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A Conceptual Framework for Analyzing California Water Allocation: Analysis of California Water Systems Under Drought Conditions

by

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Abstract

A Conceptual Framework for Analyzing California Water Allocation: Analysis of California Water Systems Under Drought Conditions

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Rocco V. Cappalla

Alleviating excess demand for water is a reoccurring issue in California. An analytical framework is developed to examine the different ways to eliminate excess demand for water in California. Four ways are examined in the marshallian cross framework. First, shifting the supply schedule to the right. Second, shifting the demand schedule to the left. Third, increasing the price of water to the equilibrium point. Fourth, closing the excess demand gap by administratively rationing the quantity of water consumed. The role of institutions in determining the price of water and building infrastructure to increase the stock of water is examined.

An analysis of household water consumption behavior during the drought of 1987-91 reveals that households voluntarily forwent water consumption. Models of social capital are used to explain the forgone water consumption by households during the drought. The determinants of demand include social capital. The traditional reliance on increased physical capital as a way to reduce excess demand for water is compared to the use of social capital as a way to reduce excess demand. Social capital will increase in importance as physical capital exhibits decreasing return to investment.

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Chapter 1: Introduction

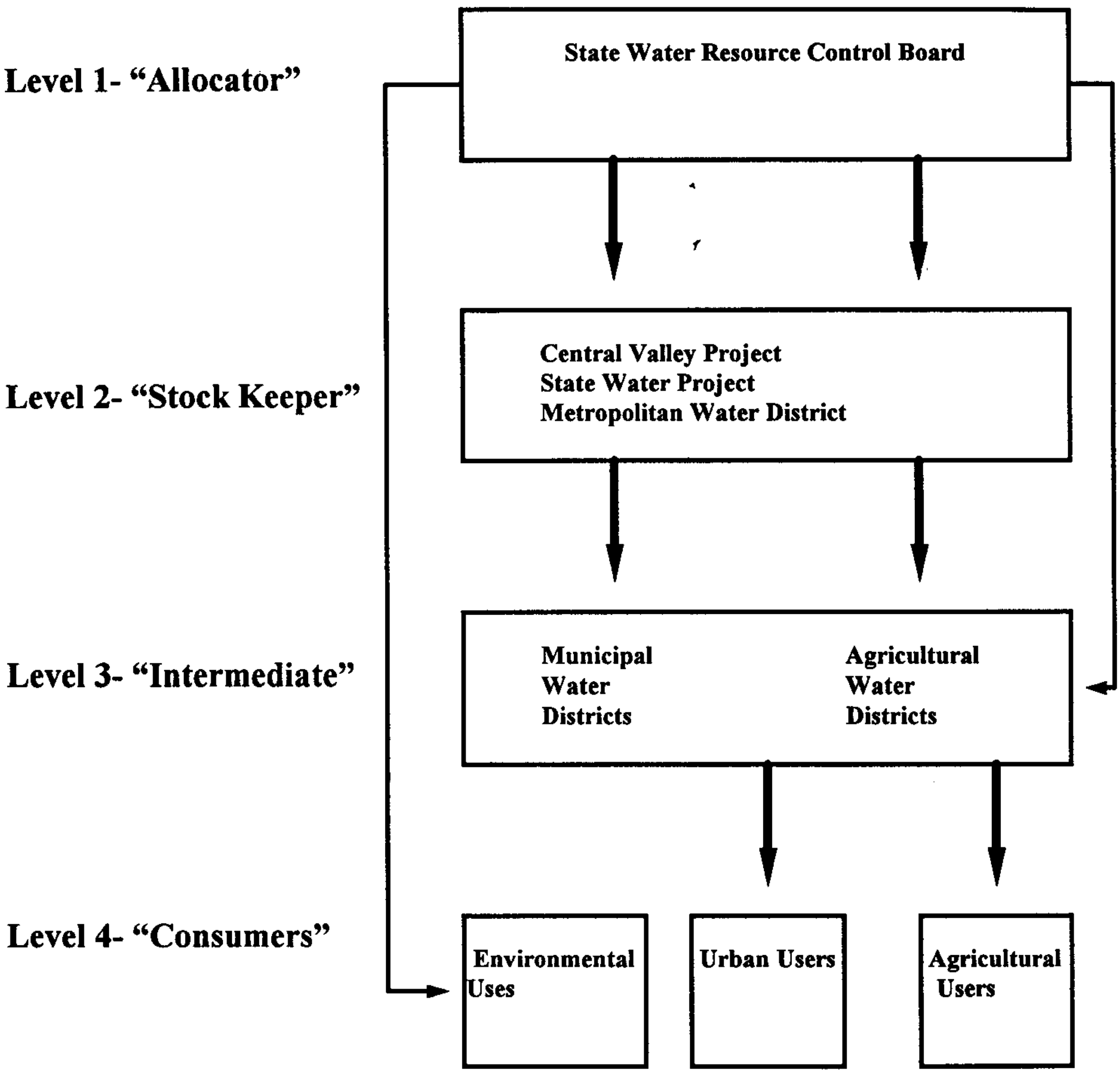
Water allocation in California is an important public policy issue. The drought of 1987-1991 affected agricultural users, urban users and environmental uses. At the height of the drought in February 1991, the Central Valley Project announced cuts of 75 percent to agricultural users and 50 percent to cities. The State Water Project cut off water deliveries to agricultural users and reduced deliveries by half to water districts that serve primarily urban areas (NYT, 15 Feb 1991). Many of the issues that surfaced during the drought are unresolved. One such issue is the appropriate response when supply is less than demand. In 1996, California has over 30 million residents, a 20 billion dollar agricultural sector and an environmental movement that all desire water. Meeting the needs of these diverse groups is an important issue in California today.

Water in California is scarce. In an average year California uses 82.5 % of the runoff in its river basins. In dry years that figure increases to 112.7%(Vaux, 1986). In addition surface water is highly variable as it is highly dependent upon rainfall. Ground water is an important source of water for the state. However, for most aquifers the extraction rate cannot be increased without creating an overdraft. Increasing the rate of water extraction from the Colorado river is not a viable option as the rules governing water allocation among western states are unlikely to change soon.

Water allocation in California today is characterized by central administration. In the framework developed here water allocation is divided into four levels for analytical clarity. At level 1, the highest level, use rights of water are allocated administratively by regulatory boards to lower organizational levels. These use rights are granted without a price. The relationship between level 1 and lower levels is adjudicatory. At level two, surface water is captured and stored by client-oriented organizations such as the CVP and the SWP and sold on a contractual basis to level 3. Since water is traded at a price, a market exists between level 2 and level 3. Level 3 is primarily composed of groups of end users such as municipal water districts and farmers organized into agricultural water districts. In addition to water purchases from level 2 organizations, level 3 organizations typically hold senior water rights allocated from level 1 which are developed into water supply by building storage and conveyance infrastructure. Level 2 differs from level 3 as level 2 does not sell water directly to end users while level 3 sells directly to end users. Level 3 organizations sell water to level 4 users. Thus, a market exists between level 3 and level 4. Level 4 is composed of the final users; farms, households and industry (Burton, 1992).

Figure 1 illustrates the organizational structure of surface water allocation in California. At level 1, the State Water Resource Control Board (SWRCB), allocates surface water rights to lower levels. Some of these water rights are allocated directly to level 4 environmental uses. Many of these water rights are allocated to level 2 organizations, such as the Metropolitan Water District (MWD), State Water Project (SWP) and the Central Valley Project (CVP). They build, maintain and operate the storage and conveyance facilities that are required to use the surface water in the state. These level 2 organizations sell water to level 3 organizations, such as municipal water districts and agricultural water districts. The level 1 SWRCB also allocates some water rights directly to the level 3 organizations which then develop the water rights. Thus level 3

Figure 1. Organization of Surface Water Allocation



organizations purchase water from level 2 as well as develop water rights that were originally allocated to them by the SWRCB. Level 3 then sells water to level 4, the final users.

Figure 2 illustrates the organizational structure of ground water allocation in California. Groundwater allocation is much less hierarchical than surface water. At Level 1, three different types of organizations allocate ground water. First, groundwater management agencies that are mandated by the California Legislature to limit the amount of water extracted from an aquifer. Second, level 3 surface water organizations with responsibility for groundwater allocation. Third, court adjudicated water basins that determine the quantity of water that a well owner is permitted to extract. Level 2 is dormant as the stocks are stored naturally in the ground and conveyance is limited since most ground water stocks are used near the extraction site. Thus level 1 organizations allocate water rights administratively to level 3 and level 4. Level 3 organizations sell groundwater to level 4 final users. In cases where level 4 final users are allocated groundwater rights directly from level 1, the holder of the right is permitted to extract water from the aquifer.

Figure 3 illustrates the organizational structure of California's share of Colorado river water allocation. California's share of Colorado river water is allocated among level 2 and 3 organizations by the level 1 SWRCB. Level 2 only exists for water destined for urban use and consists of the MWD. The MWD sells water to level 3 municipal water districts. These municipal water districts sell water to level 4 municipal end users. Water destined for agricultural use is extracted from the Colorado river by level 3 organizations such as the Imperial Irrigation District. These level 3 organizations sell water to level 4 farmers.

Figure 2. Organization of Groundwater Allocation

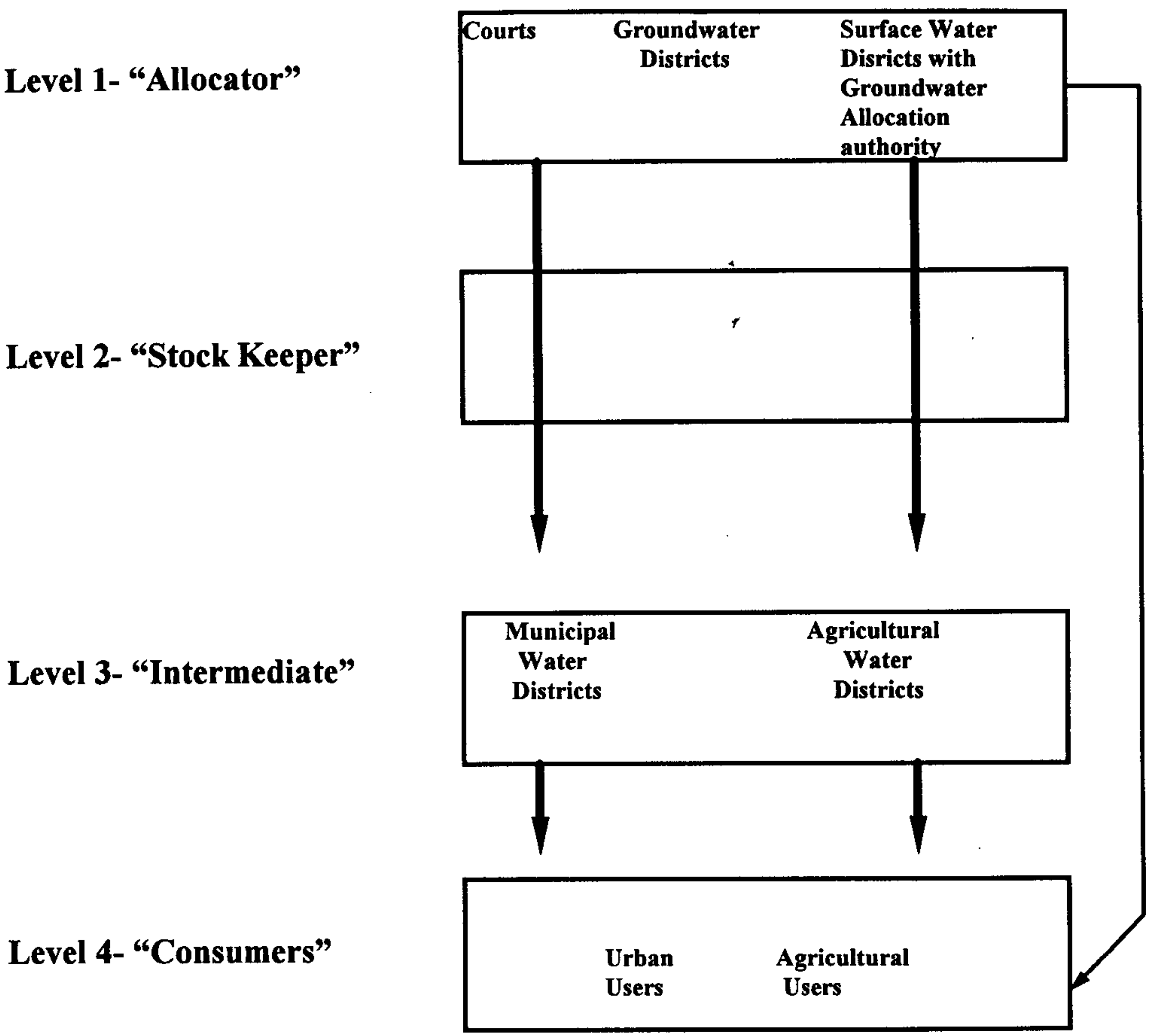
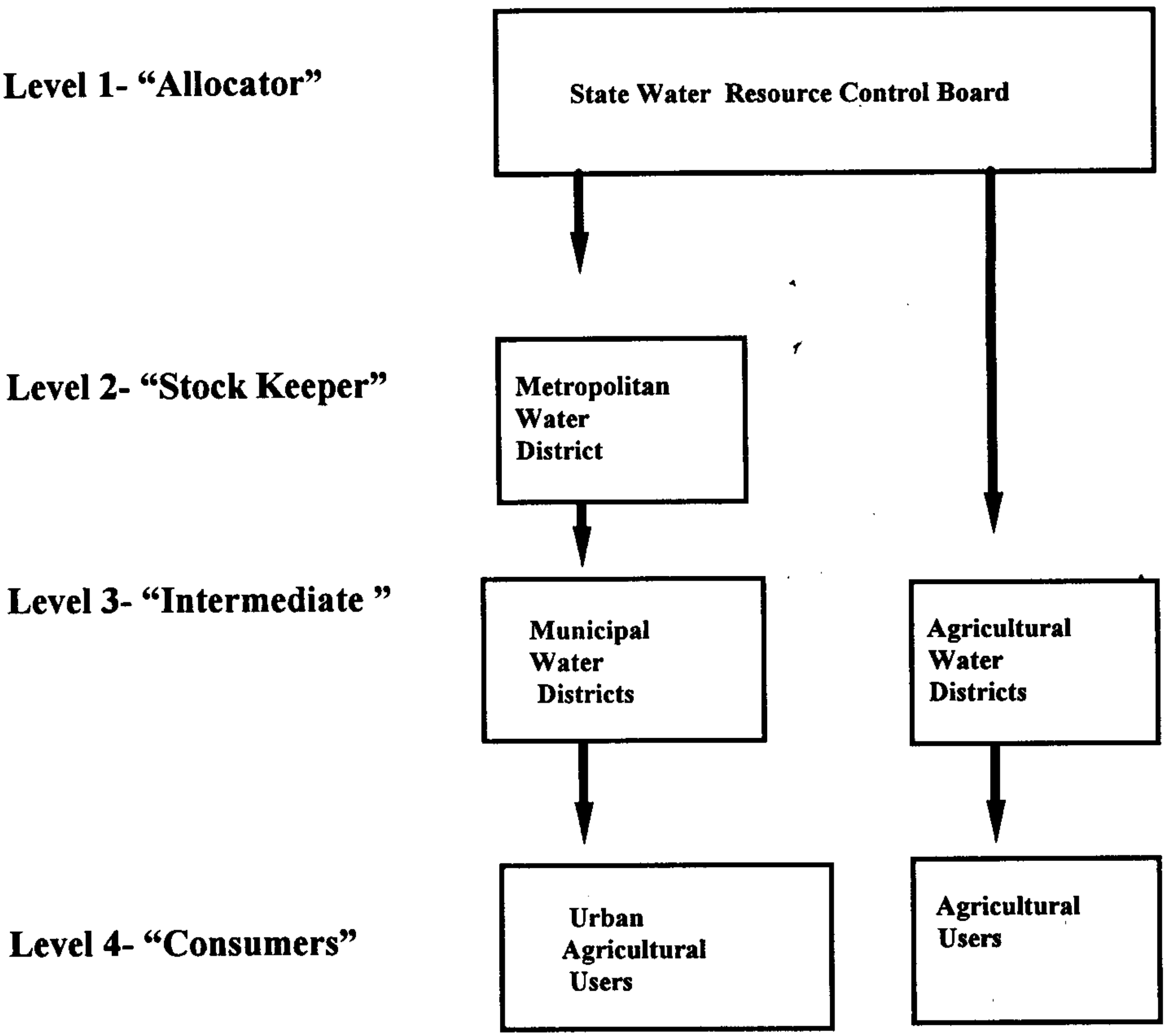


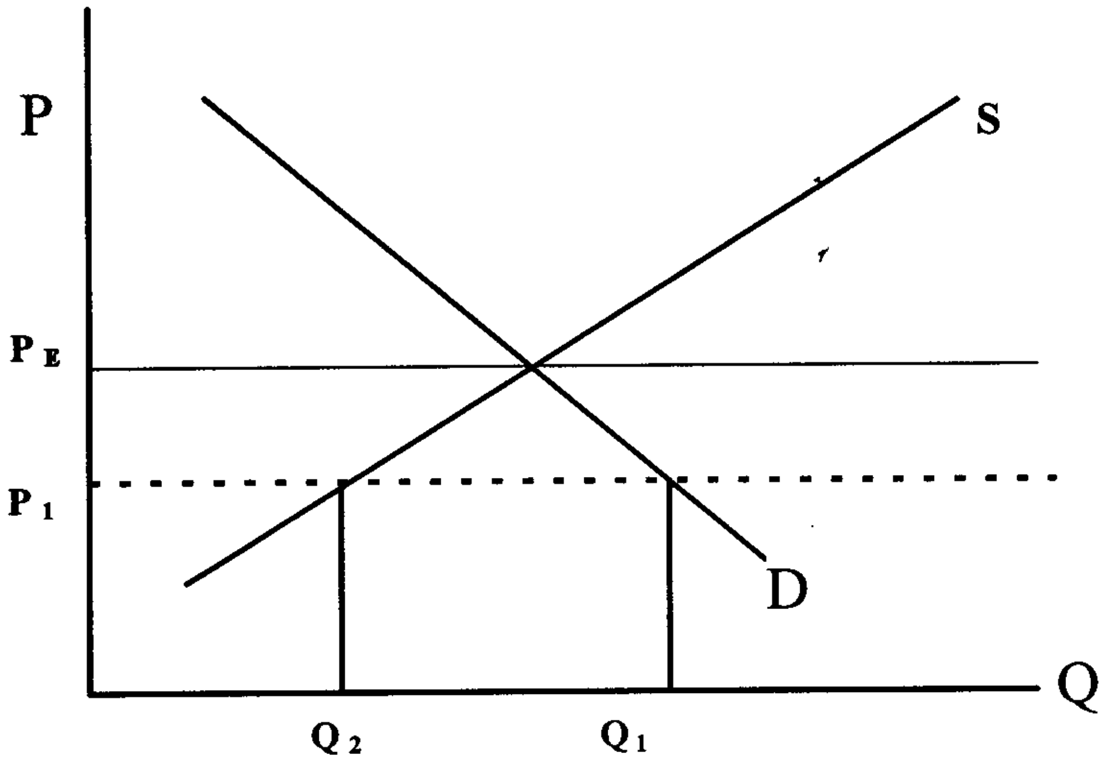
Figure 3. Organization of California's share of Colorado River Water Allocation



This description of the organizations that allocate water is complemented by a description in Chapter 3 of the institutions or rules that dictate, a) how the allocation of water rights from level 1 to level 2 is determined, b) how institutions determine the price of water traded between level 2 and level 3 as well as the price between level 3 and level 4 and c) the stock at level 2 and 3 which is highly dependent on investment in infrastructure.

As water moves between levels 2 and 4 exchanges occur at administratively fixed prices. Water prices do not change to reflect the equilibrium of supply and demand. Price is determined exogenous to the market. The price is set to cover the costs of infrastructure loan payments, maintenance and general operation of the water system at all three levels. The organizations that set prices are not profit maximizers and do not set prices to equilibrate supply and demand. In Chapter 5, the effect of changing prices is explored. At cost-covering prices, when quantity supplied is less than quantity demanded, excess demand is present. Figure 4 shows excess demand as the quantity between Q_1 and Q_2. This paper seeks to construct an analytical framework to explain how to alleviate excess demand for water in California. The analytical framework is used to situate the following question. Why did urban households respond to the drought of 1991 by foregoing water consumption?

Figure 4. Excess Demand



At P 1 , Excess Demand is the quantity demanded between Q_1 and Q_2

Chapter 2: Conceptual Framework

The conceptual framework uses a Marshallian cross as the foundation to analyze the possible ways to alleviate excess demand for water. Because water systems for all groups and the rules that govern water allocation are not homogenous each of the major sources of supply and demand of water will be analyzed in detail in chapters 3 and 4 respectively.

The concepts of stock and flow are important for analysis of natural resources. Stock refers to the amount of the resource that could be utilized. The water stock in California is the water that has been captured in reservoirs and ground water. The flow is the supply schedule which shows the relationship between the quantity supplied and the price. The supply schedule is a function of stock and conveyance infrastructure.

$$\textit{Quantity supplied} = f\left(\textit{Price of water} \mid \textit{Stock, Conveyance infrastructure}\right)$$

Institutions affect the quantity supplied in two different ways. First, the price of water in the level 2-3 water market is determined exogenous to the market. The rules of the level 2 organizations determine the price of water in the level 2-3 market. The same occurs in the level 3-4 market. The rules that govern the operation of level 3 organizations determine the price of water sold to level 4 end users. Second, the infrastructure needed to create stock and conveyance infrastructure requires investment that would not be forthcoming if institutions were not present to Invest capital into infrastructure projects. Chapter 3 analyzes the role of institutions in building stock and conveyance infrastructure.

The demand schedule is a function of numerous factors depending on the use of the water. Urban[1], agricultural and environmental demand schedules are analyzed in Chapter 4. In chapter 6, I will focus on the relationship between the urban demand schedule and social capital. The determinants of quantity demanded are stated below:

$$Quantity\ demanded_{Urban} = g\ (Price\ of\ water|,\ Income,\ Population,\ Preferences,\ Social\ Capital\ )$$

$$Quantity\ demanded_{Agricultural} = h\ (\ Price\ of\ water,|\ Irrigation\ technology,\ Price\ of\ agricultural\ products,\ Farmer\ preferences,)$$

$$Quantity\ demanded_{Environmental} = j\ (Price\ of\ water|,\ Income,\ Preferences,\ Demand\ for\ recreation\ services)$$

Quantity $demanded_{Urban}$+ Quantity $demanded_{Agricultural}$ +Quantity $demanded_{Environmental}$ = Total quantity demanded

The point where the supply and demand curves intersect determines the equilibrium price. If price is determined endogenously by the intersection of the supply and demand curves then no excess

[1] Urban demand consists of Municipal and Industrial use of water. Municipal includes, but is not limited to household use. For the purposes of this paper urban use is considered household use.

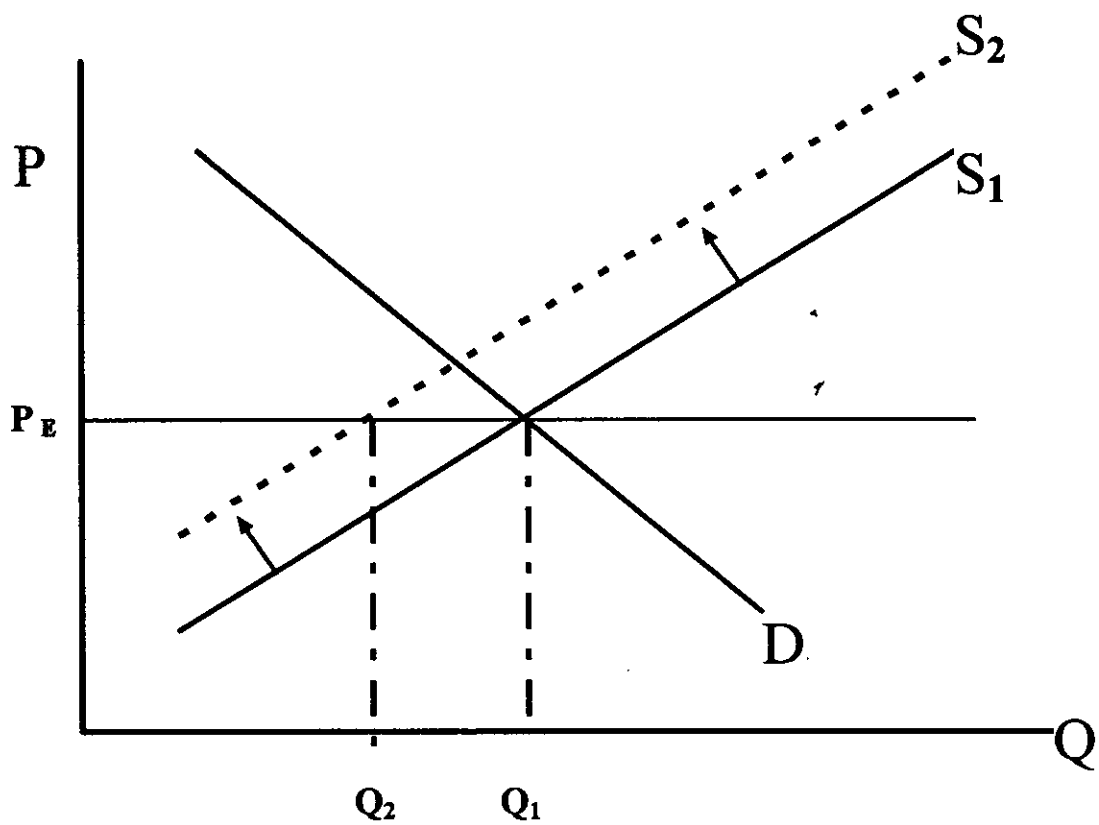
demand is present. However if the price is set outside that then excess demand (excess supply) will result if the price is lower (higher) than the equilibrium price.

Excess demand can be caused by a number of factors. First, given a supply and demand, the price of water can be set too high. If the price is set exogenous to the market this can happen if the rules for determining the price select a price higher than the equilibrium price. Second, if the price is equal to the equilibrium price initially, then an increase in population can shift the demand curve to the right. Third, Figure 5 shows the excess demand created by a drought which is conceptualized as a supply shock in which the supply curve shifts to the left. Excess demand is shown as the quantity between Q_1 and Q_2. In this framework excess demand can be alleviated in the four different ways shown below or in some combination thereof.

First, the supply curve could be shifted to the right to eliminate excess demand. The price is administratively fixed in this example. Shifting the supply curve to the right is the traditional method used by level 2 stock keepers to address long-term excess demand. There are some constrains to shifting the supply curve to the right: 1) Additional infrastructure development requires large capital investments and time to implement. In a drought the time required to build additional infrastructure may preclude this option. 2) Additional infrastructure has declining returns to scale and may have limited effect in shifting the supply curve to the right.

Second, the demand curve could be shifted to the left. As in scenario 1, price is held constant. Demand is a function of numerous variables as outline above. Changes in the magnitude of the

Figure 5. Drought induced supply shift.



1) A drought occurs.

2) Drought induces a supply shift from S_1 to S_2.

3) At P_1, excess demand is the quantity between Q_1 and Q_2.

factors other than price can shift the demand curve. Demand as a function of social capital might explain why the demand curve can shift inwards. Chapter 6 will address shifts in the urban demand curve due to social capital.

Third, a combination of decreased quantity demanded and increased quantity supplied induced by a higher price could eliminate excess demand. The quantity of water demanded would decrease along with leftward movement along the demand curve. The quantity of water supplied would increase with movement along the supply curve. A supply response to a higher price depends on the marginal cost of producing more water. Block pricing has been introduced by some level 3 organizations as an incentive for level 4 final users to reduce their water consumption.

Fourth, the excess demand gap could be closed by an administratively rationing water by quantity. This is different from reducing excess demand as the demand is present but not being met. Some criteria is required to determine what users will receive water and how much they will receive. The rationing can occur at different levels. Level 2 organizations administratively rationed water to level 3 during the drought of 1987-91.

Here I use total supply and demand for water. However, the rules that govern water allocation between levels 1&2 and water prices vary greatly between the different levels of organization, as well as between different user groups. In addition, elasticities of supply and demand are different among user groups. Thus in Chapters 3 and 4 I break down total supply and demand into the different levels of organization and user groups.

Chapter 3: Supply

3.1 Introduction

Surface water in California is concentrated in the northern part of the state while the population is concentrated in the southern part of the state. Thus the stock of water requires transportation to become effective supply. The supply of water is dependent on both a stock of water as well as conveyance facilities to transport the stock to the source of demand.

In this chapter, surface water, groundwater and water extracted from the Colorado river are examined in terms of their stock, flow and conveyance characteristics. The rules which determine water rights are presented in section 3.5.

3.2 Stock and conveyance of surface water in California

The traditional method of increasing the stock of surface water was to build infrastructure to capture a greater percentage of surface water flowing to the sea. At the stock-keeper level, the largest developers of surface water stock are the Central Valley Project (CVP) and the State Water Project (SWP). The CVP, which is administered by the US Bureau of Reclamation was started in the 1930's and was not completed until the 1950's. It currently stores and distributes 7 Million Acre Feet[2] (MAF) or about 20 % of California's developed water in years with normal precipitation. The majority of that water is used for agriculture. The SWP was started by California governor Pat Brown in the 1960's and supplies and delivers 2.8 MAF or about 8% of

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[2] An acre-foot is defined as the amount of water needed to cover one acre of land with water one foot in depth. It contains about 326,000 gallons of water and is about the average amount of water used by a family of four for one year of average household use.

California's developed water. Of that 2.8 MAF roughly 70% goes to non- agricultural use and 30% to agricultural uses (Water Education Foundation, 1996). Intermediate level water organizations also build infrastructure capable of capturing stocks of water and distributing water to end users. The scale is typically smaller than level 2 organization projects. Increasing water stock in the future by building more infrastructure is not a viable option in the 1990's for a number of reasons. Vaux (1986) points out that the costs of proposed water projects are greater than costs of past projects. The returns to water projects have been declining as the number of prime sites is limited. Increased concern about the environmental impacts of water storage and conveyance facilities has increased the costs of building new dams as well as increasing political opposition against new water projects. Shabman (1995) writes that federal support for water development projects has drastically declined to the point where it appears the "... Bureau of Water Reclamation appears to be out of the water project construction business"

3.3 Stock and conveyance of Colorado river water

The share of water allocated to California from multi-state providers of water such as the Colorado River is fixed. California's claim to Lower Basin Colorado River water was fixed by a US Supreme Court decision, Arizona v. California (373 US 546, 552, 1963), at 4.4 MAF per year (Tarlock, Corbridge and Getches, 1993). Thus at level 1 the stock of water that can be allocated to level 2 and 3 organizations is fixed. Oamek (1990) explores the possibility of interstate water transfers from the upper Colorado River Basin to the lower Colorado River Basin (which includes California) and concludes that 400,000 AF could be transferred if institutional constraints were overcome. He points out that, "without some sort of reciprocating agreements none of the states in the Colorado Basin allow private parties to enter into water transfer pacts that cross state boundaries." Of course this leaves open the possibility that public entities could enter into agreements, but profit maximization is not a typical goal of public agencies.

3.4 Stock and conveyance of ground water

Ground water stocks provide about a third of California's water in an average year and up to two-thirds in dry years (Water Education Foundation, 1996). California has a large stock of usable groundwater estimated to be 400 MAF. In years with average rainfall and runoff, 15 MAF of water a year is extracted and used (California Department of Water Resources, 1994). The pumping and conveyance facilities are typically operated by level 3 organizations and in some cases by level 4 agricultural users who extract water directly for farm use.

3.5 Rules for allocating water stock

Surface water stocks are allocated to holders of surface water rights. Most water rights are embodied in the 12,000 water permits issued by the SWRCB. Many of the water permits are issued to level 2 stock keepers. However some water rights belong directly to the level 3 organizations. The intermediate level organizations purchase water from the stock keepers and then sell the water to final users. Many farmers have water contracts with level 3 organizations that extend up to 40 years that specify the amount of water and the price. These contracts are not water permits but can be considered an extension of the allocation by permit system.

Ground water rights are allocated at the local level. Burton (1992) points out that the State of California has little control over groundwater rights as the ownership of land confers the right to sink a well and pump groundwater. However the State requires landowners overlying a common groundwater basin to organize groundwater management districts to regulate the amount of groundwater each landowner is allowed to withdraw from the aquifer.

While there are numerous levels at which allocation of water rights are made, all property rights are dependent on legitimation from the society that grants them. Bromley (1991) defines a right as "the capacity to call upon the collective to stand behind one's claim to a benefit stream." At level 1 this means that the policy process influences the rules that the SWRCB must follow when allocating permits. These rules can and do change. The following institutions are the cornerstones of water allocation at level 1 and 2.

3.5.1 Legal and Administrative Framework

California has a unique set of water rights that combine Riparian water law, Prior Appropriation water law and administrative law. State agencies such as the SWRCB administratively allocate water rights in accordance with all applicable judicial rulings and administrative law. The SWRCB issues permits which allow the holder to use the water resources of the state.

3.5.2 California Constitution

The California Constitution was amended in 1928 with Article X, Section 2 which requires that all uses of the State's water be both "reasonable" and "beneficial". This amendment mitigated the rights of riparians to a undiminished stream of water. The definition of reasonable and beneficial use is evolving and the determination by the courts and on reasonable and beneficial uses of water illustrates that water rights in California are not absolute. Tarlock, Corbridge and Getches (1993) points out that recreation was added to the list of beneficial uses in the mid-twentieth century and this led to protection of in-stream flows.

3.5.3 Riparian and Prior Appropriation

California recognizes both riparian rights as well as appropriative rights. These two traditions of water law are different in their origins, method of establishing water rights and methods for alleviating excess demand.

Riparian doctrine has its roots in English common law and was adopted by the higher rainfall states of the Eastern US. The main tenants of riparian doctrine are:

1) Water rights are acquired by ownership of land abutting a body of water.

2) The water must be "reasonably" used on adjoining land.

3) Not limited in quantity, except reasonable in relation to other riparians.

4) Not lost through non-use.

5) Exists independently of demands of appropriators.

6) In times of shortage, senior appropriators may not deny use of senior appropriators sharing the same water source.

The Prior Appropriation doctrine was developed in the western US where lack of rainfall and the early economic activities of mining and agriculture greatly shaped its development.

The main tenants of the Prior Appropriation doctrine are:

1) The first party to divert and reasonably, beneficially use a specified quantity of previously unused water acquires a continuing right to its use.

2) Subsequent rights are inferior to all those previously established and superior to those established later.

3) Water rights are subject to forfeiture for non-use.

The SWRCB allocates water using prior appropriation doctrine (Burton,1992). Some water rights were established before the SWRCB came into existence in 1913. Many of these rights are riparian in nature.

3.5.4 Public Trust

The Public Trust doctrine requires that public trust resources be balanced against other water claims such as agricultural, mining, and industrial use The Public Trust Doctrine, which has its roots in Roman Law, was the legal basis of the 1983 California Supreme Court case National Audubon Society v. Superior Court of Alpine County (33 Cal.3d 419) in which the rights of public trust resources were required to be balanced when granting water rights to "beneficial" uses, such as providing water to the City of Los Angeles (Loomis, 1995). The significance of the public trust doctrine is that allocation of water rights depends on how the claims of public trust are balanced against other claims in the legal system.

3.5.5 The Federal Government

The federal government shapes the rules of water allocation in California through numerous acts of Congress, administration of federal lands, federal laws concerning the environment, and other federal rules. The principle acts of Congress are the Federal Powers Act, the Reclamation Act and federal legislation concerning the Colorado river .

The Federal Powers Act applies to hydroelectric projects in the state. Since the water stock behind many dams serves the dual purpose of hydroelectric electricity generation as well as potential water supply the Federal Energy Regulatory Commission has a role in the allocation rules of water stock in California.

The Reclamation Act of 1902 created the Bureau of Reclamation which built and administers the Central Valley Project. The agrarian ideal of homesteaders farming 160 acre plots in the Central Valley was essential to the passage of the act and to subsequent congressional legislation that authorized the CVP in 1933. A result of this legislation was a price for water determined administratively that made farming profitable for homesteaders. Currently there are three prices[3].

[3] The GAO(April 1994) lists the three water rates. The first is a "fixed contract rate" that is intended to repay the capital costs of CVP infrastructure without interest. Operation and maintenance (O&M) costs are paid on a per acre-foot basis. The second is a "full cost rate" which is a result in the Reclamation Reform Act of 1982. The full cost rate includes O&M costs as well as capital costs with interest. The act also changed the acreage limit a farmer could irrigate with water purchased at fixed contract or full cost rate from 160 to 960 acres. The third rate is the "cost of service rate" which includes payment of capital costs with out interest by 2030, operating and maintenance deficits by 1985 and annual O&M costs every year. These different prices for water are set based on what the Bureau of Reclamation administratively decides should be included in the cost of water to agricultural users.

These exogenously determined prices are illustrative of the relationship between price and the water rights farmers hold in the form of water contracts. The holders of water rights have not paid back the capital and interest to the federal and state agencies that built the infrastructure required to create a stock of water and deliver it to their land. The public has tacitly agreed to allow farmers to buy water at a price that does not cover the costs normally accounted for in infrastructure construction is a property right of the type used by Bromley.

The Colorado River Compact of 1921 allocated the water of the Colorado River between the Upper Basin States (Colorado, Utah, Wyoming and New Mexico) and the Lower Basin States (Arizona, California and Nevada). The Upper Basin States allocated water among themselves in the Upper Basin Colorado River Compact of 1949. The Lower Basin States could not agree on the allocation of the 7.5 MAF allocated to them in the Colorado river Compact of 1921. The US Congress apportioned 4.4 MAF to California in the Boulder Canyon Project Act of 1928. This decision was upheld by the Supreme Court in Arizona v. California (1963). The Supreme Court has original jurisdiction over disputes between states and uses the principle of "equitable apportionment"(Getches, 1985). This allocation occurred at pre-level 1 in the analytical framework here.

Since the Colorado River runs through a number of states in the Western US the Supreme Court has jurisdiction over disputes between the states. The federal government is also involved in the allocation of Colorado river water since it has a treaty with Mexico guaranteeing a minimum river flow of 1.5 MAF into Mexico (Getches, 1985).

3.5.5 Water transfers

The institutions that govern allocation of water rights is set out above. However another set of institutions determine if water rights are transferable between organizations at the same level. Figures 1,2 and 3 illustrate the vertical direction of water transfers in California. Transfers of water horizontally is an issue that is central to a expanded water market.

Markets come in many different forms and the Water Banks[4] that were created during the 1987-91 drought transferred water from level 4 agricultural users to non-agricultural level 3 organizations. The temporary nature of the water banks avoided legal challenges to the "reasonable and beneficial" clauses in the rules of water allocation. If water banks became permanent, the definition "reasonable and beneficial" could be disputed in court.

[4] A water bank is defined as a formal mechanism for pooling surplus water rights for rental to other users.

Chapter 4: Demand

4.1 Introduction

The demand for water has expanded rapidly in California as population growth and increased demand for environmental uses of water shifts the demand curve to the right. In this chapter the demand function will be disaggregated into agricultural, urban and environmental uses. In addition, social capital as a demand shifter will be examined.

4.2 Shifting of the urban demand curve

Urban demand is composed of municipal and industrial use. Municipal use in this paper is approximated to be household use. Household use is a function of price, income, population, preferences and social capital. Growth in demand is a function of growth in population. Howitt (1995) uses a 6% annual growth figure in his model of California water supply and demand. Predicting the rate of population growth is difficult but increasing population will push the demand curve out to the right. Lowering per capita use of water as a method to shift the demand curve to the left is the subject of Chapter 6.

4.3 Shifting of the agricultural demand curve

The agricultural demand curve is a function of irrigation technology, price of agricultural products, and farmer preferences. The demand for agricultural products creates derived demand for water in agriculture. Derived demand for water is a function of price for agricultural products that use water as an input in the production process. Farmers generally purchase their water from level 3 organizations. In addition many farmers have water rights to underground water granted to them by level 1 groundwater rights allocators. In times of drought farmers may increase the amount of water extracted from aquifers to which they have water rights.

4.4 Shifting of environmental use demand curve

The environmental use demand curve is a function of income, preferences, and demand for water-based recreational services. Water-based recreational services are activities such as fishing and canoeing. When level 4 consumers demand water-based recreational services they create a derived demand for minimum in-stream flows to support fish, as well as wild and scenic rivers.

Preferences for environmental use of water has led to legislation protecting the water needs of fresh-water wetlands and the Bay Delta requirements (California Department of Water Resources). The demand from consumers at level 4 is not direct market demand, rather it is channeled through the political process and results in allocation at level 1 and distribution at level 2 of water to environmental uses. An example of this process at level 1 is the SWRCB revoking the water permits granted to the city of Los Angeles to extract water from the steams that flow into Mono Lake. An example of this process at level 2 is the Central Valley Project Improvement Act of 1992. This legislation earmarked for environmental use 800,000 acre-feet of water from the water allocated to the CVP by the SWRCB. The interests of citizens concerned about the impacts of water diversion are represented by interested agencies and parties such as the US Fish and Wildlife Service, the state Department of Fish and Game, and private environmental groups such as the Environmental Defense Fund.

4.5 Demand shifts from Social Capital

Social capital theory posits a link between individual utility and the utility of other people, objects, or institutions. Social capital models are used by Robison and Hanson (1995) and Schmid and Robison (1995) to explain behavior that is difficult to explain using the assumption that individuals seek to maximize their own utility and that the utility of others is not a concern of theirs.

Social capital has its roots in work by Coleman (1988), "Social Capital is defined by its function. It is not a single entity but a variety of different entities, with two elements in common: they all consist of some aspect of social structures, and they facilitate certain actions of actors-whether persons or corporate actors-within the structure." Flora and Flora (1995) define social capital as, "networks of reciprocity and mutual trust involving shared symbols and collective identity." Putnam (1993), Gwilliam (1993), Siles (1992) and Lynne (1995) have demonstrated the existence of social capital and the difference in outcomes that results from its presence.

The presence of social capital causes individuals to take the utility of others into account when making a decision. Frank (1988) suggests that pursuing self-interest is incompatible with its attainment. If an individual is known to be untrustworthy and unwilling to keep a commitment then that person will forgo opportunities to increase their self-interest that would have been offered had they been trustworthy.

Social capital can be modeled in numerous ways. I will look at three below.

Rational-actor model.

Robison (1996) introduces a number of social capital coefficients in his definition of a utility function. A rational actor is maximizing his utility which is given as:

$$Max_x U = U[\pi_i(x), K_{ii}(x), \pi_j(x), K_{ji}(x), K_{ij}(x)]$$

where the first term is the utility of own income and is the sole term of the neoclassical model. The second term is the social capital to oneself. The third term is utility in j's income. The fourth term is social capital of j towards I. The fifth term is social capital toward j.

Disaggregating the reasons households reduced water consumption into the different aspects of social capital is a empirical question that could answered with further research.

Emotive Model

Schmid and Robison (1995) propose a emotive and cognitive model of social capital. They define the emotive aspect of social capital as "reflected in such words as love, caring, sense of community, sympathy, guilt and hatred." The cognitive model adds complexity of the decision making process and assumes that individuals do not calculate every decision they make. It posits that habit and rules of thumb are the way that some decisions are made. Bounded rationality (Simon, 1991) and limited information limit the continuous marginal calculations that are assumed in a rational actor model. This model assumes that consumers don't calculate every gallon used whenever the tap is turned on.

In this model people may save water because they have social capital to themselves or because they are willing to share the burden of decreasing water use with their neighbors, even if they could out bid them for the water and maintain previous levels of use. The boundaries between the different components as envisioned in a rational-actor model may be too blurred in the respondents own mind to be disaggregated into crisp components. It may be sub-conscious pattern recognition (Margolin).

Meta-Preference Model

Lynne (1995) proposes a meta-preference model of social capital. In this model there are two types of preferences. First are meta-preferences which are the preferences that are preferable to the society. The second are the preferences of the individual alone. Lynne uses meta-preferences to explain the adoption of water saving technology by strawberry growers in Florida. In this model the strawberry growers have two preference functions. The first is the individual preference which is to maximize profit. The second is the meta-preference which is to save water. The decision of the farmer is between the two utility functions. Lynne shows that the idea of meta-preferences is not new. Its roots can be traced back to Adam Smith and his authorship of " two books, the Wealth of Nations with its appreciation of the self-seeking 'I' nature of humans, and the Theory of Moral Sentiments, with its recognizing the attention that the individual pays to the 'We'..."(Lynne, pg 68). Another conception of the meta-preferences is that of the "multiple self". An individual may have meta-preferences (be of more than one mind) preferring a to B , but nevertheless choosing B and regretting it later on.

Chapter 5: Change of Price

5.1 Introduction

Eliminating excess demand by increasing the price is sketched out as solution 3 to excess demand in Chapter 2. Prices can be set administratively, as is commonly the case in California today, or they can be set on a willing-seller/willing-buyer basis. The effect of a change in the price of water depends on the price elasticity of demand and the supply-flow response to a price change. The reason why elasticities are important is that if a group, say farmers, has a high price elasticity of demand, then a given change in price will induce more movement along the demand curve and a greater reduction in quantity demanded than the same change in price for a group with a low elasticity of demand. On the other hand if a group, say urban users, has a low price elasticity of demand, then a greater change in price may be required to reduce quantity demanded as compared to users that have a high price elasticity of demand. Thus, changing the price of water to reduce excess demand is dependent on the price elasticity of demand. Section 5.2-5.4 explore the possible responses to a change in price by the urban and agricultural users and environmental uses of water.

A common prescription to eliminate excess demand is to use the "market". During the drought of 1987-1991, a "water market" was proposed by the Bay Area Economic Forum (1991) as a way to eliminate excess demand. This proposal was intended to allow level 4 farmers to sell their water contracts to level 3 organizations who would then sell the water to urban consumers with a higher marginal value for water. I use "water markets" in quotation because water markets exist when water is transferred form one party to another at an agreed upon price. However in many policy discussions the "water market" is a willing-buyer/willing-seller market as opposed to a vertically structured system with administratively set prices. While "water markets" are not widespread they are operating in some places. Saliba (1987) studied "water markets" in five different sites in US.[5] Schleyer (1996) analyzes water markets in Chile.

In 1992, the Central Valley Project Improvement Act (CVPIA) was implemented and one of the key provisions allowed farmers receiving water from the CVP supplied water districts to sell their water contracts to buyers outside the CVP water district. Removal of this prohibition of trade was expected to generate "water markets" would emerge as farmers would sell their water to level 3 organizations who would then sell to urban consumers who have a higher marginal value for water. The tiered water prices mandated in the CVPIA were intended to create an incentive for farmers to sell up to 20 % of their water to users with higher marginal values. The trades that were anticipated did not occur. Numerous explanations for the lack of trades have been offered.

First, water rights have not been clearly marked. Clarifying property rights is identified as a prerequisite for market development by the GAO (May 1994). Defining exclusive property rights in Natural Resources is considered by some scholars to be the principle function of the law (Tarlock, Corbridge and Getches, 1993).

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[5] The water markets studied by Saliba are:

1) Trukee Basin, Nevada
2) Lower Sevier Basin, Utah
3) Northern Colorado Water Conservancy District, Colorado
4) Southern Arizona, Tucson and Phoenix Active Management Areas
5) Gila-San Francisco Basin, New Mexico

Second, bid prices offered to farmers are not high enough. This proposition is looked at by the GAO (April 1994) which reports that the average composite CVP farmers irrigation costs represent 1-6.6% of the total cost of production. If water prices increase the most likely scenario is that farmers will shift the mix of crops that they grow. If the cost of water as an input is relatively small then the large increase in price would be needed to induce farmers to change crops or stop farming. The ability of farmers to pass their costs on to consumers is not explored in that paper. It might be an interesting question to pursue in other research.

Third, Colby (1995) explains the importance of information asymmetries and uncertainty as well as starting points in a bargaining process. Determination of the starting point from which the bargaining process will occur is important in establishing property rights as well as bid and reservation prices. The idea of fairness being based on a baseline that not all parties agree upon is offered as an explanation. Information asymmetries have the potential to raise or lower bargaining costs and either increase or decrease the number of trades.

5.2 Price change and movement along the urban demand curve

When price is determined administratively, block rate structures are commonly used. Level 3 water agencies must also decide how to shape the block structure in a way that encourages less water consumption at level 4. Until recently most water agencies used declining block prices in which unit water costs decreased with increased usage. However, most level 3 water agencies have now switched to increasing block rates in which unit water prices increase with increased usage (Chapter 6 , pg 4, Department of Water Resources). In some cases level 3 water districts have raised prices to compensate for the decrease in revenue resulting from lower water consumption. The incentives of urban consumers to reduce consumption when the result is higher prices for the water that is consumed creates incentives that do not encourage water conservation. Burton (1994) explores the relationship between price incentives and public policy to encourage urban consumers to decrease their consumption of water. The price elasticity of demand determines the effect of a change in the price of water on the quantity used. A review of some of the studies that have attempted to estimate the elasticity of demand for households is provided by Hewitt and Haneman (1995) who use a discrete/continuous choice model with a block rate structure to explore residential demand for water. The results of their model show a elasticity of demand to be -1.6, much higher than the results of other models.

5.3 Price change and movement along the agricultural demand curve

Level 4 farmers could react a number of ways to a change in price of water that they purchase from level 3 organizations.

First, farmers could change the type of crop grown so that the new crop net income plus water sales is greater than the old crop net income. This is subject to the physical conditions of the land, the amount of the price change, as well as the relative magnitude of water costs in the total cost of production. A study by the GAO (April 1994) looking into the effects of the California drought demonstrated that CVP irrigation costs represent 1 to 6.6 % of the total cost of production in the farm models used to analyze increases in CVP water. Thus the increase in price of water required to induce a change in the type of crop grown would need to be large.

Second, farmers could adopt water-saving technology. Caswell (1991) reviews the models and determinants of technology adoption. The threshold model is used in many irrigation adoption studies which distinguishes adopters from non-adopters by heterogenous characteristics such as land quality. Caswell, Lichtenberg and Zilberman (1990) conclude that higher input prices, such as water, and environmental regulations have the greatest impact on adoption rates. Another determinant of adoption is the possible increase in labor needed to operate water-saving equipment. The availability and cost of farm labor needed when farmers switch to more efficient water-saving equipment is explored by Wichelns et al (1996).

Moore and Dinar (1995) show that water consumption by farms is a quantity-rationed input and that increasing the price will not lead to changed production or to motivate water conservation. Among the reasons why water use is price inelastic is that water costs as a percentage of total cost is so small that the net effect is insignificant.

Whittlesey and Huffaker (1995) caution that adoption of water-conserving irrigation technology at level 4 may have third-party effects due to the large irrigation back flows. Much of the water that is applied to agricultural crops is absorbed into the soil and eventually flows back into aquifers, streams and other sources of water. If those flows back into the water source are reduced then downstream users will have less water available to them.

5.4 Price change and movement along the environmental demand curve

With a market system, those who wish to use water for environmental uses could purchase water for environmental uses. The challenge of organizing individuals willing to purchase water for environmental uses would be great due to the high-exclusion costs of non-contributors, but not without precedent. Environmental organizations such as the Nature Conservancy purchase land for environmental uses. Water has been purchased by a level 3 water district in northern California for the preservation of wetlands. The allocational system influences the strategies that environmental organizations pursue with the money they collect. One strategy is to use the money for legal action and advocacy that water rights be allocated to environmental purposes. The other is to purchase water rights for environmental use. How environmental organizations induce individuals to contribute money to further goals that have high exclusion costs and why individuals contribute are issues that needs further research.

Chapter 6: Analysis of California Water Systems Under Drought Conditions

6.1 Introduction

This chapter explores water conservation by households during the California drought of 1987-1991. In response to the drought, numerous strategies were undertaken by water allocation officials at all levels to eliminate excess demand. For example, at levels 2 and 3, water transfers from level 4 agricultural users to urban users through the Water Banking program decreased excess demand. At levels 3 and 4, one of the strategies used to decrease excess demand for water was to ask households to forego consumption of water.

Evidence presented by Burton (1992) demonstrates that voluntary forgone water consumption by level 4 urban consumers resulted in reduction in demand from level 3 suppliers from between 25 and 38% below base year consumption. In fact Table 1 shows that foregone consumption was widespread and greater than the amount requested by level 3 water authorities. Other evidence is presented by Berk (1993) in the form of a personal communication from the Drought Information Center in the Department of Water Resources, "Aggressive water conservation programs apparently reduced residential water use in urban areas by as much as 28%." How households reduced consumption during the 1987-91 drought is examined by Berk (1993). Using the analytical framework, the research question answered is the following. Why did households forego water consumption during the 1987-1991 drought in California?

Table 1. Surface Water Conservation Experiences of level 2 and level 3 Municipal Distributors.

Jurisdiction	A. Conservation Requested (a)	B. Conservation Achieved (a)	C. Voluntary Additional Conservation (b)
East Bay Municipal District	15%	25%	67%
Marin Municipal Water District	25%	35%	40%
Metropolitan Water District	31%	38%	23%
Monterey Peninsula Water Management District	20%	31%	55%
San Francisco Water Department	25%	33%	32%
Santa Clara Valley Water District	25%	32%	28%
Average Voluntary Additional Conservation			41%

a. Reduction in 1991 consumption below base year consumption (1986-87 in most cases).
b. Remainder of B minus A , as a percentage of A.

Source: Burton, Lloyd. "Disputing Distributions in a Shrinking Commons: The Case of Drought in California" ***Natural Resource Journal*** **Volume 32 , 1992**

6.2 Social Dilemma's, Individual Conflicts and Multiple- Selves

The combined forgone water use by millions of people in California reduced water consumption at level 4 by shifting the urban demand curve to the left. These actions decreased the excess demand caused by the drought. The combined actions of 30 million individuals had a discernable effect on total urban demand. If we assume that individuals make water consumption decisions at the margin to maximize self-interest then urban water consumption should have remained constant; however, the empirical evidence shows that households did forego water consumption during the drought.

This phenomena has a number of different dimensions. I will look at three. The first frames the phenomena in terms of the individual versus the group. Framing the problem in these terms is common in the literature. For example, Dawes, van de Kragt and Orbell (1990) define Social dilemmas as "outcomes that are good for each group member acting individually are bad for the group as a whole." An example of this framework is given by Schelling who, as quoted by Berk, eloquently writes:

> What we are dealing with is the frequent divergence between what people are individually motivated to do and what they might like to accomplish together.... We are warned of water shortages; leaky faucets account of a remarkable amount of waste, and we are urged to fit them with new washers. There just cannot be any question but what, for most of us if not all of us, we are far better off if we all ... repair the leaky faucets, let the lawn get a little browner and the cars a little dirtier, and otherwise reduce our claims on the common pool of water...But...[mine] is an infinitesimal part of the demand for water... and while the minute difference that I can make is multiplied by the number of people to whom it can make a difference, the effect on me of what I do is truly negligible...({Schelling 1971 pp. 63-69, emphasis in original.} Berk, 1981 p 22)

In this scenario the preferences are the same. It is not a problem of individuals not knowing what their fellow citizens want. Thus the increase of human capital is not a solution. Individuals have the same preferences and they know how to produce the goods they desire. The problem is getting individuals to pay the costs of producing the good desired. Individual contributions by themselves have little effect on the production of the good, but numerous individual contributions combined together might be enough to produce a mutually desired good. It is here that social capital and human capital are sometimes confused. Human capital aims to fill gaps in individual knowledge of the production function. Agricultural extension is involved extensively in building Human capital. Social capital aims to induce individual contributions required to produce goods that require a large number of individual contributions before production can occur. Social capital posits that the utility we all derive from production of the good makes it possible for me to pay my share.

The second dimension is the paradox of individuals maximizing their self-interest at the margin to reach an objective and not getting what they want precisely because they maximized at the margin. The paradox is illustrated by the "Prisoner's Dilemma". In the prisoners dilemma both prisoners have the same preferences: both want to go free. At the margin, as in a one-shot or last-shot game, both prisoners would defect and confess. By maximizing their self-interest at the margin, neither prisoner gets what he wants: to go free. In a non-marginal game, the probability of neither prisoner confessing increases and both get what they want. Axelrod's (1984) "tit for tat" solution to the prisoners dilemma is based on players not defecting as long as the other player doesn't defect in an infinite game. The solution is dependent on non-marginal decision making.

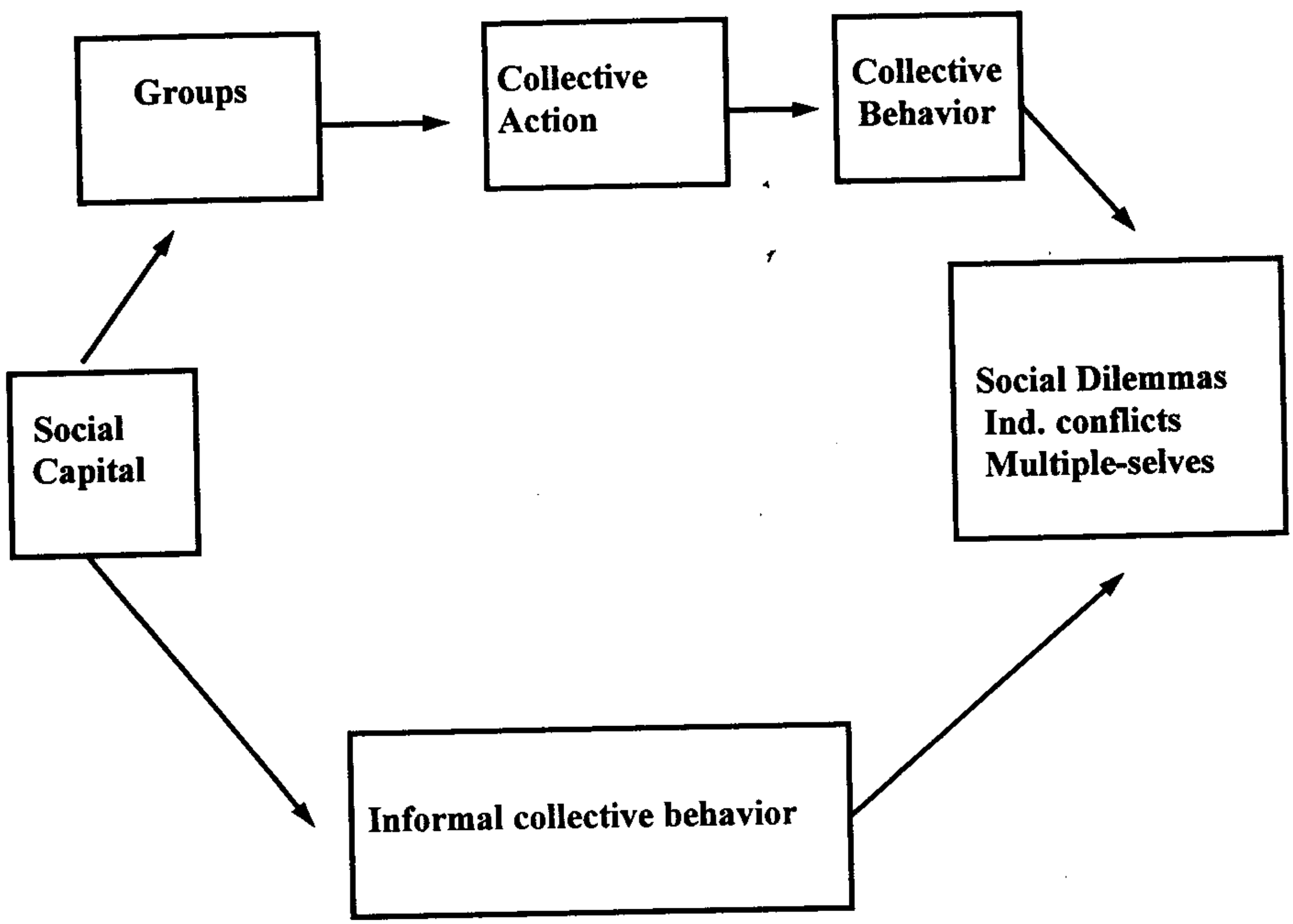
Social capital can result in non-marginal decisions by actors. An experiment by Dawes, van de Kragt and Orbell (1990) demonstrates that discussion among group members elicits higher levels of non-marginal behavior as compared to members of groups that did not have discussions. The small amount of social capital that was generated by discussion was enough to elicit higher rates of non-marginal behavior.

The third dimension is a framework in which an individual has two sets of preferences. One set of preferences is desirable for the long-term objective (forgo water consumption) while the other is desirable for immediate gratification (e.g. wash car). Individuals making water consumption decisions balances the two distinct sets of preferences. Social capital can influence which preferences are chosen by individuals with meta-preferences.

6.3 Solving social dilemma's, Individual Conflicts and Conflicts between Multiple-Selves

Solving social dilemmas is a task that is faced by natural resource managers every day. Scholars have expended considerable energy in their analysis of social dilemmas and a large body of literature has been generated as a result. Much of the work has been focused on the formation of groups that elicit collective action to solve social dilemmas. The upper path of Figure 6 illustrates the linkage typically followed in this literature. However the forgone water use by level 4 consumers outlined above did not follow the upper path. Rather it followed the lower path in Figure 6 which is much more direct. The consumers behaved collectively without the groups which are the focus of much of the literature.

Figure 6. Social Capital and Social Dilemmas, Individual conflicts and Conflicts between Multiple-selves



Top route:

The presence of Social Capital leads to formation of groups which leads to collective action and collective behavior which then lead to solutions to social dilemmas, individual conflicts and conflicts between multiple selves.

Bottom Route:

The presence of Social capital leads to Informal collective behavior which leads to solutions to social dilemmas, individual conflicts and conflicts between multiple selves.

The work on groups is valuable as it can offer insights into collective behavior, but it does not look into the root forces that induce collective behavior. Olson (1965) claimed that either government intervention or selective incentives[6] are required for groups to form and engage in collective action. The emphasis was on the group as a source of collective action.

Ostrom (1990) identifies characteristics that can be used to predict if a group will be able to form groups so as to act collectively. The characteristics she identifies are: 1) defined common boundaries, 2) congruence between distribution rules and supply flows, 3) public participation in rule formation and implementation 4) adequate compliance monitoring, 5) graduated sanctions, 6) dispute resolution mechanisms and 7) the capacity for self organization.

Ostrom (1994) uses game theory to construct a theory of group formation to induce collective action. She conducts numerous experiments to test the validity of non-cooperative game theory and loosens the conditions of non-cooperative game theory to experiment on more robust environments. Ostrom finds that in sparse environments characterized by lack of communication, not knowing the neighbors, and no compliance monitoring, individuals act as predicted in a noncooperative game theory environment. In robust environments, however, where players talk, know their neighbors, and compliance monitoring is present, players follow the rules and thus start solving their CPR Dilemma. The fact that players know their neighbors implies the presence of social capital between the neighbors. One of the results of the experiments is that the

[6] Selective incentives are defined by Olson as incentives that, "stimulate a rational individual in a latent group to act in a group-oriented way" and are not given to "those who do not join the organization working for the group's interest, or in other ways contribute to the attainment of the group's interest can be treated differently from those that do"(Olson, pg 51).

participants did not resort to the "grim-trigger strategy" if cheating on a limited scale occurred. The grim-trigger strategy predicts that if one person defects, then all the other players will defect and any cooperation will cease afterwards. This is significant in designing a response to a drought management plan as cheating by a few people does not induce all other members of the neighborhood to forgo water consumption. Non-cooperative game theory would predict that as soon as one person cheated the whole house of cards would come tumbling down and everybody would cheat.

As Figure 6 illustrates, I hypothesize that the underlying reason why groups are able to form and solve their social dilemmas is due to the presence of social capital. This hypothesis doesn't claim that groups and conscious collective action are not a valuable tool for solving social dilemmas. It does point out that such groups are not the only way to solve social dilemmas.

6.4 Social Capital as an explanation of foregone water consumption

Households faced with the social dilemma of forgoing water consumption when the actions of most other households is not known, acted in a way that was rational from the individuals larger perspective but irrational from the individuals narrow perspective of making the best choice acting alone. Yet solving the social dilemma posed earlier decreased the excess demand for water in California during the drought in 1991. The presence of social capital is hypothesized to be the factor that solved the social dilemma as level 4 consumers decided how much water to forgo. That consumers responded by forgoing even more water than they were asked to is the reason why social capital is hypothesized to be the causal factor in forgone water consumption.

Households with social capital toward their neighbors, friends, and other members of the community would explain why households considered more than their own utility when deciding how much water consumption to forego during the drought. How to increase social capital has not been explored in this paper, but would be a worthwhile endeavor.

Chapter 7: Conclusion

Excess demand for water in California is a problem that has surfaced numerous times in the past and will surface again in the future. Informing the policy debate by identifying possible methods to eliminate excess demand is an important role for applied economists. Traditional reliance on physical capital to decrease excess demand by shifting the supply curve to the right is becoming increasingly difficult as physical infrastructure projects exhibit decreasing return to scale. Further investment in physical infrastructure is increasing in unit cost as well as public opposition to water projects due to concern about the environmental effects.

Increasing the price of water as a way to diminish excess demand has been suggested as a solution to excess demand by numerous economists. Understanding the role of institutions in allocation of water by determining the price of water and in the stock of water which requires tremendous infrastructure development investment, will lead to better policy recommendations.

The role of social capital in reducing excess demand was empirically demonstrated during the 1987-91 drought in California. Households voluntarily forewent water consumption when asked to do so by the state water authorities. Such behavior is inconsistent with the self-interest model traditionally used in economics. The use of traditional model reduces the policy responses that are presented to policy makers to reduce excess demand for water. Models that incorporate the use of social capital to reduce excess demand should be developed and applied to economic problems.

While the social dilemma has been identified and extensive research has been done on the use of groups to resolve social dilemma's, the role of social capital in both creating the conditions so that groups could flourish as well as directly induce collective behavior has not been extensively studied. Further research should include a more concise definition of social capital and tools to measure social capital in its diverse settings. Understanding how goods that have joint-impact (Schmid, 1987) are produced or not produced because of the nature of the good as well as the institutional arrangements of production requires further research both in theory and in application.

References

Axelrod, Robert M., *The Evolution of Cooperation*, Basic Books, New York, 1984

Bay Area Economic Forum, "Using Water Better: A Market Based Approach to California's Water Crisis", October, 1991

Berk, Richard A, et al. "Measuring the Impact of Water Conservation Campaigns in California" *Climatic Change* July 1993 vol 24(5) p.233

Berk, Richard A, et al. *Water Shortage: Lessons in Conservation from the Great California Drought, 1976-77*, Abt Books, Cambridge, Mass, 1981

Burton, Lloyd "Disputing Distributions in a Shrinking Commons: The Case of Drought in California" *Natural Resources Journal*, Vol 32 Fall 1992

Braden, John B. "Changing Agricultural Property Rights for the Twenty-first Century: A Discussion" *Amer. J. Agr. Econ.* 77(1995):1204-1206

Bromley, Daniel W., *Environment and Economy*, Blackwell Press, 1991

Caswell, Margriet F., "Irrigation Technology Adoption Decisions: Empirical Evidence" Chapter 15 in *The Economics and Management of Water and Drainage in Agriculture*. Edited by Ariel Dinar and David Zilberman, Kluwer Academic Press, 1991

Caswell, Margriet, F., Eric Lichtenberg, and David Zilberman, "The Effects of Pricing Policies on Water Conservation and Drainage" *Amer. J. Agr. Econ.* 72(1990): 883-890.

California Department of Water Resources, *Bulletin 160-93 The California Water Plan Update*, Oct 1994

Colby, Bonnie G. "Bargaining Over Agricultural Property Rights" *Amer. J. Agr. Econ.* 77 (1995):1186-1191

Coleman, James S. "Social Capital in the creation of Human Capital" *American Journal of Sociology* Volume 94 Supplement S95-S120

Dawes, Robyn M., Alphons J. C. van de Kragt, and John M. Orbell, "Cooperation for the Benefit of US-Not Me, or My Conscience" in *Beyond Self-Interest*, edited by Jane Mansbridge, University of Chicago Press, 1990

Dudley, Norman J. "Water Allocation by Markets, Common Property or Capacity Sharing: Companions or Competitors?" *Natural Resources Journal*, Vol 32, Fall 1992

Flora, Cornelia Butler and Jan L. Flora, "The Past and Future: Social Contract, Social Policy and Social Capital" *Increasing Understanding of Public Problems and Policies 1995*, Farm Foundation 1995

GAO, "Water Subsidies: Impact of Higher Irrigation Rates on CVP Farmers"April 1994.

-------, "Water Transfers: More Efficient Water Use Possible if Problems are Addressed" May 1994

Getches, David H., "Competing Demands for the Colorado River" 56 U. Colo L. Rev. 413, 415-20 (1985) in *Water Resource Management 4th Edition*, edited by Dan A. Tarlock et al

Gwilliam, Kent R., *Farmland Leasing and Contract Choice in Michigan: The Influence of Social Distance* Unpublished Ph.D. Dissertation, Michigan State University, 1993

Hewitt, Julie A. and W. Michael Hanemann, "A Discrete/Continuous Choice Approach to Residential Demand Under Block Rate Pricing" *Land Economics* May 1995, Vol 71(2):173-192

Howitt, Richard E. "Malleable Property Rights and Smooth-Pasting Conditions" *Amer. J. Agr. Econ.* 77(1995):1192-1198

Israel, Morris and Lund, Jay R., "Recent California Water Transfers: Implications For Water Management" *Natural Resources Journal*, Vol 35, Winter 1995

Loomis, John B. "Public Trust Doctrine produces water for Mono Lake: The state of California's Water Resource Control Board decision # 1631" *Journal of Soil and Water Conservation*, May-June 1995 Vol 50 No. 3 p.270

Margolis, Howard, *Patterns, Thinking and Cognition: a theory of judgement*, University of Chicago Press, 1987

Moore, Michael R. and Ariel Dinar "Water and Land as Quantity Rationed Inputs in California Agriculture: Empirical tests and water policy implications" *Land Economics*, Nov 1995 71(4):445-462

New York Times, "Water Cut Again For Californians" February 15, 1991, page A 13

Oamek, George Edward, "Economic and Environmental Impacts of Interstate Water Transfers in the Colorado River Basin", Center for Agricultural and Rural Development, CARD Monograph 90-M3 Ames, Iowa

Olson, Mancur, *The Logic of Collective Action*, Harvard University Press, 1965

Ostrom, Elinor, *Governing the Commons: the evolution of institutions for collective action,* Cambridge University Press, 1990

----------------- , *Rules, Games, & Common-Pool Resources,* University of Michigan Press, 1994

Putnam, Robert, *Making Democracy Work: Civic Traditions in Modern Italy,* Princeton University Press, 1993

Robison, Lindon J., "In Search of Social Capital" Unpublished Manuscript.

Robison, Lindon J., Steven H. Hanson, "Social Capital and Econpmic Cooperation" *Journal of Agricultural and Applied Economics* July 1995, 27(1):43-58

Saliba, Bonnie Colby, et al. "Do Water Market Prices Appropriately Measure Water Values?" *Natural Resources Journal* Summer 1987 No. 3

Schmid, Allan, *Property, Power and Public Choice,* Praeger Press, 1978

Schmid, Allan A. and Lindon J. Robison "Applications of Social Capital Theory" *Journal of Agricultural and Applied Economics,* July 1995, 27(1):59-66

Schleyer, Renato Gazmuri and Rosegrant, Mark W. "Chilean Water Policy: The Role of Water Rights, Institutions and Markets", *Water Resources Development,* Vol 12(1) pp33-48 (1996).

Shabman, Leonard " Demosclerosis: Assessing the Argument" *Amer. J. Agr. Econ* 77(1995):1135-1140

Siles, Marcelo E. *The Role of Social Capital in Michigan Credit Markets* Unpublished Ph.D Dissertation, Michigan State University, 1992

Simon, Herbert, "Organizations and Markets" *Journal of Economic Perspectives* Volume 5 Number 2 Spring 1991 Pages 25-44

Tarlock, Dan A., James N. Corbridge and David H. Getches *Water Resource Management* 4th Edition, 1993, Foundation Press, Westbury, New York

Vaux, Henry J. Jr., "Economic Factors Shaping Western Water Allocation", *Amer. J. Agr. Econ* 68(1986):1135-1142

Water Education Foundation, " Lay persons guide to water transfers" Sacramento, CA 1996

Whittlesey, Norman K. and Huffaker, Ray G. "Water Policy Issues for the Twenty-first Century" *Amer. J. Agr. Econ.* 77 (1995):1199-1203

Wichelns, Dennis "Labor costs may offset water savings of sprinkler systems" *California Agriculture*, January-February 1996

Young, Robert A., "Why Are There So Few Transactions among Water Users?" *Amer. J. Agr. Econ.* 68(1986):1143-1151

Zilberman, David "Water for California Agriculture: Lessons from the Drought and New Water Market Reform" *Choices*, Fourth Quarter, 1994