markets need in order to function. One of the reasons for this is the very limited number of actually functioning water markets with sufficiently long experience. The other reason is that these systems have not been extensively studied from an institutional point of view.

The purpose of the following papers is to contribute to the discussion about water markets from an institutional perspective. The papers compiled here emphasize the need to look at the institutional frameworks that have contributed to the functioning of existing water markets. This is especially important if, as is the case right now, the theoretical models for water markets are being derived from industrialized countries but are being introduced into developing countries, where the institutional conditions often differ substantially from those implicitly assumed by the theorists.

The papers are therefore aimed at practitioners who are interested in how water markets function in practice, at decision makers who are faced with the challenge to decide which type of water resources allocation system to implement in their region, and at academics interested in analytical-descriptive case studies of existing water markets that provide more information on how to conceptualize the functioning of such from an institutional point of view.

The markets presented here are situated and representative of three very different settings. The first paper analyzes a local water market, dating from 1854, in Ceará, Northeast Brazil. The water in the area is principally used for irrigating about 1,500 ha of sugar cane. In Paper II, the water market of the Siurana-Riudecanyes District, that has been functioning since 1904 in North Western Spain, is discussed. Water from the Riudecanyes reservoir is used for irrigation of primarily hazelnut (4,000 ha) and urban/industrial supply. Paper III presents the water market functioning in the Northern Colorado Water Conservancy District of the state of Colorado, United States, since 1959. The District encompasses an area of overall 600,000 ha and the water is used for irrigation, municipal and industrial water supply. Irrigation water is shared by about 125 ditch companies, ranging from 250 ha to 22,000 ha in size.

The water market in the Cariri region, in the hinterland of the state of Ceará, Northeast Brazil, trades water from the Batateira Spring, which becomes the river Batateira. In this area, the local sugarcane farmers developed in 1854 a

system of water rights and water allocation, which is in existence to this day. Paper I describes the historical evolution of this system, its current situation, and discusses its importance in relation to the contemporary discussions about water resources management in Ceará and at international level.

While the Cariri experience has to be regarded as a small isolated system, it provides valuable data and experiences concerning the importance of a functioning market for indicating the value of water, the possibilities of measuring and enforcing water rights, and the willingness of water users to cooperate and organize themselves in order to assure a secure water supply.

Paper II analyzes the water market of the Camp de Tarragona in Spain, which presents a valuable model applicable to developing countries for effective allocation, utilization, and management of resources. The innovative financial approach involving irrigation and municipal users, the active participation of the water users, the structure of the managing institutions, and the size of the framework have enabled the market to operate since the Siurana area was granted its initial water concession in 1904.

Water titles for the Siurana-Riudecanyes transfer system have been tradable among the members of the Irrigation Subscribers Association and the municipalities of the Camp de Tarragona since its construction. This special arrangement has given rise to an active water market since the beginning of the century, with permanent and temporary water rights transfers among farmers and between farmers and municipal water supply companies that provide water for domestic and industrial users in the Camp.

The Irrigation Subscribers Association represents the central force behind the long history of the system. Because of its size, the active role of its members and the transparency in its functioning, it possesses the ability to adapt to the specific circumstances and needs of the region. As the irrigation and municipal users participate in the administration of water resources, their expertise in local issues allows them to effectively influence the development of the water market and fairly resolve any disputes which may arise.

The Association has also pioneered several activities aimed at improving its efficiency, reducing waste, and further optimizing the use of water, all of which are heartily adopted by its members because of the value they are able to assign and identify in the resource as a result of the existence of the market. Also, contrary to other irrigation districts, funds for operation, maintenance and debt repayment for the infrastructure have always been completely covered by the water users through their contributions to the Association (the Association manages, operates and maintains all the hydraulic infrastructure of the system).

The involvement of local government institutions, such as the city council of Reus, has also had a significant impact on proper functioning of the water market. By providing a large part of the funding for the original works and staying actively involved in their management, the city has played a major role in creating the present system. Most importantly, urban water supply needs have been adequately fulfilled because Reus has been allowed to enter into operations within the market.

Paper III presents the water market that has developed in the Northern Colorado Water Conservancy District in the Western United States, which is an often-cited example of a large, effective, functioning water market. The analysis shows that the market is based on elaborate institutional arrangements that have permitted it to function, namely: it affects only supplemental water; water rights are usufructuary; there are no third-party interests; and the market is run by a transparent user-based administration, which has its main underlying structure in the "ditch companies" as well as participating industries and municipalities.

The water traded in the District's water market originates from a large water storage project

transferring water from the east slope of the Rocky Mountains to the west slope where the District is located. When the project was finalized in the late 1950s, it provided supplemental supplies which had not previously been allocated. Therefore, as in the case of the Camp of Tarragona, new institutional arrangements for allocating and trading could be implemented without such obstacles as historical use and vested interests in the status quo. Also as in the Camp, new water rights were allocated as usufructuary rights, i.e. the water is still property of the United States Government and no user can acquire rights to return flows. This mechanism facilitates the transfer of the rights because it negates third-party interests.

As in the other two examples, the market is possible because of the existence of a physical delivery system in the District, which could be economically constructed to facilitate the transferability of water rights. However, the efficiency of this physical delivery system, and thus that of the market, is due to the administrative infrastructure of the District, which provides adequate information on seasonal water availability, prices and the distribution of water to potential traders under a transparent user-based management approach. The "ditch companies" (small scale organizations responsible for running collective irrigation systems, of which, in 1998, there are about 125, with an average size of about 5,000 ha), local industries and municipalities provide the lower skeleton of this administrative infrastructure and facilitate that the water use rights are registered, measured, administered and enforced so that the owner or buyer of the rights is assured that they will be honored.

Water trading has taken place in the region in various forms for at least 100 years. For this reason, the market's set-up and structures were innovative, but the concept of water trading was not. Thus, the cultural environment favored the functioning of the market. As part of this culture, members of the District have displayed a clear determination to preserve the agricultural characteristic of the region and have designed several constraints for the market. For instance, sales of water to out-of district users are restricted and there seems to be informal pressure to keep seasonal water prices low to protect agriculture. Although these rules certainly have a negative impact on market efficiency, the fact that it is possible to introduce this type of constraints also shows that a market can be designed in such a way that political and social objectives are accommodated without making the market mechanism non-functional.

Although situated in completely different cultural, historical and legal environments (the only common circumstance is the scarcity of the resource in their respective areas), these three markets present institutional similarities that might be the main reason for their proven success and sustainability. Among these stand out the existence of a user-based management approach, with structures of a small and comparable size that provide transparency and accountability among its members; well defined measurable and enforceable water rights, including those concerning return flows; and adequate knowledge of the resource available for trading, either from a known and controlled source as in the Cariri or from "additional" resources transferred from other basins, as in the other two examples.

Also, although the basic features are very similar, the water users in all case studies have developed specific stipulations adapted to their social and cultural reality. For instance, the water market in Siurana-Riudecanyes is carried out through both the Association broker system and an open one in the Reus *Llotja de Contratació* (stock market), while the brokers in Colorado operate only on an open market. The farmers in Cariri developed a functioning mechanism for reallocation in case their water source was subject to diminishing yields. The water users in Colorado have norms restricting out-of-District sales of water.

The examples permit us to discuss some implications for developing countries. We can learn that the implementation of a water market still implies both government involvement and active water user participation just as other

approaches do. The Colorado and Spanish experience also make clear that a number of the institutional ingredients that would be needed for other approaches, for instance an administrative system that registers and enforces timely water deliveries, a transparent and accepted measurement system, and a well-maintained water delivery infrastructure, are equally required for a functioning market system. For these reasons, the difference between the implementation of an administrative approach and a market system may not be as large as one might expect.

The principal differences between a water market and a more administrative approach are: (i) the need for defined and transferable water use rights which are regarded as proprietary; (ii) institutions internal to the market, such as information and transaction mechanisms to facilitate the transferability of the rights; and (iii) a mechanism to negate the effect of third party interests or to mitigate impacts which might occur because of the transfer of water use rights.

While the introduction of water rights might encounter ideological opposition because water in most countries traditionally has been regarded as a public good, the Colorado and Spain examples show that a market could be developed for usufructuary rights while the water itself remains public property. For this reason, the most challenging institutional feature might not be the institution of water user rights per se, but rather the implementation of adequate information and transaction mechanisms that provide all water users with equal possibilities of participating in the market. These mechanisms would have to include access to price information, to registration, enforcement, and monitoring of rights. Although the weakness of administrative and legal systems is characteristic of developing countries, the examples of Cariri and Siurana-Riudecanyes, at the time they were established, show that these are not that complicated and deserve to be evaluated in comparison to the equally substantial institutional needs for alternative water resources management approaches.

These examples also show that the introduction of water trading might be simpler and beneficial especially in the case of supplemental water supplies. In these cases, the new institutional set-up can be developed rather independently from existing institutional arrangements, such as historical property rights, administrative allocation mechanisms, etc. Therefore, in countries that, based on a first analysis, seem to broadly feature the basic institutional requirements, water trading could be introduced in connection with new water projects and the creation of user-based management approaches. This step would be less radical than large-scale attempts to introduce water markets and the experience thus gained would provide insights in how to adapt them more broadly over time.

The papers illustrate the institutional arrangements that were adopted in these particular water markets in three specific regions of very different countries. They also illustrate that a water market can be adapted to local economic, social and cultural conditions without serious repercussions on its functioning. Although the general application of case studies is always limited, the examples provide a number of thoughts concerning the institutional aspects of water markets. They also show that water markets can improve the efficient allocation and use of water and provide flexibility in the management of water during periods of shortage. However, the adequate institutional framework has to be in place before the markets can function effectively.

Whether this framework exists or how it can be developed will depend on the local conditions and culture and this issue must be carefully addressed before a decision can be made with regard to the possible adoption or introduction of a water market system.

WATER ALLOCATION AND TRADING IN THE CARIRI REGION - CEARÁ, BRAZIL

Karin E. Kemper, José Yarley de Brito Gonçalves and Francisco Willian Brito Bezerra

Introduction[1]

In semi-arid regions, the scarcity of water resources requires management mechanisms to take care of their allocation. In recent years, economists have suggested that water markets constitute a viable alternative to the administrative allocation of water and a number of countries are contemplating the introduction of water markets. Water markets already exist in varying forms in the United States (e.g. Colorado), Chile, and India (groundwater markets).

In the state of Ceará, Northeast Brazil, the government is implementing a new water resources management system, taking into account the economic value of water and placing emphasis on the participation of stakeholders in the management process. Until recently the state played a negligible role in water resources management and the institutional arrangements have been shaped by the activities of federal government agencies, principally DNOCS[2], and by water users' own arrangements.

This paper focuses on the case of the Batateira Spring in the Cariri Region, in the south of Ceará, where local sugarcane farmers implemented their own water allocation system as early as in 1854.

The Cariri experience is discussed in light of the institutional arrangements that the farmers established in order to manage their water resources. The system, which is still in existence, is limited in size and has not led to a fully-fledged water market, but it has permitted commercial transactions to occur and has led to a certain flexibility of use of the resource.

For a water market to function, certain preconditions have to be in place; well-defined water rights, measurement devices and routines, enforcement and sanctioning mechanisms, and specifications concerning return flows. In addition to a description of the water allocation system at the Batateira Spring, the paper analyzes in which way these factors are taken into account.

The purpose of the paper is to document the existence of this localized water allocation system in Ceará, and to discuss its relevance in view of the state government's efforts to introduce a new water resources management system in Ceará and in relation to the context of water markets in general.

Physical Background

The Cariri Region

The Cariri region is situated in the southeast of the state of Ceará in Northeast Brazil. Traditionally, it has been one of the more prosperous regions of the state due to its favorable climate, which, while also semi-arid, has a generally higher precipitation than the interior of the state. Its annual rainfall, which ranges from 700 to 1,000 mm is comparable to the precipitation at the coast. In addition, it is the only region of Ceará with an abundance of groundwater resources, which permit a secure supply of water for agriculture.
The region's prosperity used to be mainly based on sugarcane production. In recent years, it has

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[1] A shorter version of this paper was published in Portuguese with the title 'Um sistema local de gerenciamento e alocação de água - O caso da Fonte da Batateira no Cariri - Ceará, Brasil,' in Vieira et al. (eds.) 1995. *Desenvolvimento Sustentável dos Recursos Hídricos.* Artigos selecionados do XI Simpósio Brasileiro de Recursos Hídricos e II Simpósio de Hidráulica dos Países de Língua Oficial Portuguesa. Recife: ABRH.

[2] The National Department of Works Against Droughts (*Departamento Nacional de Obras contra as Secas*)

been complemented by the evolution of the towns of Juazeiro do Norte and Crato as regional trade centers.

The southern border of the Cariri region is constituted by the Araripe Plateau, *Chapada do Araripe*, which also stretches into the states of Pernambuco, Piauí and Paraíba as shown in the attached map of Ceará and the *Chapada do Araripe* (Source: Studart et al., 1994).

The Springs of the Araripe Plateau

The Araripe Plateau has an altitude of about 1,000 m. On its top, which has a surface of about 7,500 km^2, the vegetation consists of shrubs and trees. Farmers practice agriculture and part of the plateau is a federal forest. (The figure in the map shows a geological profile of the Plateau).

The upper part consists of a permeable sandstone layer, the so-called Exu System, *Formação Exu*. At an altitude of about 700 m, the Exu System meets a second layer, the Santana System, *Formação Santana*, which consists of impermeable rock. During the rainy season, which typically lasts from January through April, that part of the precipitation which does not return by evaporation to the atmosphere infiltrates through the first layer. However, when it reaches the rock, a water-bearing layer is formed and, due to the slight inclination of the Santana System, diverted to the northern side of the Plateau, where the water reappears in the form of springs. In total, 307 springs emanate from the Araripe Plateau, 256 on the Ceará side, 43 in Pernambuco and 8 in Piauí (Mont'Alverne, et al., 1994). According to Frischkorn et al. (1994) and Studart et al. (1994), the volume of the spring water is directly dependent on the amount of rainfall during the previous rainy season and on the infiltration capacities of the soil on the top of the Plateau.

The total volume of water produced by the springs amounts to 40.5 million m^3 per year (Mont'Alverne et al., 1994). The water is used for municipal, agricultural and industrial uses in the region. The municipalities of Crato, Barbalha and Jardim possess the springs with the highest yields and are supplied, almost exclusively, by their water. In Crato, 80% of the town's water supply comes from artesian wells and is pumped from the Missão Velha aquifer.

Table 1 shows the yield of the 12 largest springs in the area, measured in 1993. In terms of yield, the Batateira Spring is the most important one.

Table 1. Yield of the 12 Largest Springs in the Area

Name of the Spring	Municipality	Yield (m^3/h)
Batateira	Crato	376
Pendência	Missão Velha	352
Farias	Barbalha	348
Cocos	Barbalha	182
Saco	Porteiras	182
Caldas	Barbalha	180
Bica do Sozinho	Crato	154
Coqueiro	Crato	140
Boca da Mata	Jardim	133
Camelo	Barbalha	120
Água Grande	Crato	113
Santa Rita	Barbalha	102

Source: Mont'Alverne, A.A. Frota et al. 1994.

The Batateira Spring

The Batateira Spring arises close to the city of Crato and eventually forms the Batateira river, a tributary of the Salgado river. The Salgado flows into the Jaguaribe river, discharging into the Atlantic Ocean. The distance from the source of the Batateira river to its confluence with the Salgado is approximately 8.5 km.

The spring has a number of users, all of them sugarcane farmers. Their ancestors developed, in 1854, a system of allocation of water rights, which is in existence still today and will be discussed in detail in the following chapters. While it is known to the authors that a number of other springs in the area are also shared by

several users, none of those seems to have a well-developed formalized system comparable to the one of the Batateira Spring. The reasons why users of other springs did not adopt a similar system could be related to a different distribution in land property rights around the springs. This could be subject for further research.

Historical Evolution and Components of the Water Rights System[3]

In the middle of the last century, when Cariri was a prosperous sugarcane growing region, the farmers who lived along the river Batateira, in order to avoid recurrent conflicts over water use, agreed to allocate a certain amount of water to each farm *(sítio)*. A formal contract was signed in 1854. The components of the system that evolved from that contract are discussed in the following.

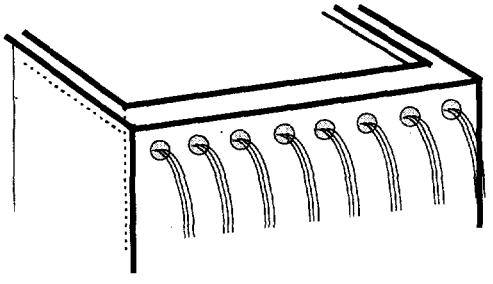
Definition and Measurement of the Water Rights

One of the recurring issues in water allocation systems is the measurement of water rights. If the rights cannot be measured, the right holders do not have an incentive to adhere to their share of the water because their use cannot be controlled anyway.

The Cariri farmers chose to use an old Portuguese measure called *telha* which can be described as a tube with a diameter of 18 cm with an inclination of 1:1,000. According to the contract, the yield of the spring in 1854 was 23 *telhas*, which means that the volume of water that came from the spring permanently filled 23 tubes as illustrated in Figure 1.

One *telha* corresponds to a volume of 64.8 m^3/hour. The yield of the spring at the time thus was 1,479 m^3 per hour. The farmers decided to divide 22 telhas between themselves and to reserve one *telha* to keep a minimum flow of water in the river. The fact that they decided to leave a minimum flow of water is one of the examples of the farmers' consciousness of how to manage their resource. Unfortunately, nowadays, the "extra telha" has disappeared and the full flow is allocated for agricultural use.

Figure 1. Schematic Illustration of Water Passing through a Wall with *Telhas*



Initial Allocation of the Water Rights and Ownership Patterns

When one wants to implement a new allocation system for water, a crucial factor is the initial allocation of the water rights. A number of mechanisms can be envisaged, for example, calculations based on historical use; calculations based on the possibility of making beneficial use of the water; or auctioning of water rights to the highest bidder, as recently practiced in Australia (Cestti and Kemper, 1995).

The farmers at the Batateira Spring chose to allocate the *telhas* based on the size of their farms, i.e. based on the potential beneficial use they could make of the water. Since all farmers grew sugarcane and knew each other's farms and production, this mechanism probably did not constitute any major technical problems. Figure 2 depicts the allocation pattern in 1855.

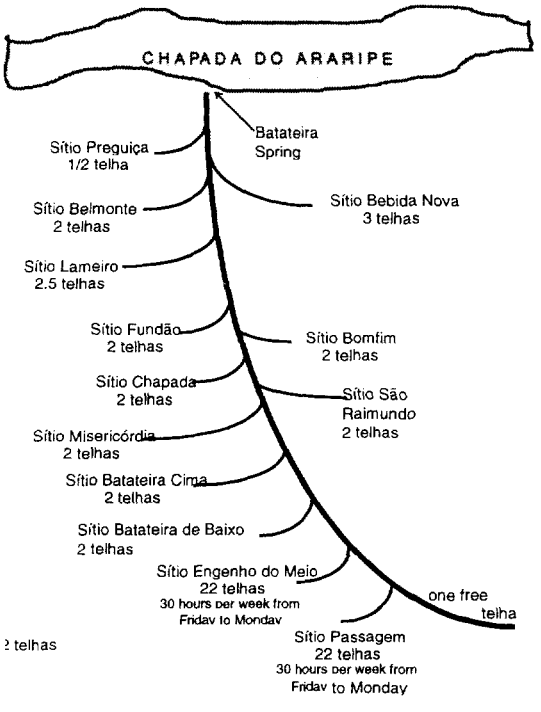
The figure shows that 13 farms, overall about 1,500 ha, shared the water rights. Already at that time, however, a number of smaller farms used water that they drew from the larger ones, but there is no data about how many they were.

[3]The information in this and the following chapters is based on documents, i.e. contracts, and on interviews with a number of water owners. The owners interviewed are direct descendants of the parties to the first, main, contract in 1854 and live and farm in the area.

This split took place primarily because of the hereditary system in the Cariri-region, which led to a progressive subdivision of the lands in each generation. Since the sons of the original owners of the lands also needed water for their activities, the water right was split up between the old and new farms. The precise measurement by means of the *telhas* permitted the allocation of the water to a growing number of right holders. One effect was that while in the beginning the water rights were expressed simply as *telhas*, they eventually came to be expressed as *telha-hours*, i.e. someone might own a right of three *telhas* for 12 hours every day, or a right of 2.5 *telhas* twice a week.

Figure 2. Water Ownership Pattern at the Batateira Spring in 1855

Crato Municipality, 1855 - 23 telhas



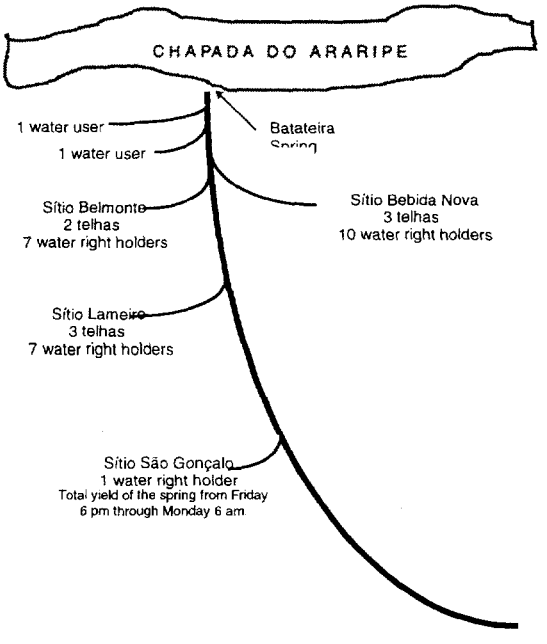
Source: Crato Register and personal comm.

In the 1930s, two families managed to assign themselves a special right. It is not quite clear if these rights were bought from the other farmers or if they were obtained by political force. The information provided by the interviewees is not conclusive and the relevant documents are not accessible.

The special arrangement consists of almost exclusive allocation of rights over weekend supplies. Each of the two families obtained the right, every second weekend, to all of the water of the springs from Friday at 6 p.m. through Monday at 6 am. The other owners of the water continued with their water rights during the week. The so-called "weekend rights" are still in existence today. Figure 3 depicts the ownership pattern in 1995.

Figure 3. Water Ownership Pattern at the Batateira Spring in 1995

Crato Municipality, 1995 - 8 telhas (although the yield of the spring has decreased to 5.8 telhas, officially 8 are still allocated)



Source: Crato Register and personal comm.

As shown in the figure, although the yield of the spring has decreased to 5.8 *telhas*, officially rights to 8 *telhas* still exist. The figure also illustrates that a number of different users hold rights that belong to one farm, *sítio*, e. g. there are ten right holders who during the week share the three telhas of the *Sítio* Bebida Nova.

Legal Aspects of the Water Rights

According to the interviewees, in 1854 the water was originally bought from the town council, *prefeitura*, of Crato. Since then, the right holders have considered themselves as the owners of the water. The rights are also formalized by official documents available in the register office, *cartório,* of the town of Crato. While this is in violation of current Brazilian legislation, which stipulates in the Water Law of 1997 that all water is public property, there has hardly ever been any enforcement of this stipulation. Examples abound of public dams having been appropriated by private land owners and private dams being constructed without permission on rivers all over the Northeast.

In Ceará, the state started to become active concerning water resources management only in 1986. In 1992, it passed its first Water Resources Law and is currently working on the implementation of a new water resources management system for the whole state. In this century, the main actor concerning water resources has been the federal agency DNOCS, the National Department of Works against Droughts, but DNOCS was not active in this part of the Cariri region. For this reason, the farmers of the Batateira Spring have been working in a *de facto* legal vacuum and the development of their system and the belief in their water ownership has to be considered from this perspective.

Return Flows

When trying to design a flexible water allocation system, an important aspect to be taken into account relates to return flows. While it is possible for a downstream water user A to acquire the right over return flows by upstream user B, it will be virtually impossible to reallocate the water from upstream user B to downstream user C if C is located below A, because A would lose B's return flow.

The Cariri system has taken account of this problem and does not permit that a water right owner could acquire the right to the return flows by another owner. The measurement of the available telhas has always taken place at the source, so that the owners can use their water as they want without having to take into account the impact on third parties if they augment or diminish their water use, as long as it is within the maximum limit of their right.

Diminishing Yield and Forfeiture of Water Rights

With hindsight, the 1854 contract contains a surprising stipulation: While the yield of the spring was 23 telhas in 1854, it was agreed that if it diminished over time, the downstream users would lose their right - without compensation. We do not know why the farmers anticipated the decrease of the yield. Perhaps it already had diminished and that was one of the reasons for the contract in the first place. In any account, we know today that the yield has diminished considerably and that the downstream rightholders have had to give up their rights. If we compare Figures 2 and 3, we can see that the number of farms with water rights has decreased from 13 to 3 and that it is mainly the downstream users who have been left without water.

According to the interviewees, the cessation of the rights took place peacefully. At least one party recently tried to keep its right, but interestingly, the local judge in Crato judged according to the 1854 contract, allocating the remaining rights to the upstream owners as stipulated in the contract.

Enforcement and Sanctions

For parties to have confidence in their contract, it must be possible to enforce its stipulations and to sanction non-compliers. The enforcement role can be played by the state, or by the parties themselves. As mentioned above, the state has not acted in this area and the farmers seem to have taken care of their system mostly by themselves.

According to the interviewees, the possibilities of enforcement of the water rights have varied over time. In former times when the larger farmers still had more political power, it was easy to punish outsiders who tried to steal water because the right holders could call on the help of the local people in power. Nowadays, they seem to rely mainly on self-policing, with mixed results. Each farm has a so-called *levadeiro,* who is sent to the spring when it is the time for his farm to open the hole of the *telha.* If more than one *levadeiro* is there, they monitor another. But when one is alone there is room for misuse. The interviewees mentioned that it happens that outsiders to the system bribe *levadeiros* to divert some of the water to their lands, although this is not very frequent.

Another problem are outsiders who are friends of the water right holders. According to one interviewee, it would be easier to sanction a foreigner than to start an argument with a friend. For this reason, a certain diversion of water by friends, through small tubes directly from the spring, is tolerated.

The latest interviews also indicated that the sudden activity of the state government in the field of water resources management generates a certain insecurity in the system. The rules of the game are changing and the farmers do not know if the presence of the state will have implications for the validity and enforcement of their rights.

The Value of Water

From the data available, we can calculate the yield of the spring (see table 2).

The table shows that the yield has diminished progressively during the past 70 years, but the reasons for this development are not clear. The precipitation pattern in the Cariri region has not changed during this time period. According to Mont'alverne et al. (1994), a possible explanation might be the change in the landuse pattern on the Araripe Plateau. Due to deforestation the infiltration capacity of the soil may have diminished so that the run-off does not infiltrate and recharge the springs as it used to. If also the other springs in the area are subject to this diminished yield, this development should be of concern to the people living in the area because of the long-term effects of an interruption of the hydrological cycle on water availability for human, agricultural and industrial consumption. No studies have been carried out about the actual extent of deforestation and its effects.

Table 2. Yield of the Batateira Spring in Selected Years

Year	Number of Telhas	Yield (m3/h)
1854	23	1490
1920[a]	20	1296
1980[b]	8	518
1993[c]	5.8	376

Sources:
a Mentioned in Brito, M.S. 1985.
b According to one interviewee, he reduced the number of holes to 8 about 15 years ago. We take this as an indication that the yield of the spring in 1980 was 8 *telhas.*
c The figure is based on actual measurements by Mont'Alverne et al. 1994. There are still 8 *telhas* at the spring, but they do not get a full flow anymore.

As we have seen, neither the state nor the federal government have interfered in the Batateira water right system. At the same time, the water users built up a system of measurable water rights, and they used the water for sugarcane production.

The very fact that they took the step to implement the system shows their appreciation of an assured water supply. Over the years, the system has also allowed commercial transactions of water to occur. It is not possible at this stage to find out how many water rights have actually been traded during these years. Most likely, there were not very many commercial transactions because the number of owners has been very limited. Also, as indicated above, a number of the rights were split by heritage of land and no payments were involved.

However, the records about these transactions are not readily available. It has to be noted that at present the Batateira water is traded without any attachment to the land. Anybody can buy a number of *telhas* from a user of the system without any linkage to the original ownership right of the land.

The scarcity of a good is indicated by its price if the price is set in a free market. It is expected that when its availability decreases, its price will increase. In spite of the scarcity of data for actual water prices, certain benchmarks exist that give an indication of the value of water over time. One interviewee told of his grandfather who, in 1925, decided to install a water mill. For this, he needed more water rights than he had and so he bought 3 *telhas* (194.4 m^3/h) for 2,000 loads of *rapadura*[4].

Already in 1925, the system of full *telhas* had been split up so that a farm would not own 3 telhas but rather a certain number of hours of a flow of 3 *telhas*. The interviewee's grandfather bought 12 hours of 3 *telhas* a day during weekdays, which corresponds to 46,656 m^3/month.

The most recent transaction known to us is the purchase of 58 hours of 3 telhas every second weekend by another interviewee who owns a sugar mill and produces sugarcane and *cachaça*, sugarcane brandy. In 1993, she paid US$40,000, in cattle and *cachaça*, for the water right. We can compare these two purchases. Nowadays one load of *rapadura* costs US$50, i.e. the 1993 transaction corresponded to 800 loads of *rapadura*. In former times the weight of one block of *rapadura* was 1 kg as compared to 700 g today. Today's 800 loads therefore correspond to only 560 old loads of *rapadura*. In 1925 one load of *rapadura* bought a perpetual right of 23 m^3 a month while in 1993 the same load would buy 40 m^3 a month. In other words, the price has been cut in half. While this does not seem to correspond to economic theory because one of the crucial inputs for sugarcane production, water, has become much scarcer, one has to take into account that sugarcane is not the cashcow it once was. Rather, it can be defined as a medium to low-value crop and a number of farmers have stopped cultivating sugarcane altogether. The decreased price for water reflects that it is being put to a relatively low-value use.

The price paid in 1993 can also be compared to the price paid for permanent water user rights in the water market that has developed in the Northern Colorado District in the Western USA and to the price paid at an auction of water rights in Australia in 1988 and 1989. In 1992, a permanent water right in Colorado cost US$1.18/$m^3$ and in Australia about US$0.11 (Cestti and Kemper, 1995). The price paid by the interviewee for the Batateira water in 1993 corresponds to US$0.14/$m^3$ year, i.e. it is somewhat higher than in Australia, but considerably lower than in the United States. The reasons may be that in Colorado a number of buyers are municipalities which usually have a far higher willingness to pay than farmers. In Australia, however, the auction was limited to private irrigators, so that the Australian price is more comparable to the situation at the Batateira Spring than the price paid in Colorado. The comparison indicates that water for sugarcane production in the Cariri region is still valued about as highly as in a well-developed economy.

In Ceará, the state is about to implement a tariff system for bulk water. While industries have been used to paying for (treated) water, up to now, water has been entirely free for private irrigators and virtually free for irrigators in public projects (Kemper, 1996). Interviews have shown that specifically the large water users, who are sugarcane growers, are ardently opposed to water pricing. According to them, sugarcane production would not be viable

[4]*Rapadura* is raw brown sugar, a very nutritious sugarcane product, which used to be an important part of the basic diet in the region. *Rapadura* is produced in form of blocks the size of which is 17 cm x 10 cm x 3.5 cm each, weighing approximately 1 kg. One *rapadura* load (carga de rapadura) is equivalent to 100 units of the product and used to be employed as a kind of currency at the time, just as today farmers in Mato Grosso use sacks of soybeans as a currency.

anymore if water tariffs were levied. In this context, however, the comparison with the sugarcane producers in the Cariri region permits the conclusion that there is ample scope for levying a tariff on the raw water.

A further observation is that, by paying this price, the buyer mentioned above demonstrated her belief in the water rights system as late as in 1993. This defies the notion that it is an ancient anecdotal system which survives in the minds of some farmers. It also is an indication of the absence of the state in this area, although the 1992 state water resources law explicitly attributes the right to award water user rights to the State Secretariat of Water Resources.

Another indication of the value of the water is the price that the farmers at the Batateira Spring pay for the services of the *levadeiros*. In February 1995, the price was 5 Reais (= US$5,50) per work day. Not every farmer has a water right for every day and has to pay a *levadeiro* every day, but if it was calculated on a monthly basis, the *levadeiro* would receive about R$150/month, which is more than two minimum salaries[5]. Given that certain days several *levadeiros* from different farms make their way to the spring, the enforcement system can be considered expensive. Also these prices give an indication of what it might be worth to the stakeholders in other basins, to control the use of water.

Conclusions and Recommendations

The Importance of the Cariri System for the State of Ceará and other Regions in the Semi-Arid Northeast of Brazil

The above discussion has illustrated that farmers in the Cariri region implemented a system that was tailored to their needs and that still survives 140 years later. The system compares favorably with contemporary thinking about water resources management and allocation issues: it guarantees measurable water rights, has an enforcement mechanism (*levadeiros*, the local judicial system, and self-enforcement) and certain possibilities of sanctioning. It also is flexible because it allows the voluntary reallocation of water rights to different right holders and it provided from the beginning for the possibilities of diminishing yields. Even third-party impacts are taken care of because return-flows cannot be appropriated.

It seems that the system has had a satisfactory performance concerning security of water availability for right holders and flexibility of the allocation of the resource. On the other hand it has not been able to prevent the decrease of the Batateira Spring's yield. Also, as pointed out above, the enforcement and sanctioning system seems to have been weakened in recent years.

The question arises if the allocation system at the Batateira Spring is transferable to other areas in Ceará, in the Northeast of Brazil or even other countries. The Cariri experience certainly gives important indications about the value of water in Ceará today. They can be used as examples for the implementation of a tariff system in other parts of the state.

Concerning the overall system, however, two special features have to be pointed out, which limit its applicability to other regions. First, the system developed in the absence of government involvement. The Cariri example shows that there has been a demand for a water allocation system and that the water users have been willing to pay for it not only in financial terms, but also in terms of time and effort. The situation is different when an outside agency attempts to implement a management system in a given institutional framework, as for instance in the Curu Basin where DNOCS, a federal government agency, for more than four decades had the central role of allocating water.

The other feature relates to the small number of homogeneous actors. The people who instituted the system at the Batateira Spring and who have lived with it ever since are well-off farmers who, due to their geographical proximity, have known each other very well. In many cases, the farmers also are related to each other. It is well-

[5]In February 1995, one minimum salary was R$70.

documented in the literature (e.g. Ostrom, 1990) that small groups have a better chance of organizing to protect otherwise open-access resources than larger groups. Second, homogeneous groups have an advantage in dealing with each other in comparison with heterogeneous groups because they have the same needs and concerns.

The Curu Valley, for example, has about 2,700 irrigators, five of which are agroindustries, two public irrigation projects, and the rest range from subsistence farmers to farmers with far more than 500 ha. In addition, there are fishermen, and a number of municipal users. In that case, both the start-up of a water resources management system and its enforcement become significantly more complex than in the limited case of the Batateira Spring. On the other hand, the Cariri experience shows that water users were willing to organize when they perceived a need and could see a gain from their activities. It thus is possible to achieve a certain organization and self-enforcement. The lack of a similar system in other parts of the state may thus be explained not by the lack of demand but by the problems in organizing large groups and by the centralizing position of the governmental agency that has assumed the function of a water allocator.

Finally, caution has to be taken concerning the protection of the spring. The aim of the new water resources management system in Ceará is not only to introduce greater efficiency of allocation and use, but also to achieve sustainability. As far as could be found out by the authors, the water owners at the Batateira Spring never tried to protect their source. They just dealt with the water once it emanated from the spring. However, the yield depends on the water that filtrates through the Araripe Plateau. For this reason, their system is vulnerable to external influences that they do not have control over. There clearly is a role for the state to clarify what has led to the diminution of the yield and if this development has taken place at the other sources, too. This illustrates that a water-right based system alone does not protect the water source. It is only one tool in the overall context of water resources management.

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THE SIURANA-RIUDECANYES IRRIGATION SUBSCRIBERS ASSOCIATION AND WATER MARKET SYSTEM

Ramón Tarrech, Manuel Mariño and Glen Zwicker

Introduction

The water market of the Camp de Tarragona in Spain presents a valuable model applicable to developing countries for effective allocation, utilization, and management of resources. The innovative financial components, the active participation of the water users, the structure of the managing institutions, and the small size of the market have all enabled it to operate since the Siurana-Riudecanyes area was granted its initial water concession in 1904. The summary and analysis of the Siurana-Riudecanyes example contained within this report highlight the essential elements of this particularly successful users association and water market system.

Unlike the standard center-periphery models of development, the Siurana-Riudecanyes system resulted from the initiative of local reformers who promoted the construction of the Riudecanyes dam. The *Comisión de Pantanos* (Reservoir Commission) brought together the interests of the urban middle-class and small landowners concerning two ideas: (i) the city of Reus needed to guarantee its water supply and (ii) the agriculture of the region could not prosper without water. The first issue of shares at 50 pesetas each in 1911 provided private capital for the construction of the largest public works project undertaken in the history of the Camp de Tarragona. The irrigation subscribers and other users who acquired rights to utilize the water resources constituted the Irrigation Subscribers Association of the Riudecanyes Reservoir, which was created as a public corporation responsible for the management of the system and the costs necessary to construct, repair, operate and maintain all works and infrastructure of the system.

The Siurana-Riudecanyes District

The Siurana-Riudecanyes irrigation district currently covers 4,000 ha of land in Baix Camp in the Province of Tarragona (Spain) and delivers approximately six million cubic meters of water each year. The hydraulic infrastructure consists of two dams (one on the Riudecanyes River and another on the Siurana River), an inter-basin channel 16 km long, two main distribution channels about 35 km long, and the corresponding distribution network. The Riudecanyes dam (3.2 hm^3 capacity and 30 km^2 contributing basin) began service in 1918 with the dual purpose of irrigating the Camp de Tarragona and supplying water to several municipalities, including the city of Reus. The growing necessities of the area led to the construction of a major canal, completed in 1949, which derives waters from the Siurana River (90 km^2 contributing basin) through a connecting tunnel. Another canal, called the Canal Nou, was constructed in 1964 to increase the amount of water which could be distributed from the Riudecanyes reservoir and enlarge the irrigable zone. To supplement the limited regulatory capacity of the system, a headwater dam in Siurana (12.5 hm^3 capacity and 60 km^2 contributing basin) was completed in 1971 and the Riudecanyes dam was raised in 1991, augmenting its capacity to 5.32 hm^3.

Various combinations of private and public funding have been used throughout the history of the Association to finance the investments. In accordance with the 1911 Law of Public Works, the initial investments were funded through a 50% contribution by the State, 40% as a loan to be repaid after twenty years by the direct beneficiaries of the water (farmers, the city of Reus, and other users), and 10% immediate contribution by the beneficiaries. The most recent works, such as the raising of the Riudecanyes dam, have been financed according

to the decentralized Catalonian approach with equal contributions by the Generalitat de Catalunya and the beneficiaries (roughly 450 M pta each). The beneficiaries' contribution was raised by the issuance of new water rights for the added water capacity of the system.

As has been mentioned, operation and maintenance costs for the infrastructure have always been completely covered by the water users through their contributions to the Association (these also cover the loan repayment for the initial infrastructure). Except for the maintenance of the Siurana dam, which is performed by the regional water authority, the Association manages, operates and maintains all the hydraulic infrastructure of the system.

Even though it is a publicly held corporation, the Association has been forged as an institution which operates in practice as a private corporation. The General Assembly of Irrigation Subscribers, the highest level of representation of the entity, has a structure and function equivalent to the general assemblies of shareholders of private corporations. The principal responsibility of the Assembly is the election of the Directive Council, which functions similarly to the board of directors of a private corporation and determines the primary objectives of the institution. A Regional Administrator named by the Council serves in the same capacity as an executive director and oversees daily operations. Due to the active role of the members and the transparency of the Association's function, the Directive Council and the Administrator are closely monitored by the users, for whom water represents a critical asset.

Tables 3 and 4 present a summary of the Association's income and expenses (operation and maintenance and repayment of investments) since 1972. These figures reveal that the Association has generally been able to operate with financial gains which support a substantial rate of investments for improving the hydraulic infrastructure. They also illustrate some aspects of its functioning, as the reaction of the market to changing situations or the transfer of "extra"

Table 3. Income Derived from Water Used for Urban Supply
(all figures expressed in US dollars)

Year	Reus	Other Cities	Extra	Total	Price per m^3
79-80	153,000	35,000	38,000	226,000	0.08
80-81	139,000	0	0	139,000	0.08
81-82	74,000	74,000	0	148,000	0.06
82-83	55,000	85,000	71,000	211,000	0.05
83-84	56,000	34,000	141,000	231,000	
84-85	40,000	51,000	0	91,000	0.04
85-86	48,000	36,000	0	84,000	0.05
86-87	55,000	44,000	0	99,000	0.05
87-88	58,000	18,000	224,000	300,000	0.08
88-89	57,000	33,000	0	90,000	0.05
89-90	83,000	17,000	59,000	159,000	0.12
90-91	89,000	80	64,000	153,080	0.07
91-92	100,000	500	0	100,500	0.09
92-93	80,000	0	0	80,000	0.11
Average	77,643	30,541	42,643	150,827	0.07

Source: Comunidad de Regantes. Memòria i Comptes d'Explotació

water to urban uses when scarcity makes it necessary as can be illustrated in the following comments:

- Water prices fluctuate according to supply conditions. "Regular" water prices paid by water supply companies vary according to discharges from the reservoirs and these are reflected in the tariffs as water companies have strong incentives to pass on to the final consumers cost of supplying water and their scarcity value too. It is interesting to note that urban consumers are willing to pay for a valuable resource to them. In the case of Reus, no subsidies are needed because people prefer to pay higher prices than suffer water shortages.

- The provision in the Association arrangement for the concept of "Extra" water (additional water deliveries over established agreements) allows the transfer of water from agricultural to urban uses when these are needed to supplement the supply. When this occurs, the urban users compensate the holders of the water rights paying to the Association a negotiated price. As water companies negotiate the transfer price from agriculture to urban uses on behalf of the urban consumers, and the Association negotiates on behalf of the farmers, there is a power equilibrium between monopolistic and monopsonic positions and "fair" transfer prices are established. Because both parties have similar information on the water demand and supply conditions, the nature of the negotiation is symmetric.

- "Extra" water is an additional source of financing for the association. This source has been used through the 80s for improving the financial strength of the association (see table 2). However it can also be used for covering poor management by selling off the water assets (see year 79-80 table 2). Thus, as this source does not represent an out-of-pocket cost to the members of the association, association management has a certain "free hand" in its use.

There are five clearly differentiated periods in the recent history and finances of the Association (Comunidad de Regantes, 1979-1994):

a) The early 70s. Stable situation where income and expenses were more or less balanced.

b) Late 70s. Sharp increase in the expenses of the community due to the lack of ability to contain current expenses (increase in wages and personnel size). That was offset by depleting the water assets, since management was not willing to increase user fees because of problems of public acceptability. The continued deficits brought the major crisis of the history of the Association. The Directive Council and the Administrator of the Association were ousted by the angry shareholders and a new Council was elected.

c) Early 80s. A program for cost cutting (reducing from thirty to five full-time employees) and for increasing revenues (through an acceptable new system of user fees) brought the association to financial health. The cash-flow generated was used for upgrading and improving the distribution network which led to further cost cuts.

d) Late 80s. Once a strong financial position was achieved, the association prepared itself for pursuing the goal of convincing the Regional Government that the Riudecanyes dam should be raised. This explains that the association only decreased slightly their user fees so that they could capitalize the Association.

e) The 90s. Still strong revenues as these years are the aftermath of the raise of the Riudecanyes dam but there is a tendency to return to a stable, balanced income statement. It is characterized by a decrease of both revenues and expenses as agriculture

was suffering a bad period as well as urban users.

Thus, we see that there is a good system of government accountability in place and yet enough room for management decision-making for taking advantage of investment opportunities.

The Water Rights

In Spain, ownership of water resources belongs to the Nation, but the right to use the water may be obtained through a government concession granted by the regional water authorities. The administrative concession which pertains to the Siurana-Riudecanyes system was awarded to the Irrigation Subscribers Association in 1904 under the condition that two-thirds of the total water would be utilized for irrigation purposes and one-third for urban supply needs, particularly for the city of Reus.

The two-thirds of the total water of the concession to be utilized for agriculture was allocated through titles. These titles were

Table 4. Annual Finances of the Irrigation Subscribers Association
(all figures expressed in dollars)

Year	Annual Income	Total Expenses	Balance	Investments in Works
1972	74,400	82,300	-7,900	61,900
1973	171,000	122,400	48,600	40,300
1974	166,000	139,200	26,800	59,500
1975	144,700	180,300	-35,600	68,700
1976	186,500	180,000	6,500	73,200
1977*	157,900	198,000	-40,100	71,600
77-78	318,700	312,200	6,500	30,100
78-79	380,200	448,100	-67,900	21,400
79-80	393,700	518,600	-124,900	83,900
80-81	463,100	300,500	162,600	58,900
81-82	314,200	175,500	138,700	119,100
82-83	324,600	160,600	164,000	213,000
83-84	379,800	125,600	254,200	80,900
84-85	196,000	135,500	60,500	218,500
85-86	266,600	151,200	115,400	7,200
86-87	331,200	171,000	160,200	0
87-88	530,200	196,400	333,800	7,600
88-89	290,200	222,400	67,800	32,600
89-90	573,700	268,800	304,900	16,300
90-91	657,700	392,900	264,800	0
91-92	763,800	402,300	361,500	61,300
92-93	354,900	354,649	251	73,200
Average	338,141	238,111	100,030	63,600

Source: Comunidad de Regantes. Memòria i Comptes d'Explotació

distributed to the members of the Association through fixed price public offering, based on the contributions made for the construction of the Riudecanyes dam and the irrigable land owned. A total of 3,750 water titles were initially designated for an irrigable zone of 1,500 ha. The maximum number of titles which could legally correspond to one hectare was 2.5, but compliance with this norm has traditionally been lax due to the growing intensity in agricultural use of water in the region.

For the increase of the regulatory capacity of the system and the expansion of the irrigable area to 4,000 ha, 6,250 additional titles have been issued (1,150 designated initially for urban water supply and 5,100 for agriculture users), making a total of 10,000 issued titles. The titles additional to the initial 3,750 were also allocated through public offer, at the price required to raise the funds needed to finance the construction of the Siurana dam. Each of the titles gives its owner the right to use 1/13,275 of the water available each year[1]. Rights and obligations (service charges and share of operation and maintenance costs) are thus calculated in proportion to the number of titles possessed.

Water titles in the Riudecanyes-Siurana system have always been tradable among the members of the Association, that include both farmers and the municipalities in the area. This special arrangement has given raise to an active water market since the beginning of the century, with permanent and temporal water rights transfers among farmers and between farmers and municipal water supply companies that provide water for domestic and industrial users.

The Water Rights Market

The evolution of techniques, changes in cultivation, and the fact that the irrigable zone is much greater than the initial 1,500 ha with titles, have led to a continually active water rights market in the region. The ability to permanently or temporarily transfer water titles represents a significant option for both agricultural and municipal interests. By providing mobility for the scarce resources in an environment characterized by small landholders, notable crop diversity, and changing urban supply needs, the market has served the purpose of effectively allocating the water.

This market is limited to the municipalities and landholders of the region because the ownership of land within the irrigable zone is a requirement for the ownership of a water title[2]. The sale and purchase of titles generally represents the responses of the water users to long-run supply and demand conditions and involve both transactions between different landowners and between the Irrigation Subscribers Association and the area's municipalities, particularly the city of Reus. This system has allowed Reus to partially recuperate its investments by selling or renting titles to landowners when they have not been necessary and, in recent years, purchase and rent titles from irrigation subscribers in order to supplement its resources and fulfill new requirements, such as increased water transfers to industrial areas.

Although no legislation addresses temporary transfers, they exist *de facto* and allow water users to react to short term conditions in the region. Owners of titles who do not need them may sell or transfer their rights to other users who require the water for a specific period of time. Some users keep their titles as insurance against the drying out of less reliable water supply sources and lease the titles when those

[1]The rest of the available water (3,275/13,275 or about 25%) belongs to the city of Reus as part of an agreement among this city and the irrigation association which dates from the construction of the Riuadecanyes dam

[2]Legally, only land owners and municipalities of the Baix Camp can posses water titles and this has to be documented by anybody buying a title. However, since this can only be controlled in one direction of the transaction, there have been cases where farmers have sold their land and kept the water titles, even though it is contrary to the Association rules.

sources fulfill their needs. Others utilize the water available from their titles only if the exploitation costs of alternative sources (ie. groundwater) are higher than the potential income gained by transferring their rights. The return flows are very limited and are not taken into account in the system.

Table 5. Evolution of Title and Temporary Transfer Prices

Year	Title (current US$)	Transfer (1 year) (current US$)	Endowment (m^3 per title)
1911	0.50*		180
1970			300
1972	210*		500
1976	570^	50-60	500
1980	1,900^	100	500
1986	4,760^	260	500
1990	3,330^	150	500
1993	2,620^	60	600

* subscription price
^ market price

Source: Comunidad de Regantes. Memòria i Comptes d'Explotació.

As shown in Table 5, the maximum prices paid (US$ 0.52 per m^3 for yearly leases and US$9.5 per m^3 for permanent transfers) for the titles correspond to the middle of the 1980s due to the general scarcity of water in the Camp de Tarragona, the maximum demand for water in agriculture because of the high prices of the hazelnut (principal product of the area), and the expansionist phase of the macroeconomic cycle. The relatively recent decline can be explained by a reversal of these factors, especially the excess supply which arrived with the water from the mini-diversion of the Ebro River, a reduced demand of water for irrigation due to the price crisis of agricultural products (particularly the hazelnut) and the macroeconomic cycle, which is currently experiencing a recessionary phase.

The activity of the market, or the number of transactions which occur, is also directly related to the economic situation. In years when the agricultural long-term perspectives were favorable, approximately three hundred (3%) titles were sold to new owners and between 1,000-2,000 titles were leased for the season. When economic circumstances turned to be detrimental to agriculture, as in 1993, a significantly higher number of lease transactions occurred (more than 3,000 of a total number of 10,000), but few titles are sold (less than 1%).

The excess supply is usually absorbed by urban users --the city of Reus has leased as much as 800 titles annually. However, after the construction of the Ebro river diversion scheme, prices plummeted due to over supply and to the commitment the municipalities had taken to buy from the Ebro Diversion Consortium, even though market prices were lower than those charged by the Consortium[3]. Most recently, the

[3]In the late eighties, a consortium of municipalities and industries of the Camp de Tarragona sought and obtained an administrative concession to divert 4 m^3 from the Ebro river, roughly 70 km to the South. A much disputed project, the diversion consisted of: a) pipelines and pumping stations from the Ebro river to the Camp de Tarragona and; b) a remediation program to save water in the Ebro Delta irrigation network --lining of earth channels-- that would compensate potentially affected users in this area. The diversion was financed with a subsidy grant from the Government and a 20-year loan. Municipalities and industries participating in the consortium agreed to use a minimum yearly amount of water to cover through water

price of the hazelnut has risen, leading to the stabilization and increase in value of the market.

The market has also led to the breakup of large groups or "pockets" of titles owned by the same individual or group of individuals. Title ownership is now spread, including among 3,000 families. Many owners own one or two titles only, few own more than 25 titles and very few more than 50. The flexibility that the market offers has proven to be of great value for farmers and other users, allowing them to adapt to external changes and make a better economic use of this resource.

The administration of the water market has evolved throughout the history of the Association, which has registered water transfers from the beginning of the century. Initially, informal transactions with little legal or financial structure characterized the market. The *Llotja de Contractió* (stock market) in Reus later served as a meeting point for transactions formalized through commercial brokers. In the case of temporary transfers, the owner of the title simply ceded their bill of request for water to the lessee, who would then manage it according to his own best interest. In *1982* an official exchange administered by the Association was formed with the intention of improving the operation of the market for the users who wished to utilize its services.

The option of conducting business through the exchange has significantly reduced the volatility of the transfer prices and introduced more liquidity to the titles. Additionally, the exchange clarifies the transactions through the establishment of a transparent system designed to make full use of the market despite its inherent narrowness. The intermediary role of the Association is not based on legal regulation, but rather on the confidence that the participants have in its administration. As a result, the wide margin between sale and purchase which occurred when an oligopoly of commercial brokers dominated the market has been substantially reduced.

Table 6. Distribution of Water Resources in the Siurana-Riudecanyes System
(figures expressed in thousands of cubic meters)

Year	Total Water	Water Used for Irrigation		Water Used for Urban Supply (m^3x10^3)				
		Camp	(%)	Reus	Other	Extra	Total	(%)
79-80	4,701	1,919	41	2,353	429	0	2,782	59
80-81	5,342	3,626	68	1,716		0	1,716	32
81-82	7,253	4,800	66	2,064	389	0	2,453	34
82-83	9,119	5,280	58	2,324	505	1,010	3,839	42
83-84	8,302	4,850	58	1,748	229	1,475	3,452	42
84-85	7,162	4,972	69	1,748	442	0	2,190	31
85-86	6,161	4,306	70	1,591	264	0	1,855	30
86-87	6,723	4,615	69	1,875	233	0	2,108	31
87-88	8,866	5,200	59	946	131	2,589	3,666	41
88-89	6,262	4,381	70	1,659	222	0	1,881	30
89-90	3,245	1,945	60	630	80	590	1,300	40
90-91	5,623	3,300	59	1,650	9	664	2,323	41
91-92	5,382	4,218	78	1,164		0	1,164	22
92-93	5,743	4,991	87	752		0	752	13
Aver:	6,420	4,172	65	1,587	267	452	2,306	35

Source: Comunidad de Regantes. Memòria i Comptes d'Explotació

Water Management Mechanisms

According to the concession, roughly one third of the water is allocated for urban supply and two thirds to the Association, composed of both

tariffs the operation and maintenance costs of the diversion, as well as the debt service. Water delivered by the Consortium was charged in 1993 at 0.61 US$/$m^3$, which is substantially higher than the price they would have to pay for water from other sources. Today, only 3/4 of the concession is being used.

agricultural and urban supply interests (a maximum of two-thirds of the total water flow in the Siurana-Riudecanyes system may be used for irrigation purposes). A profile of water resources allocation over the last fourteen years is given by Table 6. This table shows that the distribution requirement (two-thirds irrigation, one-third urban supply) stated in the 1904 water concession has been generally adhered to, with the city of Reus as the major destination for water used for urban supply.

Under this scheme, the Irrigation Subscribers Association is responsible for the direct management of all water resources in the area, although water rights include irrigation water rights (titles), which are scattered among three thousand families, and urban supply water rights, which the city of Reus (and other small municipalities in the area) concentrates into a large block.

To prevent the alienation of farmers in water resources management decisions, an agreement that favors farmers has been reached concerning the voting system on issues associated with the concession. Under this system, the votes are only related to the number of titles that are owned (8,850 titles for irrigation and 1,150 titles for urban supply) and not to the total share in the concession. Table 7 below illustrates how the ratio of votes does not reflect the proportion of water used by each activity (Comunidad de Regantes, 1960).

Table 7. Voting Ratios for Water Resources Management

Activity	Water Used*	Votes
Urban Supply	2,306,000 m^3 (35%)	1,150 (11.5%)
Irrigation	4,172,000 m^3 (65%)	8,850 (88.5%)
Total	6,478,000 m^3	10,000

* based on averages from 1979-1993

Source: Comunidad de Regantes. Memòria i Comptes d'Explotació

The overall efficiency of the management system is demonstrated by the fact that the maintenance costs for the Riudecanyes dam, which is overseen by the Association, are one-tenth of the maintenance costs for the Siurana dam, which is overseen by the regional water authority. The Association has also pioneered several activities aimed at improving its efficiency, reducing waste, and further optimizing the use of water. Some examples are:

- the entity developed the implementation of information systems for the administrative management and irrigation campaigns
- a system of bonuses and incentives has been established for the Association members in order to minimize water losses and reduce other O&M costs in the network
- all works are sub-contracted to private companies
- the personnel is limited to 5 regular employees and 12-15 temporary staff that are hired to operate the irrigation system each summer; the workers are well equipped to perform their functions, as illustrated by the fact that a radio-telephone system is used for a prompt response to any emerging eventuality in the network

Conclusions and Policy Implications

The water management scheme in the Camp de Tarragona has been characterized by the establishment of market mechanisms that lead to the proper allocation of resources, offer flexibility in the competition among different uses of water, and yield a high degree of economic efficiency in its use. The collaboration between the direct beneficiaries of the concession and the institutions charged with its management have provided the basis for the market since the beginning of this century.

The Irrigation Subscribers Association represents the central force behind the long history of the system. Because of its size, the

active role of its members and the transparency in its function, it possesses the ability to adapt to the specific circumstances and needs of the Siurana-Riudecanyes region (see, for example the conditions for self-governing irrigation systems in Ostrom and Gardner, 1993). As the users participate in the administration of water resources, their expertise in local issues allows the Association to effectively influence the development of the water market and fairly resolve any disputes which may arise.

Local government institutions, such as the city council of Reus, have also demonstrated a significant impact on the water market. In the Siurana-Riudecanyes example, the city of Reus has been a catalyst for the unique structures currently in place. By providing a large part of the funding for the original works and staying actively involved in their management, the city has played a major role in creating the present system. Most importantly, urban water supply needs have been adequately fulfilled because Reus has been allowed to enter into operations within the market.

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THE WATER MARKET IN THE NORTHERN COLORADO WATER CONSERVANCY DISTRICT - INSTITUTIONAL IMPLICATIONS

Karin E. Kemper and Larry D. Simpson

Introduction

This paper deals with the water market that has developed in the Northern Colorado Water Conservancy District ("District"). The District has been chosen as a case study because it has been in existence since 1937 and water trading has taken place within the District since 1959. Its long-standing experience can therefore be used to illustrate one example of an institutional and physical framework for a water market and to discuss what implications that framework might have, in institutional terms, for developing countries. Second, the District has come to be an often-cited example of a functioning water market. However, these analyses generally focus on the fact that trading is taking place and do not deal with the underlying structures that allow the trading to take place. If the District is to be used as a model, then it is necessary to analyze the conditions that have made it a model.

Although the District primarily fulfills other water resources management functions in addition to providing a framework for water trading, for the purposes of this paper the principal focus is on the latter feature of its activities. It is of course only one example of how a water market can be made to function and what the institutional prerequisites look like. However, while some features of the Northern Colorado Water District are peculiar to that specific setting, a number of these features can be generalized.

In the following, some theoretical considerations are presented, followed by a historical background of the water market within the District. Subsequently, the institutional features will be described and the effects of the market, with a focus on reallocation, will be discussed. Finally, some implications of the Colorado experience are discussed in relation to developing countries.

Water Markets and Institutional Analysis

In neoclassical economic theory, markets are assumed to be the most efficient instrument for economic transactions. Actors in the market implicitly know, and follow, the rules of the game. However, it is never spelled out what the rules of the game are and how these are enforced. An evolving branch of economics, the New Institutional Economics, tries to fill this gap in traditional economic theory and examines institutional arrangements with regard to their effects on the efficiency, costs and benefits of economic transactions.

The rules of the game for economic actions are thus provided by institutions, such as laws, norms, and customs. Depending on their design they can facilitate or constrain economic actors' activities. In the case of markets, laws defining property rights and judicial procedures help actors to agree on contracts, to monitor and to enforce them. Sometimes the buyers and sellers themselves set and enforce the rules (e.g. in the water market in Cariri, Ceará), but in most cases, organizations such as courts and technical agencies are part of the institutional framework that provides the basis for the functioning of the system.

In the case of water markets, a number of institutions are necessary to make them function. The basic requirements, analyzed in the case of the District, are property or user rights to water (including their definition, initial allocation, measurement and return flows), contracting mechanisms, availability of and access to information, and an administering and enforcing agency.

As will be seen, the District introduced a number of institutional features. They are not necessary requirements for a water market, but they illustrate how a local system evolves according to its members', often political, decisions. The additional features concern, *inter alia*, the restriction of sales of the water rights out of the District and limits on the ownership of water rights.

Finally, some physical features of the District's distribution system have to be discussed since a water market can only function if the water can be transferred physically between different uses. For this, an adequate storage, distribution and measurement system has to exist.

An important feature of the New Institutional Economics is its acknowledgment of the historical evolution of institutions. The institutional framework in a given region or country conditions the way in which innovations will be accepted and assimilated. North (1990) speaks of so-called path dependence. This view is also corroborated by Putnam's research in Italy (Putnam, 1993). For 20 years, Putnam followed the implementation of a new administrative municipal system in many different regions of Italy. Although the new system was the same for the whole country, the results varied significantly. Putnam argued that the outcomes were related to the different historical backgrounds of the different regions, which had led to diverging features of social organization, such as trusts, norms and networks. In his terminology, the *social capital* of the regions varied.

Putnam has been criticized for being fatalistic because an extrapolation of his thesis would dictate that if a region has an endowment that does not promote efficient, economic development, then any attempt to change it will be futile because of historical reasons. However, a more constructive interpretation of his work is that if the importance of different endowments in terms of social capital and other institutional arrangements is recognized and if they are analyzed in advance, then the chances that new institutions can be successfully adapted to the local conditions are enhanced. The history of development aid has shown that local institutions have too often been neglected, leading to the failure of theoretically reasonable development projects (Ostrom et al., 1993).

Consequently, in the context of water markets, there is a necessity to know, first, what types of institutional arrangements would have to be in place to make them work and, second, whether these institutional parameters can be identified or created in the specific institutional setting being considered. This paper focuses on the first of these needs.

History of the District

From Water Users' Association to Water Conservancy District

The Northern Colorado Water Conservancy District is located in the western United States in the State of Colorado on the eastern slope of the Rocky Mountains. It covers an area of 600,000 ha in a region characterized by an arid climate with an average annual precipitation of less than 375 mm. While on the District's side of the Rocky Mountains, many of the natural streams dry up in the summer, the western slope receives more precipitation, primarily in the form of winter snowpack.

Farming on the high plains of northeastern Colorado started in the late 1800s to provide food for the mining communities and for the U.S. Cavalry. When the annual precipitation in the region proved to be inadequate for rain-fed farming, farmers joined forces in privately-owned "ditch companies" to construct diversion structures and storage reservoirs for irrigation. Due to the growth of the agricultural economy the demand for water kept increasing. In the 1930s, a disastrous drought made it clear that supplemental water supplies would be needed in order to stabilize and augment the locally available resources. Therefore, alternatives for diverting water from the surplus supplies on the western slope of the Colorado Rocky Mountains were studied and agricultural leaders in northeastern Colorado organized themselves as

the Northern Colorado Water Users' Association to promote the construction of a transbasin water project.

Since they were not able to finance such a project by themselves, they sought the cooperation of the U.S. Bureau of Reclamation (USBR), an agency that had the task of promoting small-scale irrigation farming in the dry regions of the United States. The USBR required that a local organization with the ability and authority to repay a part of the project costs sponsor the project and sign a repayment contract for this obligation. Therefore, in 1937, the state legislature of Colorado passed the Conservancy District Act which provided for the organization of Water Conservancy Districts. Almost immediately, the Northern Colorado Water Users' Association, supported by petitions by the citizens in the region, reorganized itself as the Northern Colorado Water Conservancy District.

The District assumed an obligation to repay the cost of the water delivery portion of the planned transbasin project. In exchange, it was granted the perpetual right to the use of all of the water developed by the project. The United States, on the other hand, reserved the right to all power revenues from the project while agreeing to pay all of the costs associated with the development of the power system as well as one-half of the perpetual operation and maintenance costs of works used for both power and the delivery of water. Upon completion of the project, the U.S. turned over to the District the operation and maintenance responsibility of the water delivery facilities. Gradually, the joint-purpose facilities were also turned over to the District so that now the entire system, except the power plants, is operated and maintained by the District. Furthermore, the District had the responsibility for the allotment and distribution of all the water developed by the project[1].

[1]For a more detailed description of the district's history see Howe et al (1986)

The Colorado-Big Thompson Project

The project that eventually evolved was the Colorado-Big Thompson (C-BT) Project. It transports water from the Colorado River watershed on the west slope of the Colorado Rocky Mountains, under Rocky Mountain National Park, and channels that water into the South Platte Basin watershed on the eastern slope as shown in Map 1.

Construction started in 1938 and was concluded in 1957. The water storage components of the C-BT Project consist of 12 reservoirs. Delivery of water takes place from the east slope reservoirs as a supplement to the flows of the six local streams in the District. In 1994, the distribution system consisted of 154 km of canals, conduits, and siphons and 55 km of tunnels. The 12 reservoirs have a total capacity of 1,247 Hm^3 and an active capacity of 1,130 Hm^3. Furthermore, there are three pumping plants with a total installed capacity of 41,000 horsepower.

The C-BT Project was constructed for the storage and delivery of an annual average of 310,000 acre-feet of water (382 Hm^3 per year). In order to facilitate the allotment of the water 310,000 acre-foot units were created. These 310,000 units were allotted to individual water users and municipalities located within the District service area. The allotments were based on the existing needs of the water users, e.g. their previous water use and an analysis of their ability to make beneficial use of the supplemental water. The initial allocation process will be dealt with in subsequent sections.

Today, the District encompasses an area of 303,518 irrigated hectares and 27 municipalities and associated industries. It delivers supplemental municipal water to an area with a population of over 500,000.

Every year in the spring, the Board decides how much augmentation water is needed to make a full supply for the region and establishes a quota to be made available during the following year. The decision is based on current water storage statistics and upon snowpack measurements used to forecast prospective spring runoff. Since the C-BT water is designed as *supplemental* supply, more augmentation water is released in dry years than in wet years. In wet years, water users are expected to use their base supplies while the District stores water to be held as a reserve for the dryer years. It is estimated that the total water need for the District amounts to 860,000 acre-feet (1,060 Hm^3). In dry years, when the District delivers a full 100-percent-quota, it supplies about one third of the total water demand. The District delivers an annual average of 230,000 acre-feet (283 Hm^3). Figure 4 shows the water delivery quotas for the years 1957 through 1994.

In 1986, the District started a carry-over program. Up to that time, at the end of the delivery season, allottees who still had surplus water either left that water in the system or would sell it cheaply to any willing buyer. This implied an overall loss for the District since valuable water that could have been stored in the system, was instead placed in the local storage capacity, inhibiting its ability to store tributary water the following year.

For this reason, carry-over accounts were created which permit allottees to have their surplus retained in their account for first use

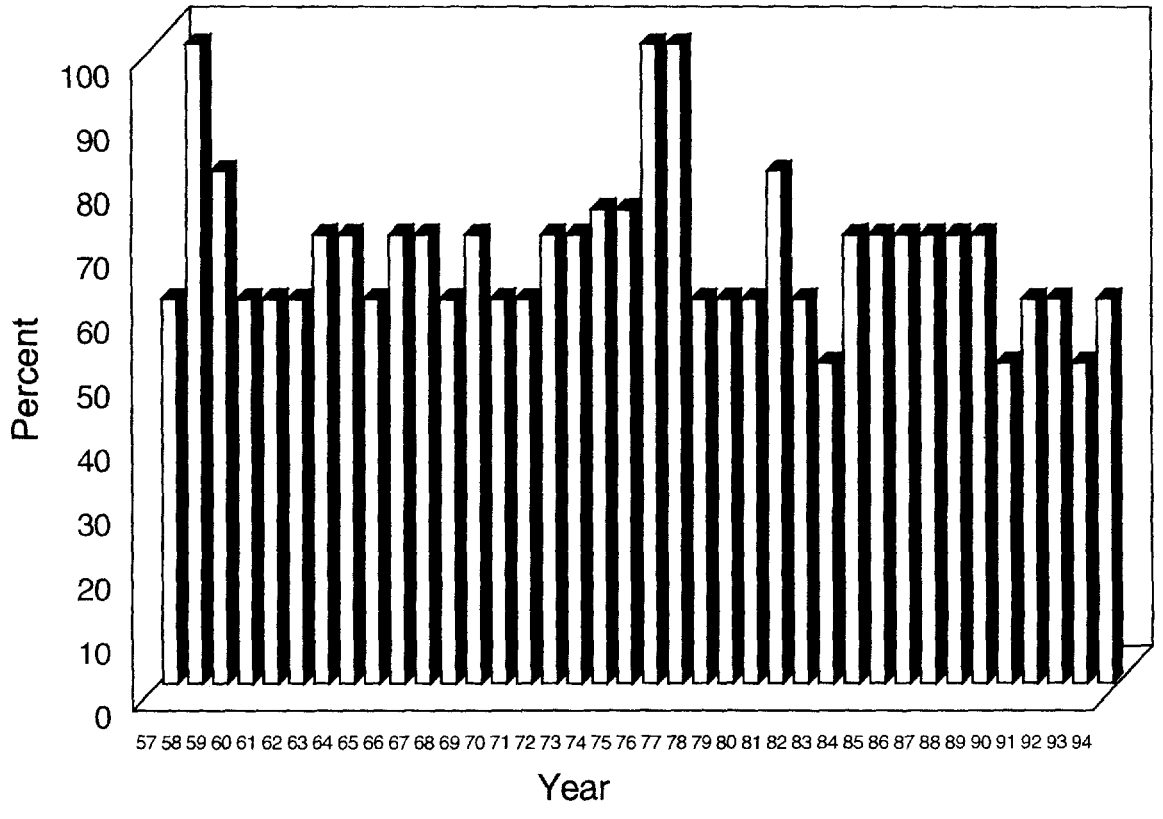

Figure 4. Water Delivery Quotas, 1957-1994. *Source: NCWCD Annual Report. 1994.*

during the period from April 1 to July 15 of the following year. In this way, they have no incentive to sell their surpluses cheaply or to infringe on the capacity of the local tributary storage system. Carry-over water has to be taken into account when interpreting Figure 1 above because, even if the quota was quite low in a certain year, substantially more water may have been delivered due to the additional release of carry-over water. This is true, for example, of the years 1991 and 1992 when carry-over supplies were substantial.

The Purpose of the District

According to the District's 1992 Comprehensive Annual Financial Report the "District was organized to acquire water; to obtain rights-of-way for certain water works; to provide for construction for water facilities; to incur contractual or bonded indebtedness; to administer, operate and maintain physical works; and to conserve, control, allocate and distribute water supplies for supplemental use; and to derive the revenues needed to accomplish its purposes".

The Water Market

This section deals with the institutional framework that has permitted the market in the District to develop. Both state laws and District rules form part of this institutional framework, as does the political geography of the District itself. Some specific aspects of the District's functioning are highlighted in order to understand in which way its set-up has facilitated, and also constrained, the functioning of the market. These aspects include the political boundaries of the District, the multi-purpose nature of the water rights, the manner in which return flows are handled, the operation of the District's Dispatch Center and registry system, the participation of water users, the ditch companies' role as primary distributors and the growing demand for municipal/industrial water in the region.

When and Why Was the Market Instituted?

A short time after the commencement of full water delivery, in 1959, the District's Board members recognized that the water demand pattern in the District would not be static and that demand would vary from year to year and between geographical regions of the District. The original 310,000 acre-feet quota was based upon an average supply for the whole District and did not take into account the variations in run-off and precipitation between different tributary watersheds. Furthermore, it did not distinguish between those users who already owned storage water that would be available from local reservoirs throughout the season and those who were entirely dependent upon direct diversion of runoff from the tributary systems.

As a consequence, the Board of Directors decided to allow the allotments of water to be leased or sold throughout the District on a willing buyer-willing seller basis. As the District had originally retained ownership of all return-flow water, even though the return flow pattern was changed there could be no claim of injury due to water transfers within the marketplace. This flexible system, designed to meet the different water users' changing needs, was instituted in 1960.

The market system was thus introduced based on the water users' own wishes. It differed markedly from the usual allocation system which was used by the Bureau of Reclamation. The Bureau normally allocates water perpetually to the same land and frequently also to the same uses (Howe, et al., 1986).

Water Use Rights

Ownership of Water Use Rights

As indicated above, the U.S. government continues to be the owner of the project and of the water, but the District owns the right to use and allocate all the water made available by the C-BT project as long as it meets repayment obligations and operates and maintains the project facilities as stipulated in the repayment

contract. The District thus does not allocate water rights, but, instead, enters into an allotment contract with the water users, providing them with a *permanent contractual right to use allotted water* under the terms and conditions in their contracts. These contracts represent a usufructuary right that has the standing of a property right under law.

Initial Allocation of Water Use Rights

The members of the District opted for an initial allocation of their new supply on the basis of the future users' needs and their ability to make beneficial use of the water. Since the project was originally constructed to provide 310,000 acre-feet of water per year, 310,000 allotment units were created and allotted to individual water users, irrespective of the quantity of water that would be delivered each year.

In order to be able to carry out the initial allocation of the water use rights, the Board of Directors asked for applications for allotments by farmers, industries, and cities. The incoming applications were processed in the order they were received. The initial allocation process took about two years. Since the number of applications exceeded the amount of allotment units available, a number of latecomers could not be allocated any water. The District placed them on a waiting list and considered their applications when other farmers subsequently declined their initial allotments. This waiting list was honored for about ten years after the initial allocation.

The District did not charge any price for the initial allotments. However, as a condition for receiving the right, the allottee had to place a lien on his property to guarantee the federal repayment obligation and the funding of sustainable operation and maintenance.

The decision on how many allotment units an applicant would receive was based on calculations by the District of how much supplemental water the applicant would be able to put to beneficial use. In the case of farmers, who constituted more than 90% of original allottees, District engineers visited the applicants' farms and carried out physical inspections to make the assessment. The main criteria employed were the soil type, the historical cropping pattern, and the already existing water supply.

Although the originally allocated water rights were free, the risk of the lien constituted an implicit price and a number of farmers in the area chose not to apply for allotments for fear of losing their farms if the District failed to meet its payment obligations.

Types of Allotment Contracts and of Water Transfers

There are three classes of allotment contracts: Class B (water for municipal use), Class C (water for industrial use), and Class D (water for irrigation use). For all types of these contracts, four important features can be distinguished.

First, since the project was originally constructed to provide 310,000 acre-feet of water, 310,000 allotment units were created and allotted to individual water users, irrespective of the quantity of water that would be delivered each year. Therefore, each contract specifies an allotment in terms of an "acre-foot unit", which is defined as 1/310,000th of the quantity of water annually declared by the Board of Directors to be available for delivery from the District. It is these units that can be rented or sold. In this manner, the allotment unit adjusts to the available water supply and is proportional to that supply as opposed to a guaranteed delivery of a specified amount of water.

Second, although the contracts specify the permitted type of water use on a *permanent* basis, the *annual* use of water is not restricted to lands, areas or services defined in each allotment contract. This allows allottees to seasonally rent and transfer water from one area of the district or class of service to another without incurring high transaction costs.

Third, an allotment contract can also be transferred *permanently*. The two parties negotiate the financial terms and submit an allotment change application to the District,

along with a small administrative fee. The buyer must agree to be bound by the stipulations of the Water Conservancy Act of Colorado, as well as the rules and regulations of the Board of Directors and the repayment contract between the District and the United States. The buyer must also demonstrate a beneficial use for the water.

Fourth, to fulfill the federal repayment obligation and operating expenses, the District levies an annual assessment to be paid by all allottees, based on the number of allotments they own. Figure 5 shows how these assessments have developed over the years. From 1939 to 1953, a fixed rate of $1,50 was levied on each acre foot-unit per year[2]. In 1953, the Board divided the District into two units, Unit 2 (lands supplied by project releases from Boulder Reservoir) and Unit 1 (remaining releases). The assessment charges on Unit 1 continued at $1,50 and on Unit 2 were set at $2.00 to offset pumping costs and to offset the fact that this region had not originally contributed to the development of the Project.

In 1959, the Board decided that the assessments for each allotment contract would continue at these fixed rates until the contract was transferred, sold or altered. From that time on it would be subject to so-called "open rate" assessments determined annually by the Board. As can be seen in Figure 5, this arrangement has permitted the Board to gradually increase assessments. The figure also shows that the annual assessments have been increasing at a slow pace and that they have been subsequently differentiated for municipal, agricultural and industrial uses. The price differentiation according to use goes back to a decision by the Board of Directors that because the District had been founded primarily for agriculture, other subsequent beneficiaries should pay a higher price than the original founders. In addition, the rate differential between uses reflects the additional costs of providing year-round stable supplies as well as the value derived from the use of the water.

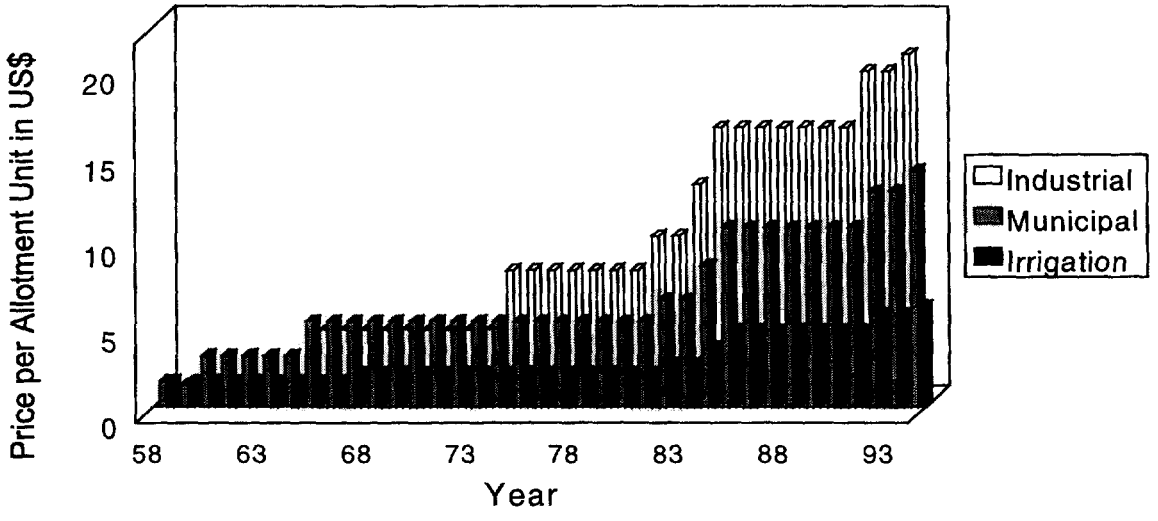

Figure 5. District Water Assessment Charges 1958-1992. *Source: NCWCD Annual Reports 1993 and 1994.*

[2] 1 acre-foot corresponds to 1,233 m^3.

Return Flows - Dealing with Third-Party Impacts

A complicating issue with regard to water transfers is the ownership of return flows. In non-consumptive uses, water that is used upstream will return to the river and can be used again downstream. In most water right systems, the downstream user will acquire the right to this return flow that is released from his upstream neighbors.

For this reason, when upstream users change their type of use, for example from non-consumptive to consumptive, or transfer their rights, these changes will have an impact on the right of the downstream user.

In the District, two types of water rights exist. They are similar in that they are detached from the land they belong to, i.e. the owner can sell or rent the water right without being forced to sell/rent the land.

What distinguishes the rights is if they were acquired under Colorado Water Law or by allotment in connection with the C-BT Project. Water rights acquired under Colorado Water Law, i.e. rights to tributary water, follow the traditional U.S. western system of appropriative water rights ("first-in-time and first-in-right") according to which senior water right holders have the first right of use before junior right owners. Therefore the market for the rights to tributary water supplies is very restricted. Only the consumptive use of water can be sold and only under the condition that no injury is done to downstream users who have developed a prescriptive right to the return flows based upon historic dependence and use. Any change in the quantity or pattern of water use must be filed with the water court of the state and all other water right holders who might face injury are given an opportunity to protect their vested rights in the courts. The outcome can take the form of monetary compensation to the downstream user or a decision by the court that sufficient water must be released by the (new) upstream user to prevent damage to vested downstream users. Since this process may be both time-consuming and expensive, the system introduces high transactions costs and may prevent desirable transfers from taking place (Howe, et al., 1986).

The water market for the C-BT allotments in the Northern Colorado Water Conservancy District, by contrast, has avoided these cumbersome problems. One of the important internal rules of the District, is that, from the beginning, the District retained the rights to the return flow of any water derived from the C-BT system.

Return flows are made available to the water users on the streams within the basin at no charge, but no user of these return flows can acquire a right to those flows or can prescript a maintenance of this return flow regimen. For this reason, the downstream user cannot be damaged or injured if either the patterns or quantity of those return flows change. This ensures that water can be transferred freely and without risk of lawsuits due to third party impacts.

Transaction Mechanisms - Contracting and Information

If water-right holders are to see a gain in the flexible reallocation of water, the transaction mechanisms need to be as simple as possible. In the District, a simplified procedure has been developed in which each allottee's units are registered just like in a banking account. For *annual* rentals, he and a prospective buyer, after agreeing on a rental price, simply have to send a postcard to the District specifying the volume of the rental, the source and the destination. As in a traditional bank-account, the signatures are verified and the transaction is registered. The water is then credited from the seller's account and debited to the account of the renter. The District does not charge any administrative fee for making the annual rental transfer nor does it share in the proceeds from the rental transaction.

For *permanent* sales of the contracts for allotment units, the procedure is somewhat more complicated. After the two parties, on a willing buyer-willing seller basis, have agreed to a

price, they submit an allotment change application to the District, along with a small administrative fee. The application is reviewed by the District to verify ownership and legal descriptions and to ensure compliance with established policies (e.g. purchase of water for beneficial use) and procedures. Thereafter the application for change is submitted for approval to the Board of Directors. Subsequent to approval by the Board, the requested change is implemented and the permanent transfer completed along with the transfer of the lien which is recorded in the records of the county or counties within which the transaction takes place.

Although the registration of the leases and sales is centralized in District offices, the District does not act as a broker. A number of private brokers operate in the area and potential buyers/sellers may contact them in order to obtain information about prospective trading partners. Also the regional newspapers carry advertisements for both sales and lease opportunities. Finally, water users may develop the transaction through personal contact with each other[3]. Information on water value is thus easily and relatively cheaply available. Furthermore, the set-up is analogous to, for instance, housing and land markets and therefore well-known to all participants.

Monitoring and Enforcing Contracts

The District is an institution that covers activities as broad as the development of new water resources and the operation of a "clearing house", i.e. the Dispatch Center where water deliveries are coordinated. Also the farmers are organized and contribute to the functioning of the distribution system. This section deals with the administrative system, the Dispatch Center and with the farmers' ditch companies.

Administrative System

According to the Water Conservancy District Act, which allowed the formation of the Northern Colorado Water Conservancy District, broad authority and charge is provided to the Board of Directors of Conservancy Districts. These powers include all the powers of a municipal corporation, such as the authority to levy assessments on the properties within the boundaries of the District, authority to include or exclude lands and the advantages of sovereign immunity and eminent domain. The Board of Directors is the governing body of the District. State District Court Judges appoint 12 directors for staggered four-year terms. These directors are appointed based upon geographic representation, proven expertise in water and broad representation of the water user community.

The District operates a Dispatch Center, which is available on a daily basis to receive and process water orders. These deliveries are coordinated with the water user's direct flow water rights through the various State River Commissioners who are responsible for the administration of the rivers and of the traditional water rights system. The District's Dispatch office is available during normal office hours to receive questions and comments and is in direct communication via VHF radios to the operations people in the field. A phone recording system is used to receive calls during times when the Office is closed. According to a District official, this system is well understood by the water users and appears to be satisfactorily meeting their needs for flexibility and reliability.

Twice each year, the District holds a one-day meeting for the water users throughout the

[3]It is interesting to note that the Siurana water market in Spain (see Paper II) which operates under surprisingly similar conditions as the water market in Colorado offers a dual system of brokerage. In that market, private brokers had quite a high profit margin since they managed to maintain a certain obliqueness of the pricing system. Clients would frequently not be informed about the going price for a water unit. Consequently, sellers would be quoted a low price by the broker and buyers a high price, leaving the broker with a handsome gain (and probably distorting the market). The administration of the Siurana market thus started to offer a non-profit brokering service parallel to the private one.

District. One meeting takes place in the spring, before the water delivery season and the other meeting in the fall after the completed delivery season. At the spring meeting, District staff present water storage projections and forecasts for spring runoff. Comments from the meeting's participants are later conveyed to the Board of Directors prior to their setting the water quota. Most of the directors are also in attendance at these meetings and are able to network directly with the users.

The fall meeting serves the purpose to review the delivery season and to discuss how to achieve more efficiency and effectiveness in the operation of the system. In both meetings the agenda also includes items of general interest, such as pending legislation, insurance, dam safety and rehabilitation, system maintenance status, etc.

The District also publishes a quarterly newsletter, covering subjects such as data on District water deliveries, water storage, and changes in policy and procedures. In addition the District has a full time Agency Coordinator whose task is to maintain communications with local and regional agencies, e.g. county commissioners, planning and zoning commissions etc. A full time Right-of-Way Administrator coordinates with regional agencies concerning activities that might affect the District's rights-of-way and its ability to maintain and operate its distribution facilities.

Finally, the District also has authorized staff to assist state legislators in drafting proposed legislation as well as a legislative advisor who maintains direct communication with the state legislature with regard to proposed legislative changes that could impact the District or its water users. In 1994, the District had 84 full-time and 10 part-time employees.

Ditch Companies

Historically, most farmers in the District have been organized in private ditch companies responsible for running collective irrigation systems. The water user rights in the ditch company are represented by the ownership of stock in the company which entitles the user to a certain proportionate share of the company's annual supply for each share of stock. This ownership also obligates the user to pay the proportionate share of the annual costs of the operation and maintenance of the system as an assessment against his share of stock. The ditch companies maintain a registry of the stock ownership, the ownership of C-BT contractual rights and an accounting of annual water entitlements and deliveries under both of these rights. In 1998, there are about 125 ditch companies, ranging in size from 250 ha to 22,000 ha (average size of about 5,000 ha).

When a farmer needs C-BT water, he will contact his ditch company's secretary. The secretary will collect all orders for the day and then inform the District Dispatch Center how much water is to be delivered to his ditch company. The C-BT water will be delivered either to the rivers to be administered by the State Commissioner for transportation to the ditch company's intake or in a few instances, delivered directly to the users or to their company systems. The water is then distributed by the ditch company internally within their system. In the case of the few users who are directly connected to the C-BT distribution system, they have meters installed at their intakes and contact the Dispatch Center directly when they want their water delivered.

The ditch companies constitute an important part of the water market's underlying structure. They exercise monitoring, distribution and enforcement functions. Certainly their existence greatly facilitates the transactions taking place in the market, particularly with regard to the annual rental market.

Market Restrictions

As noted earlier, the District has introduced a number of specific features that are not necessary requirements for a water market to function. In fact, they may even impair the efficiency of the market. These rules are

highlighted here as they are a part of the District's institutional and political framework and they illustrate how the participants in a local system adapt the rules to their perceived needs. In this case, the rules seem to be related to a perceived need for security or protectionism because they concern limitations on the sales of allotments. Regarding the trade-off between efficiency and security, the District Board and constituency obviously chose security.

Limits on Ownership of Permanent Allotments

The first market restriction is that buyers of allotments are required to demonstrate a beneficial need and ability to use the water. They cannot acquire allotment contracts simply based on their willingness and ability to pay. This is both a result of original restrictions imposed by the Federal participation in the project and of the Board's aversion to the concept of speculation in water or the development of monopoly positions in the ownership of the contractual rights of use.

The use of water under the three different classes of permanent allotment contracts is very well defined. Class D allotments are for agricultural purposes and along with the lien to guarantee payment, must be attached to a parcel of land to which the water can be delivered. This parcel of land must have been previously irrigated because the C-BT water is a supplemental supply. Due to the obvious dangers of speculation, District staff physically inspect each parcel and determine the amount of water that can reasonably be used on that parcel, based on soil type, land slopes, cropping patterns, present water supply etc. A limit on the number of units which can be attached to an individual parcel is established, based on the difference between the water provided by tributary supplies and the total amount which can reasonably be used.

The amount of water that an entity can acquire as Class B and Class C allotments is similarly restricted. An entity can accumulate a gross supply equal to twice its demonstrated average annual demand. The entity's average annual demand is based on existing demand patterns plus an allowance for planned expansions because of developments. The difference between demand and the amount of water supplied by non-C-BT sources constitutes the "demonstrated need". The reason for allowing an accumulation of twice the demonstrated need is to ensure that municipal and industrial uses, which are less able to cope with water shortages than agricultural uses, are secured even when the Board sets a low 50% quota. This accommodation towards stability of supply is also reflected in higher annual water rates as was previously discussed.

Intra-District Sales

From the beginning, it was stipulated that C-BT water could only be used within District boundaries. This is a legal requirement of the Conservancy District Act to assure that the benefits of a District only accrue to the citizens within that District. This assures that the supplies developed by and for District citizens are not sold off to higher-paying buyers in other parts of the region, in this case, the large metropolitan area around the City of Denver. This area is in great need of water supply augmentation and has made it clear that it desires to acquire water from the area within the boundaries of the District. Some of the suburban cities of this metropolitan area have recently purchased stock ownership in some of the tributary water supplies within the District but are faced with high transaction costs and the need to provide mitigation for third-party impacts.

Physical Features of the Water Market

The Water Market in the Northern Colorado Water District has several physical features, which allow it to function in the intended manner.

An elaborate *storage and conveyance system* is in place so that the water can be physically transferred with ease from one place to another and from one use to another. A highly developed infrastructure is in existence

consisting of reservoirs, pipelines, canals and tunnels which allows ease of distribution of water from the project along the front range of the mountains within the District.

Water storage facilities are of major importance since one of the aims is to provide allottees with supplemental water when their basic supplies would not be sufficient in a given year. Adequate storage allows the water supplies to be managed and stored for delivery upon demand to take account of changed uses and locations of use. It allows the year-round delivery of water as the use changes from seasonal agricultural use to municipal/industrial use.

A related necessity is a functioning *hydro-meteorological monitoring system*, which permits the District to collect and analyze data for predictions of water availability. The monitoring system is also used to monitor the distribution and delivery of water to the different allottees.

Effects of the Market

The two principal reasons for recommending the implementation of markets usually are (1) that markets permit the flexible allocation of goods according to their highest valued use, and (2) that the market's pricing mechanism leads to the goods being priced correctly so that they will be used efficiently. In the following, it will be examined if the implementation of the water market in the Northern Colorado Conservancy District has led to the outcomes that would be expected, namely to the reallocation of water according to its highest valued use and to more efficient water use.

Reallocation of Water

Since it is possible to sell allotment contracts permanently or to rent them seasonally, the occurrence and effects of these two types of transactions have to be distinguished.

Permanent Reallocation

Available statistics show that the institution of a water market indeed has led to permanent transfers of water. Since, originally, most of the water allotments were held by the agricultural sector, it is not surprising that the trend observed in Figure 6 is a gradual transfer of allotments from agricultural use to allotments for municipal and industrial use.

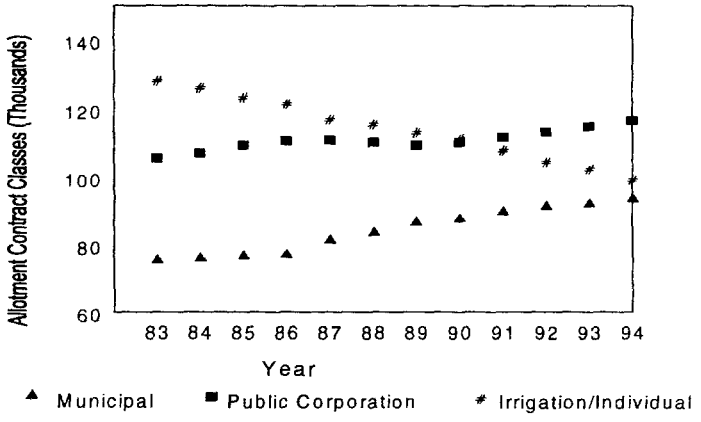

Figure 6. Ownership Pattern of Allotment Contracts by Class. *Comprehensive Annual Report 1994. Source: NCWCD*

As can be seen in the figure, the number of allotment contracts for Classes B and C shows an overall increasing trend while the number of Class D allotment contracts, i.e. water for irrigation, has decreased significantly. In 1983, irrigation contracts constituted 41% of the total, in 1994 they made up only 31%. Since allotment contracts are sold on a willing-buyer willing-seller basis, this indicates that municipal and public corporation buyers were willing to pay a higher price for the allotments than the agricultural right holders valued their possible revenues from crops grown with that water. It must be taken into account, however, that municipalities have been expanding and that urban development of land also results in the

permanent conversion of agricultural allotments associated with that land to municipal allotments.

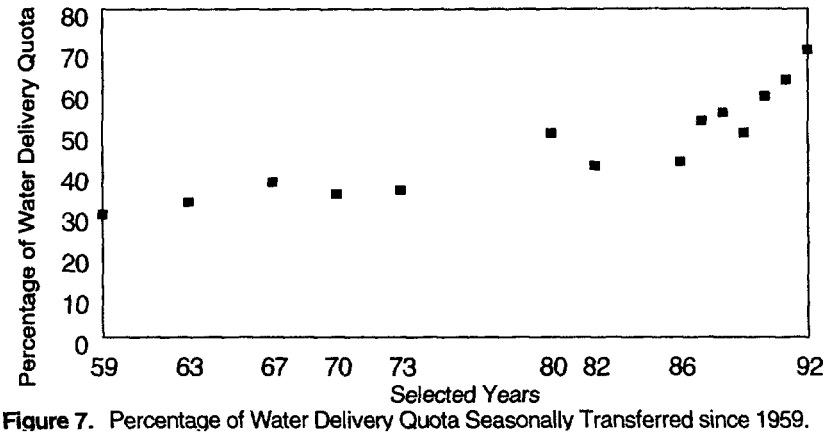

Figure 7. Percentage of Water Delivery Quota Seasonally Transferred since 1959.
Source: Personal Communication with District Official.

Seasonal reallocation

Figure 7 shows the percentage of water (of the stipulated annual water delivery quota) that has been seasonally transferred in selected years since 1959.

This figure illustrates clearly an increasing trend in the number of seasonal water rentals. In 1959, merely 30% of the water delivery quota was "moved around" compared to 43% in 1986 and 70% in 1992. It has to be noted, though, that the annual water delivery quotas vary and that 43% of the delivery quota of 0.7 acre foot (860 m^3) per unit in 1986 represented less water than it would have in 1983 when the quota was 0.5 acre foot (620 m^3) per unit. Furthermore, the carry-over program which was instituted in 1986 led to distortions in the statistics in 1991 and 1992. The figures above are calculated solely on the basis of the official quota. Therefore it must be assumed that when considering all the water delivered, i.e. the quota and the carry-over water included, the actual amount of water leased seasonally in these two years was lower than implied by Figure 7.

The interesting aspect regarding the increase in seasonal transfers is that they take place predominantly in the direction from the municipal sector to the agricultural sector, i.e. in the opposite direction compared with permanent transfers. This demonstrates that municipalities generally rent reserve accumulation of contractual water rights back to the agricultural community except during periods of scarcity. This annual adjustment mechanism provides the municipalities with assurance of stable supplies and also keeps water available for agriculture during normal years. Recent innovative alternatives to this process have been the development of option contracts between the cities and the agricultural users whereby the

Table 8. Allotments Held for Different Categories of Water Use

Year	Agricultural Use (%)	Municipal and Ind. Use (%)
1983	41	58
1984	41	59
1985	40	60
1986	39	61
1987	38	62
1988	37	63
1989	36	64
1990	36	64
1991	35	65
1992	33	67
1993	33	67
1994	31	69

Source: NCWCD. 1994. Comprehensive Annual and Financial Report.

farmer is paid for an option contract where he agrees in advance to temporarily relinquish his water on an annual basis during periods of scarcity. Figure 8 shows the actual water deliveries for agricultural and municipal/industrial use respectively over the time period from 1956 to 1992.

On the one hand this figure confirms the trend observed concerning permanent reallocations, namely that water use for agricultural purposes has been decreasing while use for municipal and industrial purposes has been increasing. In addition, however, if one reads Figure 5 in combination with Table 8, it also becomes clear that at least during the past 10 years relatively more water has been delivered for agricultural use than the percentage of allotment contracts being held for agricultural use would indicate.

The principal reason for this is that when municipalities find that they have surplus water in a given year, they rent it back to the agricultural sector. On the one hand, this is seen as positive by the farmers since it is the municipalities that have to pay the overhead costs for storage and distribution while the farmers can buy cheap surplus water from them. On the other hand, however, the fact that the municipalities have this surplus water is not purely accidental. In recent years, it has become common that developers buy farms in an area, sell the water rights to a municipality and the municipality immediately leases the water back to the farmers. The farmers are allowed to stay on the land until an unspecified date in the future when the municipality needs the water and stops leasing it to them. A case in point was the City of Thornton which, in the late 1980s when the economic outlook for Colorado was rather pessimistic and farmers were willing to sell their land, bought 104 farms along with the associated tributary water. The farmers were allowed to stay on the farms until the city would need the water in the future.

Seasonal transfers thus have taken place since the implementation of the market and their number has shown an increasing trend. One explanation for the increasing numbers of seasonal transactions can be sought in the permanent transfer of water allotments mentioned above. According to District officials, the vast majority of seasonal transactions consists of rentals from municipalities to the agricultural sector because cities try to build up a water surplus to prepare themselves for droughts and for growing future demand. In normal years, however, they have sufficient water and lease it back to the agricultural sector. Another reason for the cities' surplus build-up is the quota system. The District sets a lower quota for delivery in wet years because the farmers have less need for supplemental supplies. Therefore the cities who have more stable demands for the C-BT water have to plan for low-quota wet years rather than for dry years. They, thus, build up surplus reserves that they rent back to the farmers when they do not need it.

Farmers, on the other hand, tend not to rent their water on a seasonal basis either to cities nor to each other. Thus, the more water is acquired by cities the more will be available to be leased seasonally.

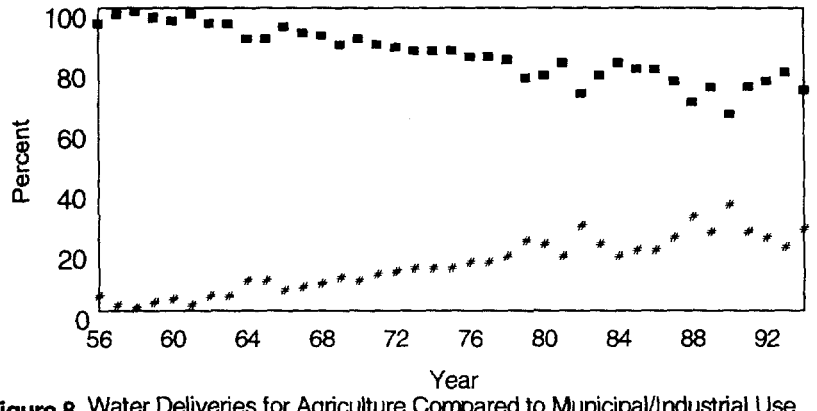

Figure 8. Water Deliveries for Agriculture Compared to Municipal/Industrial Use from 1956 to 1994. *Source: NCWCD Annual Reports 1992-1994, and information from District Officials.*

Prices

A main assumption concerning a water market is that its implementation will lead to the reallocation of water according to its highest-valued use. That value ought to be reflected by the prices paid by the different parties. It is usually assumed that a freely negotiated market price will be a better indicator of the value that different users attach to the good in question than an administratively stipulated price. In the case of the District, the question would be if the value that users attach to the water would differ from the prices that could be set by the Board of Directors if they operated under a stipulated system.

Figure 5 showed the development of the annual assessments levied by the District. In 1994, they were US$20.50 per acre-foot unit (US$ 0.017 per m^3 equivalent) for industrial use, US$13.80 (US$ 0.011 per m^3 equivalent) for municipal use and US$ 5.90 (US$ 0.005 per m^3 equivalent) for irrigation use. As stated above, the introduction of differential water assessment rates was partially based on a policy decision by the Board of Directors and does not totally reflect differential costs.

The District does not keep records of the prices the negotiating parties agreed upon for seasonal or permanent transactions. District officials estimate, however, that the prices for *seasonal* rentals during the past years were in the order of US$15 to US$25 per acre foot (US$ 0.012 to US$ 0.020 per m^3) depending on the year. Considering that most seasonal rentals are from municipalities to agriculture, it seems that these prices are at least somewhat above the annual assessment fee municipalities have to pay per acre-foot unit per year. These prices also show that farmers obviously are willing to pay more for these supplemental supplies than the $5.90 assessment they are charged annually per acre-foot unit by the District.

According to Howe and co-authors, one of the reasons for these moderate prices is the informal pressure on municipalities not to make money from their water since they are allowed to acquire surplus supplies for security reasons. "The unwritten but often stated *quid pro quo* for this special treatment is an obligation not to profit from rentals...There have been instances in which cities tried to raise prices toward a market clearing level and were quickly, if quietly, admonished by the District for doing so" (Howe et al., 1986).

Concerning *permanent* sales of allotment units, Figure 9 shows representative prices that were paid for C-BT allotments during the period 1960

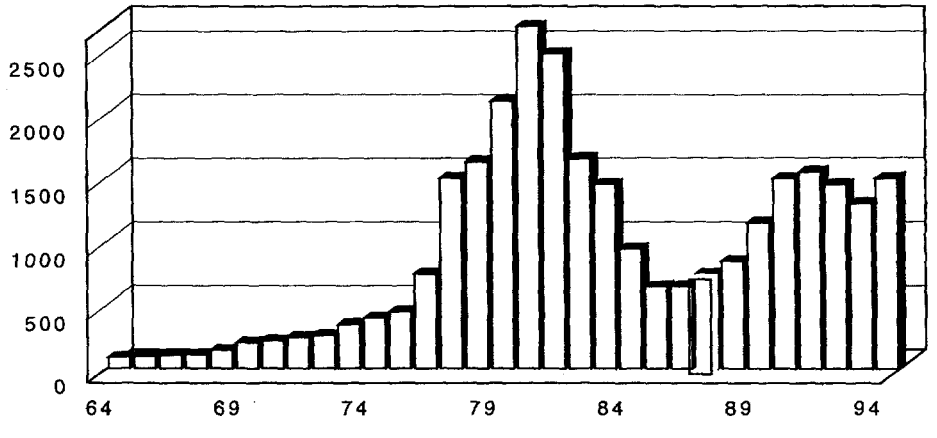

Figure 9. Representative Market Prices. US$ Per Allotment Unit, 1964-1994.
Source: NCWCD Annual Report 1994.

to 1994. This figure reveals that market prices started to increase very soon after the institution of the market in 1960. Since then they have been consistently higher than the original price of US$1.50. Purchasers obviously place a high value on the secure right to annual water deliveries. In the majority of cases, these purchasers are municipalities and industries, which, in general, value the stable water supply more highly than agricultural users.

Similarly, the fact that municipalities lease their annual surplus water back to farmers indicates that the market is flexible enough to permit a reallocation in reasonably wet years, when it is more rational to use the water to grow crops than to keep it stored for future emergencies in the cities.

It is important to note, though, that market prices have been subject to considerable fluctuation over the years and that variables, such as general economic development in the region and seasonal water availability, certainly play a role for the value that is attributed to the water resource at a given point of time. One reason for the price fluctuations certainly is the Windy Gap Project which has brought supplemental water for municipalities and industries since the mid-Eighties.

The example of the District confirms the expectation that water is valued most highly by municipalities and industries. This, on the other hand, leads to a gradual shift from agriculture to industrial and municipal production in the region and gives farmers incentives to either sell their lands (and water rights) or to conserve water and shift to the production of higher-value crops.

Since the District was founded by water users in the agricultural sector there has always been a strong bias in favor of agriculture. In this context, it is interesting to note that the very success of the water market has led to the search for new mechanisms to avoid its main effect, namely the permanent reallocation of water from agriculture to industrial and municipal use. As stated in a recent paper, the "Northern Colorado Water Conservancy District is now striving to find a solution to the problem of water-thirsty cities located along its southern boundaries. The recent acquisition by Thornton of agricultural water in Northern Colorado is just symptomatic of the needs of cities such as Brighton, Louisville, Lafayette ... These needs will not go away ... Many of the needs of these municipalities can be met without destroying our agricultural base if proper management methods, exchanges, and reuse plans are adopted and put into place" (Simpson, 1992).

One of the solutions being discussed at present are option-contracts. One is the type of drought dry-up contract previously discussed. Another is a contract where the municipalities would pay farmers an annual fee to cultivate on their farms for five years and to leave the fields fallow during the sixth year. The water saved during the sixth year would go to the city. The cities would thus have an option on the water for every sixth year. Obviously, this arrangement only works if the city has a use for the water during the sixth year or has sufficient proprietary storage to hold the water in reserve until needed. Option contracts could help to preserve the agricultural character of the region while making water available to the growing economy and cities of the area during drought years.

Water Use Efficiency

This section deals only with water use efficiency in the agricultural sector since there currently is little information with regard to industries and municipalities. Similarly, there are only general indications concerning the question of whether farmers will react to economic incentives by conserving water and leasing or selling the surplus to other users. In other words, will they use their water more efficiently than they would if there was no water market. In discussions with District employees, the picture that emerged was not clear-cut. There are a few instances where farmers financed the installation of improved irrigation equipment through the sale of conserved surplus, but more often, the funds were used for

retirement or for other investments outside of agriculture.

A program for the improvement of irrigation technologies was instituted by the District about seven years ago. Farmers can get free advice on how to improve their water use efficiency. The program works on a voluntary basis, all services are free and provided only upon request. Up to now, only about 10-15% of the people in the area have been provided with help by the program, but demand for the service has been increasing. During 1993 alone about 70 farmers participated in the program while in the years before the program only about four to six farmers a year would request help to improve their technologies. The demand for improved technologies would indicate that farmers do feel an incentive to save water even though they might not sell the surplus.

Also the carry-over program which permits farmers to carry over their surplus water in a given year has the aim to increase water use efficiency because farmers who do not need all of their allotted water can reserve it for the next water delivery season. The functioning of the carry-over program nevertheless shows that farmers are aware of the value of the water and that they seize the opportunity to save it and carry it over into the next season as a hedge against shortages.

District officials point out that farmers generally feel that they are always short of water. Probably the evidence for their efficient use of the resource should be construed as an attempt to avoid having to pay for additional water as opposed to an attempt to conserve water for sale or rental.

An interesting phenomenon are the lists that some of the municipalities have in which they register farmers who want to lease seasonal water. Some farmers buy water from the municipalities even in years when they know that they will not need it just in order to remain on the list for future years when it might be scarce. Established customers are more likely to get water from the municipalities than new ones. However, although the historical experience of the District has been that farmers in general prefer to grow more crops rather than rent their water to others, District officials see indications that this might be changing and that younger, better educated and more business minded farmers see the opportunity to conserve and rent surplus water.

In summary, with the information currently available there is no conclusive picture that water use efficiency among farmers in the District is higher than it would be if there were no water market. Nevertheless, there seems to be an increasing tendency among farmers to conserve water. This could be attributable to the fact that they are being made increasingly aware of the value of the water because the municipalities are buying more and more of the regional water supplies. If young progressive farmers are going to remain in that business, they realize that they will have few opportunities to acquire additional water in competition with the cities and are becoming more reluctant to sell the supplies that they now have. In addition, the water that has previously been sold frequently came from marginal agricultural lands and the remaining water is being used on the remaining highly productive land. This process of market selection has had a tendency to concentrate the remaining agricultural water on higher value crops and better land where the economic returns more closely justify the value of the water used.

A Functioning Market Based on an Elaborate Institutional Framework

The water market in the Northern Colorado Water Conservancy District is a functioning institution that provides its water users with flexibility in the seasonal, geographical and sectoral allocation of water.

The example illustrates that the functioning of the market rests on a whole set of underlying institutional arrangements. The market was, in part, built on the existing institutions. The

concept of water trading as represented by shares of stock in private irrigation companies goes back at least 100 years in this region. Consequently, the market mentality that pre-existed the C-BT Project was, to a large degree, responsible for the development of the present market system with regard to the allotment contracts for the water supply. The unique method for dealing with the question of return flow mitigation and third party impacts reflects lessons learned by the water user community with regard to providing an environment that facilitated the ease of transactions. The fact that Colorado law traditionally has allowed the separation of land and water rights was also a strong historical factor in the development of a market for the water separate from the land. In part, new institutions had to be created, such as the administrative set-up of the District and the internal rules that deal with third-party impacts. It is clear that mere legal stipulation of a water market is not sufficient to assure the successful introduction of such a concept. A market in water use rights necessitates a certain framework in order to function. It does not merely consist of buyers and sellers who happen to strike deals. In the following, we will discuss some of the key institutional arrangements in the water market of the Northern Colorado Conservancy District.

Property Rights

The literature about markets unanimously agrees on the need for clearly defined property rights. Regarding water, there is a necessity for the existence of measurable water use rights that are detached from land rights and that can be sold and/or rented. The Colorado experience illustrates that the water itself need not necessarily be privately owned. In the District's case, the actual water is still owned by the U.S. Government or in the case of tributary water, by the State of Colorado. The market has developed for the contractual rights to water use for the C-BT project and in the stock that represents a right of use in the instance of the private irrigation companies. Tradable rights can thus be usufructuary rights and the water resources themselves can continue to be public property. This concept is important because in most countries, the ownership of all water resides in the sovereign government or is the property of the people as a whole. This is frequently a constitutional stipulation. However, the concept of private ownership of the *concession* or *use right* for the water is generally compatible with most countries' legal and philosophical systems.

It is also extremely important that the owners of the water use right believe in the system. An important characteristic of a functioning property right system is security of tenure and the right to enforce contracts. In the Colorado case, allottees know that when they acquire their acre-foot units, the use of the water belongs to them in perpetuity and that the right will be protected by law as long as they comply with the provisions of the contract. They also know that the U.S. system provides the legal framework to enforce their contract concerning payment obligations, proof of ownership, delivery of water, etc. These three preconditions, ownership, security and enforcement will allow them to take the risk of engaging in transactions. If these conditions were not present, the transaction costs and risks might have been perceived as too high and a market might not have developed.

The same rationale applies to the initial allocation mechanism. The initial allocation of water allotments in the District was based on needs of the agricultural water users which were determined by District engineers. Again, the potential users of the system have to have confidence in the impartiality of the system. For example, in countries where the institutional environment is characterized by the possibility of corruption, it is questionable if the decisions by technical staff would be accepted. Also the power relations between potential allottees play a role and the allocation mechanism has to maintain neutrality so that powerful groups are not able to acquire more rights than they should be technically entitled to. Care must be taken to recognize historical use and, absent flagrant waste or abuse, to grandfather those historical uses.

Other allocation mechanisms than those based on physical inspection do exist, of course. It would be possible, for instance, to auction water rights to the highest bidder as was practiced in Australia, or to allocate the water rights based on historical records of water use as in Chile (Cestti and Kemper, 1995).

A fundamental aspect of the water rights in the District is that they were supplemental, i.e. they could be freely allocated without regard to existing water right patterns. For this reason, it was also possible to ignore the rights to return flows. Although one can argue that ignoring return flows is not necessarily the most efficient economic choice because the system might preclude very valuable uses of the water, it nevertheless facilitates the functioning of the market (cf. Rosegrant and Gazmuri, 1994). When implementing a water market, the extent of the importance of return flow impacts and other third party impacts will depend on the nature of the river basin. It may be more efficient to ignore the third-party effects by not legalizing rights to return flows or these impacts may have to be dealt with from a historical standpoint as is the case with tributary water in Colorado. In this context, it is interesting to note, that two other water market systems, in Chile and in the Cariri region in Ceará, do not recognize the rights to return flows either (Rosegrant and Gazmuri, 1994; Paper I).

The Colorado experience shows that different treatment of newly developed water can co-exist with the more traditional recognition of return-flow dependency within the same river system. The selection of a successful regulatory system will depend on the number and types of users and their location on the river. Howe et al. (1986) argue, for example, that in the case of water transfers within the same city, between industrial and municipal users, the types and volumes of return flows would not change. The case is different when water is transferred from upstream farmers to downstream municipalities.

Information and Transparency

In the District, all allottees have excellent access to information. The allotment contracts are uniform and can be studied by anyone interested, so that both parties to the contract know what they buy and what they sell. The members are also informed how much water is available each year so that they can plan their crops and cropping patterns according to water availability. Finally, when they want to engage in a transaction, they have broker services, newspaper ads and a personal network at their disposal to inform themselves about prices and prospective contract partners. The search costs for information are quite low.

Also in the Siruana example from Spain (see Paper II), emphasis was placed on lowering the search costs for information. Originally, the brokers acting in that market managed to keep price information from their clients. Access to information was thus unevenly distributed and certainly hampered the market. With time, the remedy for this situation was to provide public brokerage services.

Another cost related to uneven distribution of information could be imagined in countries with a large number of illiterate and a small number of well-educated water users. Most likely, well-educated water users will have an advantage when engaging in water trading, with regard to both finding trading opportunities and negotiating with a less well-informed party.

Administrative Framework and User-Based Management

The administrative framework in the Colorado case is well elaborated. It consists of, *inter alia*, a Board of Directors, a number of skilled personnel, a clearing house, a number of laws, internal rules and regulations, and the State Administrative System (River Commissioners) as well as the ditch companies.

This set-up facilitates the market transactions and provides for the security, enforcement

characteristics and access to low-cost information discussed above.

An essential role is played by the ditch companies. The reasons are historical, i.e. the ditch companies existed as organizations before the District was founded. Since they have the task of internally distributing and controlling the water that is delivered by the C-BT-project, they thus play a vital role in the micro-administration of the water market. Due to their existence, the District does not have to deliver water to each individual farmer's intake. In addition, the farmers in each ditch company can exert control on each other as well as on the District itself. We can see another parallel with the water market in Siruana/Spain, and with the water markets in Chile, where the water user associations are involved in distributing water and influencing the operation of the system as a whole.

As has become clear from the description above, the District's physical distribution system is very well developed. The most essential feature is the capability of measuring how much water is delivered. Without a credible and accurate measurement system, the water use rights cannot be assured and the users will have no faith in either the rights or the system. It is noteworthy though that the water is not delivered to each farmer directly but only to the ditch company's intake. In this decentralized anticipatory system each level has complete authority and responsibility but is still ultimately answerable to the end user.

In the Colorado experience, the Board of the District is formed of representatives of the users and each ditch company is answerable to directors elected by the stockholders of the company. This ultimate user control greatly adds to the transparency and the credibility of the operation and maintenance of the system, the assessment and collection of rates and tariffs and ultimately the credibility of the user right that trades in the open market. Without this sound user-governed base, the credibility and success of the market could not be assured. All of these pieces fit together to form the foundation of an efficient water delivery system.

Informal Institutional Arrangements

One part of the institutional framework that is rather difficult to identify concerns informal institutions such as informal norms and customs. Nevertheless, we get some indications from the above. Firstly, Colorado law has historically differentiated between land rights and water rights and in spite of high transaction costs, owners of water were able to trade their traditional water rights even before the District started its water market. For this reason, the market's set-up and structures were innovative, but the concept of water trading was not. This has to be compared with institutional arrangements in many countries where water is tied to the land or to the users and where the entire concept of water markets is new.

Secondly, the District's region has been characterized by a strong feeling that agriculture ought to be protected and a number of rules have been designed in such a way as to avoid out-of-District sales or high water prices for agriculture. Although these rules certainly have a negative effect on market efficiency, they seem to be built on a common consensus. The District's constituency obviously places a higher value on future availability of water than on short-term gains. The fact that it is possible to design this type of constraints also shows that a market can be designed in such a way that political and social objectives are accommodated without making the market mechanism as such non-functional.

The Pace of Development

The previous sections also show that change takes place slowly. The market in the Northern Colorado Conservancy District has existed for over 30 years, but efficiency considerations regarding on-farm water use seem to have come into play only fairly recently. This may well be attributed to the gradual development of water scarcity and the gradual increase in the marginal cost of new supplies. Also, the reallocation of

water rights has been taking place quite slowly. An issue not touched upon at all in this paper is the improvement of water quality. The market system as it is currently operating, does not have a great deal of influence upon the maintenance of water quality. District employees try to convince farmers that better irrigation systems necessitate less fertilizer and that they could save money by implementing efficient irrigation. However, this concept is just beginning to be accepted by the farmers.

Just as the water market in Northern Colorado has been adapted to its economic, political and cultural environment, it may be necessary to add certain features to make a market function in other settings. These features may be included right from the beginning or gradually while gathering experience with a newly-instituted market or in response to a changing environment.

Implications for Developing Countries

As pointed out by, *inter alia*, Ostrom et al. (1993), developing countries function under a number of constraints related to weak administrative structures and poor access to information. Many times, the solution seems to be the restriction of the government's role and an increased role for the market. Klitgaard (1991), on the other hand, takes the view that one has to analyze both the government's and the market's shortcomings and to improve the conditions of both.

In the case of water resources management, the existing approaches, which have been mostly based on substantial government involvement have not had the desirable results. The Water Conference in Dublin in 1992 (ICWE, 1992), Agenda 21 (UNCED, 1992) and the World Bank Water Resources Policy Paper (1993) therefore called for a rethinking of water management, emphasising two main principles, the need to manage water at the lowest appropriate levels and the need to treat water as an economic good.

In the search for an operationalization of these principles, a number of ways are conceivable, ranging from administrative systems and river basin committees to water markets. From the Colorado example we can learn that the implementation of a water market still implies both government involvement and active water user participation just as the other approaches do. The Colorado experience also makes clear that a number of the institutional ingredients that would be needed for other approaches, for instance an administrative system that registers and enforces timely water deliveries, a transparent and accepted measurement system, and a well-maintained delivery system, are equally required for a functioning market system. For these reasons, the difference between the implementation of a user-based administrative system and a market system may not be as large as one might expect (cf. Kemper, 1996).

The principal differences between the water market and a more administrative approach is the additional need for

- a system of definable and transferable water use rights which are regarded as proprietary.

- institutions internal to the market, such as information and transaction mechanisms.

- a physical delivery system that exists or can be economically constructed to facilitate the transferability of the right.

- a mechanism to negate the effect of third party interests or to mitigate impacts which might occur because of the transfer of water use rights.

While the introduction of water rights might encounter ideological opposition because water in most countries traditionally has been regarded as a public good, the Colorado example shows that a market can develop for usufructuary rights while the water itself remains public property. For this reason, the most challenging institutional feature might not be the institution of water user rights *per se*, but rather the implementation of adequate information and transaction mechanisms that provide all water users with equal possibilities of participating in

the market. These mechanisms would have to include access to price information, to registration, enforcement, and monitoring of rights. Since the weakness of administrative and legal systems is characteristic of developing countries, the fulfillment of these conditions poses special problems. However, these have to be evaluated in comparison to the equally substantial institutional needs for alternative water resources management approaches.

The experience of the water market in the Northern Colorado Water Conservancy District indicates that the introduction of water trading might be beneficial especially in the case of supplemental water supplies. In these cases, the new institutional set-up can be developed rather independently from existing institutional arrangements, such as historical property rights, administrative allocation mechanisms, etc. Therefore, in countries that, based on a first analysis, seem to broadly feature the basic institutional requirements, water trading could be introduced on a pilot basis in connection with new water storage projects. This step would be less radical than large-scale attempts to introduce water markets and the experience thus gained would provide insights in how to adapt and improve the institutional arrangements over time.

Conclusion

This paper has illustrated the institutional arrangements that were adopted in one particular water market in an industrialized country. Although the general application of case studies is always limited, the example provides a number of thoughts concerning the institutional aspects of water markets. Water markets can improve the efficient allocation and use of water and provide flexibility in the management of water during periods of shortage. However, institutional analysis shows that a number of conditions have to be in place before the markets can function effectively.

Whether these conditions exist or can be developed will depend on the institutional arrangements in the country. These issues must be carefully addressed before a decision can be made with regard to the possible adoption of a water market system as the best alternative for water resources reallocation. Precedent to the design of a reallocation framework, a comprehensive institutional analysis should be carried out to evaluate the ambient conditions and the probability of the successful introduction of market mechanisms and transferable water use rights in a specific setting.

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MAP SECTION

UNITED STATES OF AMERICA
COLORADO WATER MARKET

WATER MARKET BOUNDARIES
URBAN AREAS
CONTINENTAL DIVIDE
RIVERS
STATE BOUNDARIES

0 25 50 75
KILOMETERS

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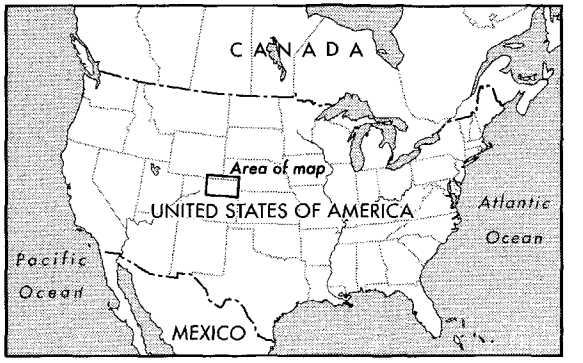

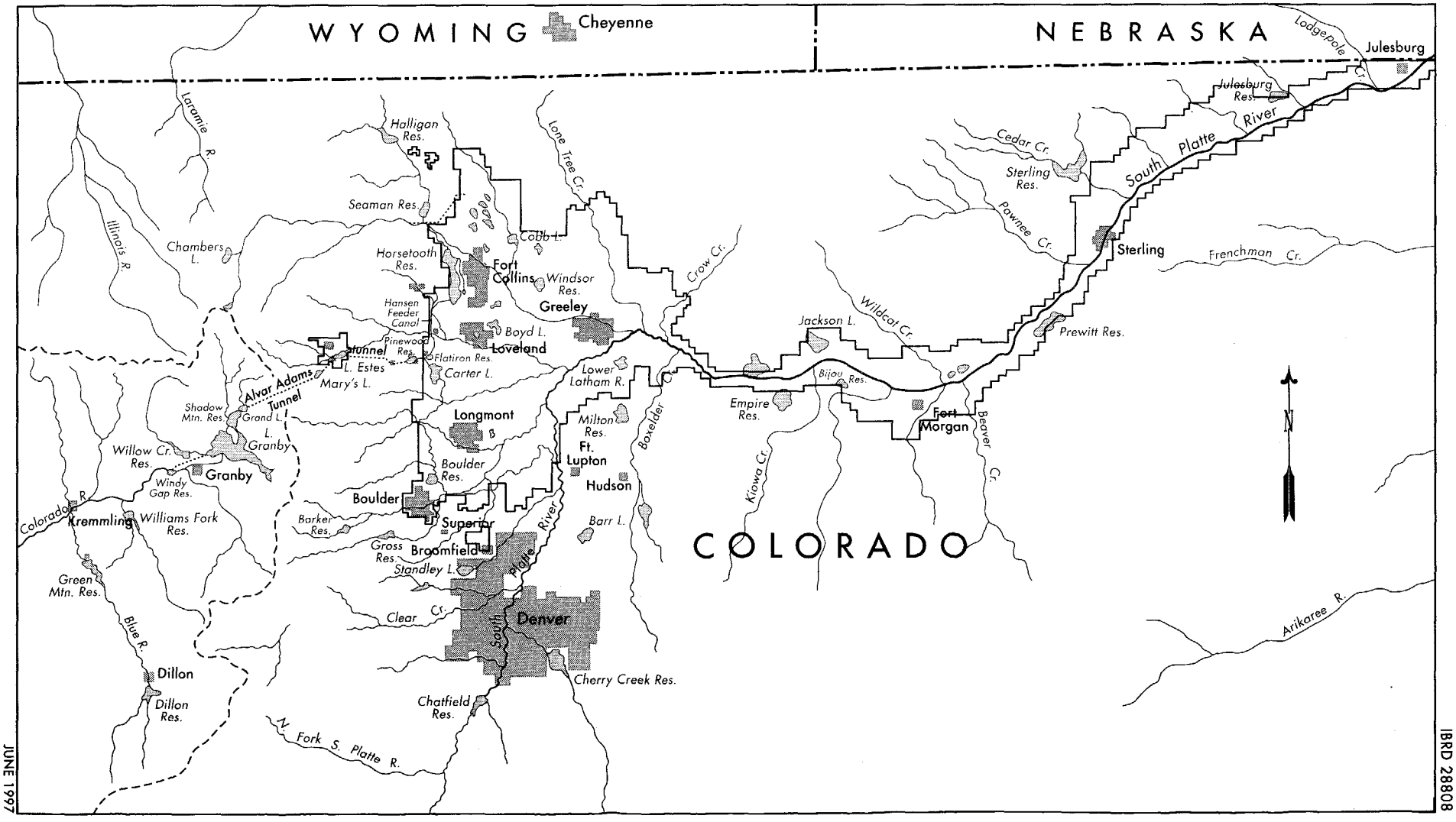

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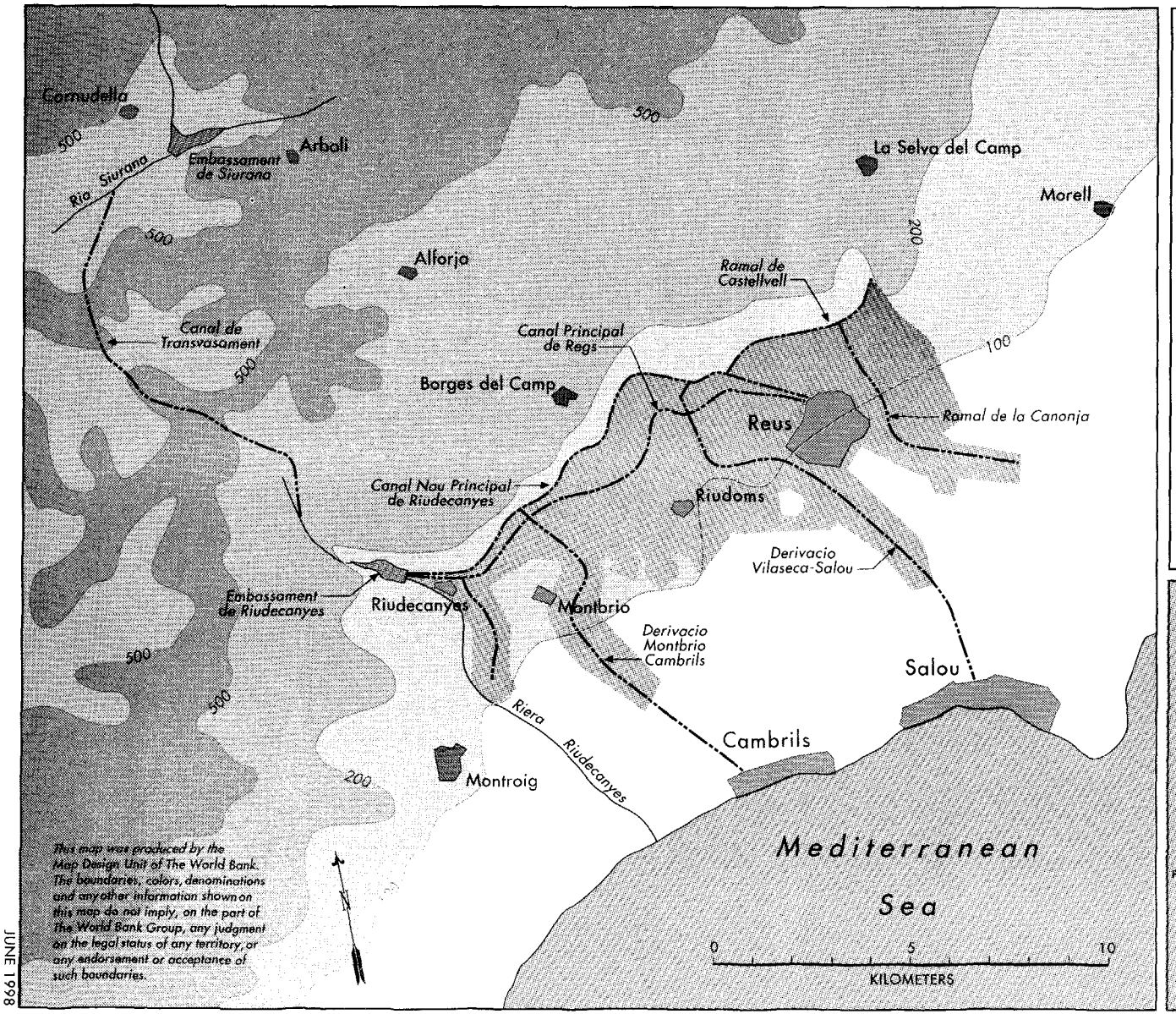
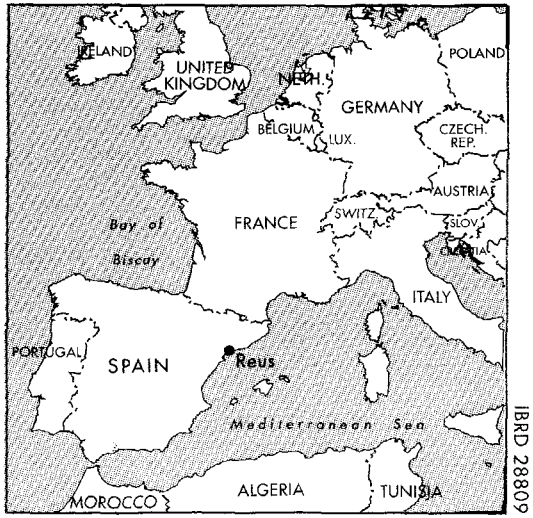


SPAIN
SIURANA-RIUDECANYES WATER MARKET

RIVERS
CHANNELS
IRRIGATED AREA
URBAN AREAS

ELEVATIONS:
500 METERS
200 METERS
100 METERS



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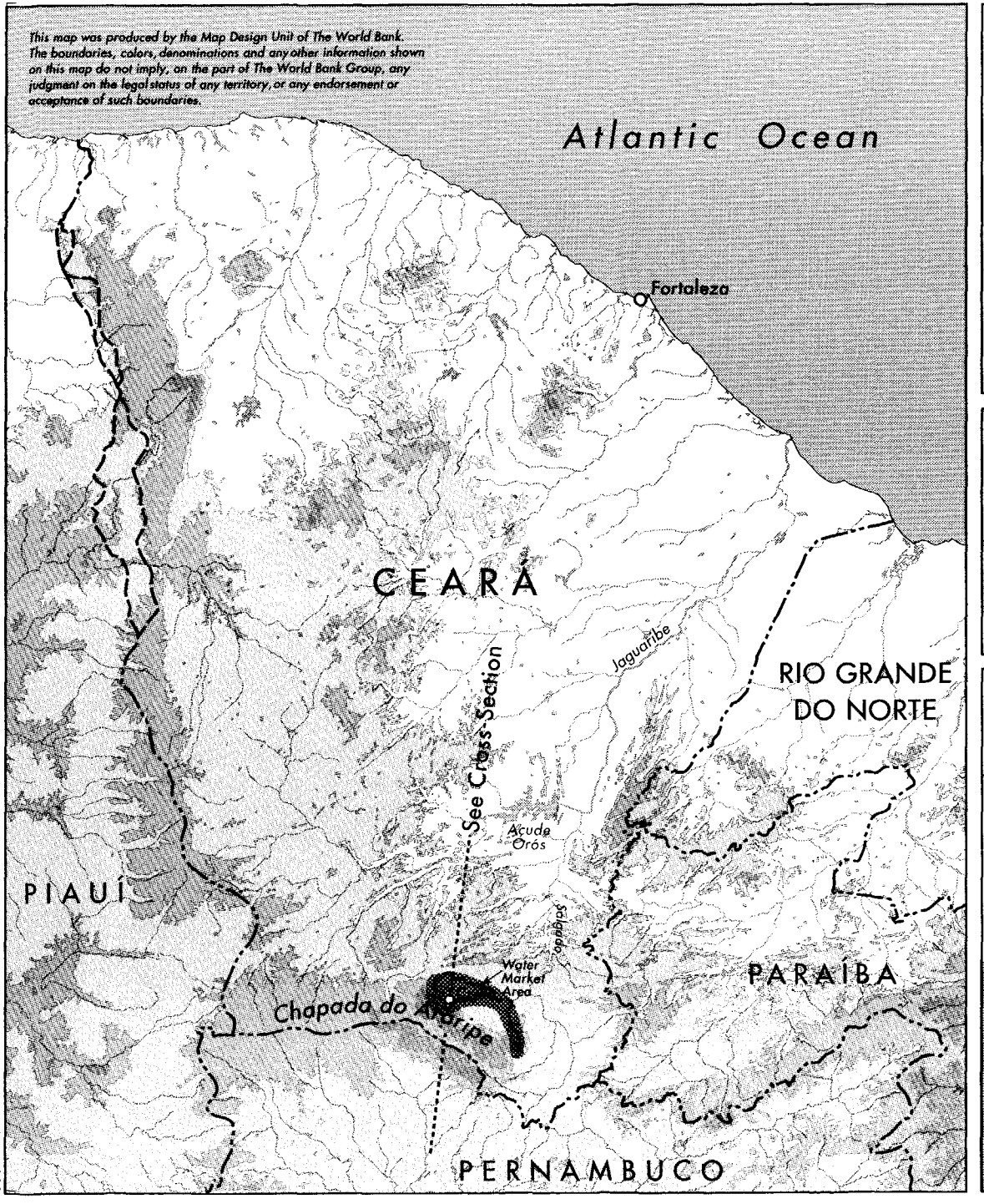
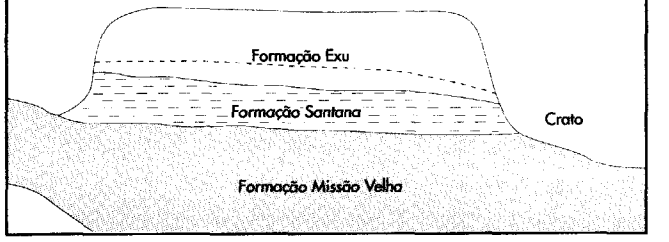


BRAZIL
CARIRI WATER MARKET

RIVERS
STATE BOUNDARIES
ELEVATION CONTOURS
ELEVATIONS IN FEET:
3000
2000
1000
0

0 50 100 KILOMETERS

CROSS-SECTION



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