1985

Water Pricing and Rent Seeking in California Agriculture

B. Delworth Gardner
Brigham Young University - Provo

Follow this and additional works at: https://scholarsarchive.byu.edu/facpub

Part of the Agricultural and Resource Economics Commons, and the Economics Commons

BYU ScholarsArchive Citation
Gardner, B. Delworth, "Water Pricing and Rent Seeking in California Agriculture" (1985). Faculty Publications. 3742.
https://scholarsarchive.byu.edu/facpub/3742

This Peer-Reviewed Article is brought to you for free and open access by BYU ScholarsArchive. It has been accepted for inclusion in Faculty Publications by an authorized administrator of BYU ScholarsArchive. For more information, please contact ellen_amatangelo@byu.edu.
Water Pricing and Rent Seeking in California Agriculture

by

B. Delworth Gardner*

*The author is indebted to Carole F. Nuckton and Ray G. Huffaker for analytical and editorial assistance.
Introduction

Without irrigation water, agriculture in California would be little more than limited livestock grazing and some dryland farming of cereal crops. With irrigation water, California produces over 200 crops and is the leading agricultural state with nearly $4 billion in sales in 1980. The state's gross cash receipts from farm sales have consistently approached 10 percent of the U.S. total every year since 1960.

Of course, water is only one of several crucial inputs utilized in agricultural production—others are land; capital in form of machinery, tools and implements; energy; chemicals for fertilizer and pest control; and perhaps most important, human effort. If production is profitable, all factors must be paid at least their opportunity costs if they are to be used on a continuing basis. Those existing in relatively fixed (inelastic) supply will earn economic rents if there are revenues left after the variable factors have been paid. Economic rent may be defined for our purposes as the difference between what a productive factor is worth in use and what it costs. If a factor of production is relatively constraining in determining the quantity, quality, and location of output, and is priced far below its economic value, economic rents will tend to be large and persistent through time.

In the irrigation economy of the west, water, probably more than any other factor of production, fits the description of a constraining input (described in the previous paragraph) that is frequently priced below its value in use. The control of water, therefore, provides access to enormous magnitudes of economic rent and is for this reason a hot political issue in
the west. Institutional arrangements in the form of water law, water pricing policies, acreage ownership limitations on land receiving subsidized federal water, lobbying for new water development, and land allocation rules have all played their roles in determining the distribution as well as the size of these economic rents. It is the thesis of this paper that some of these institutional arrangements have seriously misallocated water in terms of diminishing the value of the economic product yielded by water and its complementary inputs far below what would have been attainable under optimal water allocation.

Pricing policy is a critical issue that encompasses many other water-related problems. If water is not price-rationed to where it is most valuable, then some other rationing schemes must be employed to allocate it. If nonprice allocation criteria are used, what efficiency losses may result therefrom? For example, without market prices to reveal what the value of water is, how shall it be determined whether or not new water development is economically feasible? (Gardner, 1981).

The paper will first demonstrate that farmers are price responsive in their use of irrigation water. The literature that reports estimates of elasticity of demand will be reviewed. This will be followed by an empirical analysis of the main types of responses to higher water prices: (1) use less water on a given crop, (2) change irrigation technology, (3) shift water applications to more water-efficient crops, and (4) change crop mix to higher-valued crops. A final major section discusses the water allocating institutions in California, how their pricing and allocating rules misallocate water, and what the implications are for the distribution of economic rents.
Water Prices and Use Rates in California Agriculture

Although some argue that water is a commodity that could be most efficiently allocated via the market place where price would direct it to its highest and best use, it has almost always been considered different from marketable commodities. Historically, its seeming abundance contributed to its allocation at prices reflecting the costs of capture and distribution and often unrelated to its economic value. Legal criteria, such as "beneficial use" determined eligible user groups.

To most water planners "demand" for water frequently means projected "requirements" or "needs" for people and plants. In agriculture, water planners and engineers tend to think of irrigation water in terms of per-acre "needs" or "requirements" of the crops in an area—e.g., an acre of barley in Kern County, California, requires 1.5 acre-feet of water in a growing season; an acre of alfalfa, 4.5 acre-feet.

The California Department of Water Resources (DWR), the state agency responsible for supplying water to farmers and city dwellers through its State Water Project, bases its estimates of water demand on the apparent ability of farmers to put it to profitable use (per acre agricultural receipts for a crop minus its nonwater costs divided by the number of acre-feet needed to grow that particular crop). Crops for which the calculated ability to pay exceeds the water cost involved enter the projections; those with lower capacities, do not. The demand for water, then, according to DWR, is computed by summing over the products of water requirements and acreages of those crops "able to
pay" for the water (Willis, 1972). The quantity of water utilized per acre is assumed to be fixed for a given profitable crop.1

Partly because the "water-is-different syndrome" is so prominent (Kelso, 1967), the solution to water shortages that occur through time as "need" grows has been to develop new water supplies rather than to raise prices—to increase the supply to meet the fixed demand. The economist would find this policy quite unobjectionable so long as it could be shown that the "new" water was worth more in use than its development and distribution costs. This is precisely the aspect that is too often overlooked in water development decision making, however.

It is easy to demonstrate that water users are responsive to price. The contrast in water use between New York City with an unmetered water supply and Detroit with universal metering was cited by Chiogioji and Chiogioji (1973). During a critical water shortage in 1949-1950, New Yorkers reduced per capita consumption from 85 to 60 gallons a day in response to a vigorous water conservation campaign. Meanwhile, Detroit water consumers, comparable to those in New York in many ways other than in being metered, consumed only 49.5 gallons per capita per day without any nonprice pressures to conserve.

There are a number of studies that have attempted to estimate farmers' responsiveness to the price of irrigation water. The studies which were done in differing areas of California with different cropping patterns over a period of more than a decade all indicated considerable farmer response to

1Such prescriptions for water use are designed to maximize yield not profit (Ayer and Hoyt). Only with a zero water price are the two objectives one and the same. Generally, farmers stop using water at the profit maximizing point (where the value of the marginal product equals the water price) which is short of the yield maximizing point (where the marginal product of water is zero).
changes in water price. Although the findings differed in the degree of price responsiveness, together they contradict a widespread view that farmers are insensitive to water price changes in their production decisions.

Linear programming models were constructed by Moore (1962) for farms of different sizes on the eastern side of the San Joaquin Valley in Tulare County, California. Optimum crop programs were calculated for each model as irrigation water prices were raised from zero to about $30 per acre-foot. A given crop mix and its associated water "requirements" remained optimum over a small range in price creating a stepped demand schedule for water. The schedules were aggregated over the size groups, a linear regression was fitted and elasticities were computed. Elasticities ranged from quite inelastic (-0.14) at a low water price ($5.00 per acre-foot) through quite elastic (-1.58) at $25.00 per acre-foot.¹ For the entire range of prices considered (zero to $30 dollars per acre-foot), elasticity was -0.65—that is, for a 10 percent increase in price, about a 6.5 percent decrease in quantity could be expected.

In 1963, Moore and Hedges fit two quadratic regression equations to two distinct price segments of the same aggregate demand schedule. The resulting elasticities were -0.188 for the lower segment and -0.702 for the upper, with the overall elasticity again being -0.65. In a cross-sectional analysis of 34 California water districts, Bain, Caves, and Margolis (1966) also found a price elasticity of -0.64.

¹An elastic demand (greater than 1.0 in absolute terms) means that for a 1 percent change in price, a greater than 1 percent change in quantity demanded would be expected. While an inelastic demand (less than 1.0 in absolute terms) means less than a 1 percent change in quantity for the 1 percent price change, some responsiveness is nevertheless in evidence. It is only when the elasticity reaches zero that complete insensitivity to price is indicated.
In a 3,220 equation, 5,426 variable linear programming model, Heady et al. (1973) tested for the impacts of alternative futures on the demand for water for agriculture in 17 western states. As water price increased from an average of $7 per acre-foot to $30, irrigated acreage was reduced an estimated 14.8 million acres; dryland farming increased about 15 million acres—about a one-for-one substitution. Of course, the crop mix was correspondingly altered. Carson (1979) computed the elasticities implied by the Heady model for four incremental water price changes. As price was raised from $7 to $30 per acre-foot the elasticity estimates increased from -0.17 to -0.56 with an overall average of -0.37.

Using shadow prices from linear programming solutions to a water quality–crop production model for Imperial County, California, Moore, Snyder, and Sun (1974) found that for quantities greater than one million acre-feet, demand was quite elastic. At the then current, low price of $2.35 per acre-foot, however, and with much smaller quantities of water, demand was relatively inelastic, even though the water cost was less than its value in use.

In evaluating regional resource use for agricultural production in California in 1961-1965 and in 1980 (projected), a spatial linear programming location model was constructed by Shumway, King, and Carter (1970). Particular attention was directed in this study to water pricing on the west side of the San Joaquin Valley in two of the model's 95 assumed homogeneous production areas (HPA). Two demand functions were estimated using the parametric program observations for each HPA, and later Shumway (1970) fitted a single equation to the data points for both HPAs. In contrast to the several studies reviewed above, these estimates indicated quite an elastic
water price response. In the two-equation model, five out of six point estimates had an absolute value greater than one. The exception was -0.56 in one HPA at a very low water price--$4.70 per acre-foot. At a water price of $19.36 in the other HPA, the estimate was -2.32. In the single-equation model, at a deflated water price (1965 dollars) of $4 per acre-foot, the elasticity estimate was -0.48, becoming unitary (i.e., -1.0) at a price of about $8.50, and elastic at higher prices. At $17.00, the elasticity estimate was -2.03.

What do these "high" elasticities mean? For one thing, Shumway, King, and Carter concluded that farmers in these two HPAs would not be using all the water DWR was planning to send them—at the price DWR was planning to charge. According to their study results, the marginal cost of water to the farmer would have to be reduced between $4 and $6 per acre-foot (from a contractual price of $14.70 per acre-foot in one HPA and $19.36 in the other) before DWR's projected one-half million acres would be brought into production.

It has been demonstrated recently by Howitt, Watson, and Adams (1980) that the various linear programming (LP) approaches reported above may seriously underestimate price elasticities. They show that the quadratic programming (QP) method, which incorporates product demand functions into the objective function, will yield elasticities for water that are more elastic than will the LP method on the same data. As an example, a statewide model of nine California field crops and 28 vegetable crops1 was estimated using both the LP and QP approaches with the latter indeed yielding more elastic estimates. In the water price range from $25 to $35, the LP derived elasticity was -0.97; the QP estimate was -1.50.

---

1Perennial crops were afforded full water allocations and were not included in the model.
There are extremely important implications for policy in these elasticity numbers. For example, as Howitt, Watson, and Adams suggest, if demand for irrigation water is as elastic in the $25 to $35 price range as the numbers presented indicate, then as State Water Project prices are renegotiated in the next few years, farmers may reduce their water use by a far greater amount than expected by the water planners. Such a reduction could "offset the current predictions of severe supply shortfalls calculated under the assumption of inelastic 'needs' for agriculture." (p. 627)

In fact, if the demand for irrigation water is elastic (greater than 1.0 in absolute terms) the reductions in quantities demanded in response to price increases will reduce the total water bill. Districts selling water will receive smaller total revenues and will probably have to alter the way water is paid for.

Generations of economists have been taught that elasticity increases as we move from the short to the long run. In agricultural water use specifically, Johnston (1968) pointed out that demand in the short run is almost always more inelastic than in the long run. If the technological base of production in agriculture is in place (for example, the orchard is planted), demand for irrigation water may not be very price responsive. In the long run, however, changes can (and will) be made in this base if water is priced at a higher level.

The same point was made by Shumway (1973) in comparing his more elastic estimates with Moore and Hedges' inelastic ones. The study area for the latter was fully developed for agricultural production with the existing water distribution system well in place. By contrast, the west side of the San Joaquin Valley used in Shumway's model was "predominantly barren of
agricultural production. Consequently, water distribution facilities must be constructed . . . and would not be constructed if the price of water appeared too high." (p. 199) This means that demand for irrigation water for undeveloped land is especially price responsive.

The conclusion that has emerged from this literature review of agricultural water use in California is clear: demand for irrigation water is more price responsive than is generally believed. Underestimating this responsiveness can result in serious resource misallocations—using scarce and valuable nonwater resources in unwarranted and premature water development.

It has been shown that farmers respond to water price increases by cutting back in water use. The next section of the paper indicates more precisely how their production decisions accommodate this action.

**Farmers Responses to Increases in Water Price**

Suppose that water to the farmer became very expensive (say, $75 per acre-foot) but he could have all he might want at that price. How might he react in his irrigation practice? Three responses seem likely: (1) he might apply less water to a given crop (possibly putting it under stress), (2) he might utilize a different (more efficient) irrigation technology and/or water application practice, and (3) he might choose a different cropping pattern. These issues will be discussed in turn.

**Water Price and Application Rates**

Plant growth is determined largely by the amount of water available to the plant in the root zone during the growing season. The amount of water available in the root zone depends on the quantity that gets there from natural precipitation and the amount supplied from irrigation. The capacity of the soil to retain water is also an important factor. The plant uses some
water in the process of photosynthesis, but most is transpired from the plant's leaves. Other water is lost through evaporation from the soil surface. Table 1 shows seasonal and annual rates of potential evapotranspiration (ET) for various regions in California. The numbers in the table are maximum amounts of water that plants will use if adequate soil moisture is available, and if foliage covers all or nearly all of the ground surface. Under these conditions, approximately 90 percent of the water loss is by transpiration. Other factors determining ET rates are solar radiation, air moisture, temperature, wind speed, reflectiveness of the ground surface, and the way and time interval over which water is delivered to the land. The numbers in Table 1 reveal great differences in potential ET rates in the various regions of the state of California with the largest being in the southern desert.

Not much can be done to change basic ET. There are, however, adaptive strategies for maximizing production with limited supplies of water or for higher-cost water. Crops can be moved toward the cool season when ET is lower. Table 2 lists the seasonal evapotranspiration (ET) requirements of the major crops in the San Joaquin Valley. It is possible to change total water use by varying the types of crops grown, changing the acreages in the various crops, and shortening the growth duration of crops.

Of primary interest is the relationship between water applied and yield; the former largely influencing the marginal water cost and the latter, the marginal benefits from incremental applications of water. Research at the University of California indicates that water applications 10 percent below that producing maximum yields would reduce alfalfa yields by 10 percent; cotton, 12.5 percent; corn, 12.5 percent; grain sorghum, 10 percent; pinto beans, 23.5 percent; and pink beans, 21 percent (Stewart, 1977). Some preliminary results of continuing research suggest that "stress" irrigation
Table 1
Seasonal and Annual Potential Evapotranspiration Rates in California

<table>
<thead>
<tr>
<th>Season</th>
<th>November-March</th>
<th>April-October</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>---------------------------</td>
<td>----------------</td>
<td>---------------</td>
<td>--------</td>
</tr>
<tr>
<td>Northwestern mountain valleys</td>
<td>5.1</td>
<td>37.1</td>
<td>42.2</td>
</tr>
<tr>
<td>North coast--coastal valleys and plains</td>
<td>5.3</td>
<td>20.8</td>
<td>26.1</td>
</tr>
<tr>
<td>North coast--interior valleys</td>
<td>6.3</td>
<td>34.9</td>
<td>41.2</td>
</tr>
<tr>
<td>Sacramento Valley</td>
<td>8.5</td>
<td>40.7</td>
<td>49.2</td>
</tr>
<tr>
<td>San Joaquin Valley</td>
<td>7.9</td>
<td>40.7</td>
<td>48.6</td>
</tr>
<tr>
<td>Central coast--coastal valleys and plains</td>
<td>10.7</td>
<td>30.6</td>
<td>41.3</td>
</tr>
<tr>
<td>Central coast--interior valleys</td>
<td>10.8</td>
<td>37.5</td>
<td>48.3</td>
</tr>
<tr>
<td>South coast--coastal valleys and plains</td>
<td>12.1</td>
<td>32.3</td>
<td>44.4</td>
</tr>
<tr>
<td>South coast--interior valleys</td>
<td>11.5</td>
<td>37.9</td>
<td>49.4</td>
</tr>
<tr>
<td>Southern California desert</td>
<td>17.7</td>
<td>65.1</td>
<td>82.8</td>
</tr>
</tbody>
</table>

*a These are the rates of water loss one would observe from a well-watered lawn.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Season</th>
<th>Days</th>
<th>Total ET (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Small Grains</strong></td>
<td>November through May 15</td>
<td>200</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>December through May</td>
<td>180</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>January through June</td>
<td>180</td>
<td>21</td>
</tr>
<tr>
<td><strong>Beans (Pinto)</strong></td>
<td>April through July</td>
<td>120</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>May to August 15</td>
<td>110</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>June 15 through September</td>
<td>110</td>
<td>18</td>
</tr>
<tr>
<td><strong>Grain Sorghum</strong></td>
<td>May through September</td>
<td>150</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>June 15 through October</td>
<td>140</td>
<td>18</td>
</tr>
<tr>
<td><strong>Corn</strong></td>
<td>March 15 to August 15</td>
<td>150</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>April 15 to September 15</td>
<td>150</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>May 15 through September</td>
<td>140</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>June to October 15</td>
<td>140</td>
<td>23</td>
</tr>
<tr>
<td><strong>Cotton</strong></td>
<td>March through September</td>
<td>180</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>March 15 to October 15</td>
<td>180</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>May through October</td>
<td>180</td>
<td>32</td>
</tr>
<tr>
<td><strong>Sugarbeets</strong></td>
<td>February through August</td>
<td>210</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>March 15 to September 15</td>
<td>180</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>May through January</td>
<td>280</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>June 15 to March 15</td>
<td>300</td>
<td>29</td>
</tr>
<tr>
<td><strong>Rice</strong></td>
<td>April through August</td>
<td>150</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>May through September</td>
<td>150</td>
<td>39</td>
</tr>
<tr>
<td><strong>Perennial crops</strong></td>
<td>All year, but with winter dormant period</td>
<td>48</td>
<td></td>
</tr>
<tr>
<td><strong>Alfalfa</strong></td>
<td>All year, but slower growth in winter</td>
<td>49</td>
<td></td>
</tr>
<tr>
<td><strong>Pasture</strong></td>
<td>March through mid-November</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td><strong>Grapes</strong></td>
<td>Wine, raisin</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td><strong>Deciduous Orchards</strong></td>
<td>February-March through November</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>Clean cultivated</td>
<td>Table</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With cover crop</td>
<td>up to 48</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

might be used with perennial crops such as raisin and wine grapes and almonds—but only in areas where sufficient water is available during the winter to satisfy leaching requirements. Unfortunately, the economics of putting the plant under some stress in order to save costly water have not been worked out. Income may be higher or lower depending on costs and returns. The important point, however, is the acknowledgement that a rational farmer might very well apply less irrigation water to his crops at higher water prices than at lower ones.

Water Price and Irrigation Practice

As argued earlier, to the rational farmer the price of water may have a significant influence on his choice of irrigation practice and technology. If water is cheap, the irrigation technique and the frequency of application may be relatively inefficient in water use but quite efficient in economizing on other scarce inputs, such as labor and capital. The farmer might choose timing and longevity of irrigations that use more water but are more convenient for him. He may not find it profitable to keep his irrigation system in good repair so as to avoid leaks and seepage losses. He may have little incentive to invest in the control of thirsty phreatophytes or to switch to expensive but water-sparing irrigation systems such as sprinkler or drip.

The water supply agencies (generally, water districts as established by law and described more fully later in the paper) use pricing practices that cause the water costs to farmers to vary widely. In 1975, in Kern County, California, total surface water costs per acre-foot varied between $6.68, in the Delano-Earlimart District, and $51.07, in the Cawelo District (Table 3 and Figure 1). The disparity in groundwater costs was somewhat less—$16.05 in
Table 3
Variable and Total Water Costs and Irrigation Efficiency
Kern County, 1975

<table>
<thead>
<tr>
<th>Location</th>
<th>Surface Water Cost</th>
<th>Groundwater Cost</th>
<th>Irrigation Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>Variable Cost</td>
<td>Total Cost</td>
<td>Variable Cost</td>
</tr>
<tr>
<td>Arvin-Edison</td>
<td>14.93</td>
<td>20.83</td>
<td>22.88</td>
</tr>
<tr>
<td>Bellridge</td>
<td>25.18</td>
<td>25.18</td>
<td>—</td>
</tr>
<tr>
<td>Berrenda Mesa</td>
<td>12.53</td>
<td>33.51</td>
<td>—</td>
</tr>
<tr>
<td>Buena Vista</td>
<td>5.67</td>
<td>8.68</td>
<td>10.60</td>
</tr>
<tr>
<td>Buttonwillow</td>
<td>19.62</td>
<td>20.75</td>
<td>15.73</td>
</tr>
<tr>
<td>Cawelo</td>
<td>46.00</td>
<td>51.07</td>
<td>22.80</td>
</tr>
<tr>
<td>Delano-Earlimart</td>
<td>3.47</td>
<td>6.68</td>
<td>19.54</td>
</tr>
<tr>
<td>Henry Miller</td>
<td>15.83</td>
<td>28.20</td>
<td>9.93</td>
</tr>
<tr>
<td>Kern Delta</td>
<td>8.22</td>
<td>11.67</td>
<td>12.03</td>
</tr>
<tr>
<td>Kern-Tulare</td>
<td>—</td>
<td>—</td>
<td>31.31</td>
</tr>
<tr>
<td>Lost Hills</td>
<td>11.87</td>
<td>20.04</td>
<td>16.80</td>
</tr>
<tr>
<td>North Kern</td>
<td>10.27</td>
<td>11.94</td>
<td>16.25</td>
</tr>
<tr>
<td>Pond Poso</td>
<td>—</td>
<td>—</td>
<td>14.46</td>
</tr>
<tr>
<td>Rag Gulch</td>
<td>35.60</td>
<td>35.60</td>
<td>20.64</td>
</tr>
<tr>
<td>Rosedale-Rio Bravo</td>
<td>—</td>
<td>—</td>
<td>13.94</td>
</tr>
<tr>
<td>Semitropic</td>
<td>—</td>
<td>—</td>
<td>14.19</td>
</tr>
<tr>
<td>Shafter-Wasco</td>
<td>4.01</td>
<td>8.15</td>
<td>19.08</td>
</tr>
<tr>
<td>Southern San Joaquin</td>
<td>6.00</td>
<td>7.43</td>
<td>21.87</td>
</tr>
<tr>
<td>West Kern County</td>
<td>—</td>
<td>—</td>
<td>18.24</td>
</tr>
<tr>
<td>Wheeler Ridge-Maricopa</td>
<td>44.92</td>
<td>46.96</td>
<td>23.35</td>
</tr>
</tbody>
</table>

FIGURE 1

Kern County Water Districts
Buena Vista to $40.03 in the Kern-Tulare district (Watson, Nuckton, and Howitt 1980).

Total water costs to the farmer, of course, can be broken down into component parts, only some of which are generally relevant to his decision as to the quantity of water he will demand. It is the outlay associated with an incremental unit of water (marginal cost) that must be compared with its value.

Water districts vary somewhat in pricing practices utilized to recover their costs of supplying water. In most instances, three components make up the total water bill: "(1) A water toll charge—'user charge'—is commonly levied directly by the water district as a variable cost based on the number of acre-feet drawn. (2) A water availability and general service charge is imposed, usually on a per-acre or per-value basis. This is a fixed cost not related to the amount of water delivered and is used to service district debts . . . and pay operating, maintenance, and salary costs. (3) Finally, there are a number of indirect costs which may or may not be included in the district's quoted farm gate water costs. Such charges levied by the county tax assessor are paid as taxes rather than as direct water costs." (Watson et al., p. 47-48)

In Table 3, columns A and C are the "user charges" or variable costs per acre-foot of water, whether it be surface water (column A) or groundwater (column C). In addition to these variable costs, the fixed costs involved in items (2) and (3) above have been calculated as a per acre-foot charge and appear as a total cost for each district in columns B and D. In the case of groundwater, this includes the fixed cost in pumps, wells, etc.

There is great variation among districts between variable and fixed costs in Kern County. For example, the Rag Gulch District charged $35.60 as a water
toll per acre-foot, and there was no fixed per-acre charge. Berrenda Mesa, on the other hand, collected $12.53 per acre-foot as a variable water toll and $20.98 on a per acre-foot basis as a fixed charge. In other words, to get an additional acre-foot of water, farmers in Berrenda Mesa paid only $12.53, whereas, if the full district costs had been covered by the variable toll, the price would have been $33.51 per acre-foot. Given the elasticity of demand figures presented earlier, the impact on the quantity of water demanded would be very substantial had $33.51 rather than $12.53 been charged for the marginal acre-foot of water.

To test the hypothesis that farmers change irrigation practice and technology to conserve water when water prices are high, water costs were correlated with irrigation efficiency for the Kern County water districts. Irrigation efficiency was calculated as a ratio of the average per acre consumptive use of water in the district to the amount of water delivered to the district. Since irrigation efficiencies are measured at the district and not at the farm level, some of the water losses resulting in reduced irrigation efficiency may have occurred before water was delivered at the farm gate. If so, on-farm irrigation efficiency may have been higher than those reported in Table 3.

A correlation coefficient value of one would indicate a "perfect" relationship between water cost and irrigation efficiency; a coefficient of zero would indicate no relationship. For both groundwater and surface water the correlation coefficients are positive and closer to one than to zero: for groundwater, .732; for surface water, .642. The indication is that higher irrigation efficiencies are associated with higher costs.

One must be careful not to infer too much from the relationship between water price and irrigation efficiency. It might be a temptation to argue, for
example, that large quantities of water could be saved in agriculture simply by raising the price—water then could be moved to other uses, thus forestalling costly new water development. The problem with this line of reasoning is that not all water saved on an individual farm or even in an irrigation district is a net water saving for the basin as a whole. Much of the water lost, causing "low" irrigation efficiencies, returns to the water system in the form of aquifer replenishment or surface return flows. It is thus "recoverable" in a physical sense. Nearly all irrigated system leakage as well as tailwater\(^1\) returns to the system and is available for future use. Of course, it is important to recognize that recovering used water is not costless, since pumping is required for groundwater reuse and water quality is almost always reduced in the process of irrigation. The water picks up salts and other contaminants as it is used again and again. For these reasons farmers may find it profitable to invest in reducing water losses, even if the water is recoverable.

Recoverable losses may be reduced by:

--Improved irrigation scheduling which helps in applying water in the right amounts at the right time.

--Better drainage and salinity management which will reduce water needs.

--Automation of systems to increase application efficiency.

--Shorter irrigation runs (at the expense of more labor).

--Use of lined ditches or pipelines.

--Use of tailwater recovery systems.

\(^1\)Tailwater is the irrigation water that accumulates on the surface at the lower end of the field and is available for further use.
Water lost to evapotranspiration is lost to the entire water system and is thus nonrecoverable. If these losses can be reduced, there is an augmentation to the system's supply. Much research is being directed toward finding ways of reducing evapotranspiration within existing cropping patterns by controlling weeds and aquatic plants, and by limiting or eliminating cover crops (Gardner et al., 1981). Economists have important work to do in evaluating the economic feasibility of reducing water losses, both recoverable and nonrecoverable.

**Water Price and Cropping Patterns**

It has already been shown that among water districts in Kern County, California, those with the highest water prices facing their farmers tend to have the highest irrigation efficiencies. Another response to higher water prices might be a shift in cropping patterns to more water efficient or higher-valued crops.

As water costs rise, farmers may plant more water efficient crops. If farmers can only grow field crops such as sugar beets, wheat, feed grains, and cotton, because of climatic, soil, or market conditions, they may switch to those that have lower ET requirements.

In a linear programming model of two "typical" 640 acre Yolo County, California, farms—one with high grade soil, the other with medium grade—Hedges (1977) showed how cropping patterns in the optimal mix would shift as water prices rise. The optimum cropping pattern for the high grade soil farm at a zero water price called for 150 acres each of tomatoes, sugar beets, and wheat plus 47 acres of alfalfa, 65 of beans and 38 of safflower. As water prices were raised, alfalfa acreage was the first to be reduced,
gradually dropping out entirely at $13.50 an acre-foot. Safflower—a low water using crop—expanded in acreage as did barley which replaced sugar beets at the highest water price $22.50. Similar results were obtained for the medium grade soil farm.

Seasonal evapotranspiration may also be reduced by shifting to a variety of an existing crop that requires a shorter growing season. Or, if climatic conditions permit, farmers may plant earlier to avoid the hot season when high evapotranspiration occurs. At the limit, after all these adjustments have been made, if the water is not available or if it costs too much, acreage may have to come out of crop production.

Another response that farmers might make to higher water prices is to shift to higher (per acre) value crops. Since water has become more expensive relative to other inputs, the tendency is to use more of the latter to the extent that they are substitutable. This can mean using labor, land, and capital more intensively which could bring on a crop mix change away from field crops toward high-value (and high-cost) orchards, vineyards, and vegetables.

Another reason for shifting to high-value crops as water prices rise involves risk management. High-value crops also tend to be high-risk crops—both in terms of yields and prices (Lin, Dean, and Moore, 1974). Higher water prices may induce farmers to abandon the low-average-profit, low-risk crops in favor of high-value, high-risk crops.

---

1One of the indirect impacts of cropping pattern shifts not accounted for in this analysis is the effect on prices. For example, reduced production of alfalfa could be expected to increase alfalfa prices depending on the elasticity of demand for alfalfa facing affected farmers. If the price rose in response to decreasing supplies, less acreage would have to shift to other crops in the process of reaching a new optimum. These price effects are usually accounted for by employing a quadratic programming rather than a linear programming model.
To test the hypothesis that high water costs are associated with higher valued crops, a cross-sectional analysis was made of 20 Kern County water districts\(^1\) using 1975 data from Watson, Nuckton, and Howitt (1980). Recall that surface water costs among the districts ranged from a high of $51.07 per acre-foot in Cawelo to $6.68 in Delano-Earlimart; groundwater from a high of $40.03 in Kern-Tulare to a low of $16.05 in Buena Vista (see Table 3). A weighted groundwater and surface water cost average was constructed and used as an explanatory variable in two linear equations fitted by ordinary least squares.

The dependent variable in the first equation was the percent of the district's acreage in orchards, vineyards, or vegetables (high per acre revenues and costs); in the second equation, the dependent variable was the percent of the acreage in field crops (low-value crops). (Rice was excluded from the analysis because of its high water requirements and because its cultivation in the area is determined primarily by soil and drainage conditions.)

In the regression equations, a positive sign on the water price coefficient would be expected in the first and a negative sign in the second. Obviously, water price is not the only explanatory variable affecting cropping patterns. Others are soil and drainage, possibilities of frost, and available markets. The Kern County water districts cover areas in the foothills on the east side of the valley, older production areas on the east side, areas on the newer west side, and areas in the valley trough where soils are very heavy and drainage is a serious problem. In the regression, a soil variable was

\(^1\)West Kern Water District was excluded from the group of districts analyzed because in 1975 only 633 acres were planted and it was therefore an insignificant part of the total acreage.
included representing the percentage of the district's land with better soil (scores of 60 and above on the Storie Index). The expected sign of this variable would be positive in the first equation and negative in the second. Dummy variables were used to represent the combined influence of all variables associated with location.

**Equation 1: Orchards, Vineyards, and Vegetables**

\[
OVV = -16.936 + 0.927 \text{WWC} + 0.242 \text{SOIL} + 37.59 D_1, \\
\quad (2.16) \quad (1.62) \quad (3.75) \\
+ 3.182 D_2 - 7.985 D_3 \\
\quad (0.32) \quad (-0.55)
\]

Numbers in parentheses are t values.

\[R^2 = .72\]

**Equation 2: Field Crops**

\[
FC = 102.03 - 0.988 \text{WWC} - 0.085 \text{SOIL} - 42.39 D_1, \\
\quad (-2.13) \quad (-0.53) \quad (-3.91) \\
- 0.014 D_2 + 16.565 D_3 \\
\quad (-.001) \quad (1.06)
\]

\[R^2 = .72\]

where

\(OVV = \) percent of district acreage in orchards, vineyards, or vegetables.

\(FC = \) percent of district acreage in field crops, excluding rice.

\(\text{WWC} = \) weighted groundwater and surface water cost per acre-foot.

\(\text{SOIL} = \) percent of district acreage above 60 on the Storie Index.

\(D_1 = 1\) if district is in the foothills, 0 otherwise.

\(D_2 = 1\) if district is on the west side, 0 otherwise.

\(D_3 = 1\) if district is in the valley trough, 0 otherwise.
The two equations explain the variation in the respective dependent variables equally well ($R^2 = .72$), and both water cost coefficients have the expected signs and are statistically different from zero at the 97.5 percent confidence level, using a one-tailed t-test (the first in the positive direction; the second, negative). The soil variable had the expected signs but was not statistically significant. The foothill dummy explained some of the difference in cropping patterns among districts. The statistically significant coefficient reflects the fact that it is in the gently sloping terrain of a nearly frost-free thermal belt in which many of the county’s orchards and vineyards flourish.

The conclusions of this section on the impacts of water price are quite clear. The elasticity of demand for irrigation water is "high" for very good reasons. Water price really matters because farmers can and do adjust by: (1) using less water on a given crop, (2) undertaking investment that increases irrigation efficiency, (3) substituting water-efficient crops for those less efficient, and (4) shifting to crops which have higher nonwater costs, higher risk and a higher per-acre value. Evidence has been presented supporting all these conclusions. Then, are we to assume that water allocation in agriculture is optimal? Unfortunately, we cannot. The reason is to be found in the institutional framework that determines water pricing and allocation. In California, that framework centers on the water districts and their management practices.

Institutions Governing Water Allocation in California

A fantastic array of private and public institutions exist in California for the purpose of developing and allocating water resources. They number in
the thousands and employ operating rules established broadly by enabling legislation. These rules largely determine the distribution of economic rents connected with water use and influence the efficiency of water development and use. The more significant institutions will be described briefly.

The important private entities are commercial water companies and mutual water agencies—combined they number in the hundreds and are quite old. Their principal purposes are to establish rights to water use and to sell and deliver water to users. The mutual agencies sell water to members at supply costs and are thus nonprofit. The water companies sell water to customers within their service areas (Wallace and O'Connell, 1966) at whatever prices the market will bear, and the profits are distributed to stockholders as with any other private company. It is not known how much water is allocated by these private entities, but the mutual companies are more frequently utilized in irrigation, whereas the commercial companies are more heavily involved in serving urban customers.

The public water districts of great significance in supplying water to agriculture in California are the reclamation districts, authorized by legislation in 1867; the irrigation districts, authorized in 1897; the water districts, authorized in 1913; and the water storage districts, authorized in 1921. Some of these districts and the quantities of water handled are listed in Table 4. Reclamation districts' primary purposes are to reclaim and protect lands from overflow and to irrigate lands both inside and outside the district (Ibid.). Irrigation districts supply, distribute, and salvage water for beneficial use. Water districts and water storage districts may produce, store, and distribute irrigation water to individual farmers.

The significant point is that each of these public districts becomes in essence a nonprofit wholesaler of water to farmers. They may have water
Table 4.

<table>
<thead>
<tr>
<th>Contractor</th>
<th>Volume Delivered (acre-feet)</th>
<th>Principal Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Westlands Water District</td>
<td>1,250,279</td>
<td>CVP</td>
</tr>
<tr>
<td>Kern County Water Agency</td>
<td>788,409</td>
<td>SWP</td>
</tr>
<tr>
<td>Central California Irrigation District</td>
<td>527,894</td>
<td>CVP</td>
</tr>
<tr>
<td>Municipal Water District--Southern California</td>
<td>479,565</td>
<td>SWP</td>
</tr>
<tr>
<td>Orland Water User Association</td>
<td>252,788</td>
<td>CVP</td>
</tr>
<tr>
<td>Lower Tule River</td>
<td>223,000</td>
<td>CVP</td>
</tr>
<tr>
<td>Tulare Lake Water Storage District</td>
<td>201,202</td>
<td>SWP</td>
</tr>
<tr>
<td>Arvin Edison Water Storage District</td>
<td>191,200</td>
<td>CVP</td>
</tr>
<tr>
<td>Madera Irrigation District</td>
<td>188,888</td>
<td>CVP</td>
</tr>
<tr>
<td>Tulare Irrigation District</td>
<td>186,000</td>
<td>CVP</td>
</tr>
<tr>
<td>San Luis Canal Company</td>
<td>169,711</td>
<td>CVP</td>
</tr>
<tr>
<td>Delano-Earlimart Irrigation District</td>
<td>168,100</td>
<td>CVP</td>
</tr>
<tr>
<td>Southern San Joaquin Municipal Utility District</td>
<td>138,700</td>
<td>CVP</td>
</tr>
<tr>
<td>Chowchilla Water District</td>
<td>129,867</td>
<td>CVP</td>
</tr>
<tr>
<td>Panoche Water District</td>
<td>113,745</td>
<td>CVP</td>
</tr>
<tr>
<td>San Luis Water District</td>
<td>104,291</td>
<td>CVP</td>
</tr>
<tr>
<td>Santa Clara Valley Water District</td>
<td>103,745</td>
<td>SWP</td>
</tr>
<tr>
<td>Dudley Ridge Water District</td>
<td>80,356</td>
<td>SWP</td>
</tr>
<tr>
<td>Firebaugh Canal Company</td>
<td>79,162</td>
<td>CVP</td>
</tr>
</tbody>
</table>

*CVP = the Federal Central Valley Project
SWP = the State Water Project

supply sources (including rights) of their own, both surface water and groundwater, or they may be contractors for water developed by the federal government through its Central Valley Project or by the State of California through its State Water Project. They are governed by boards of directors, may have powers of eminent domain, and have the power to sell general obligation bonds, levy water charges, and impose ad valorem taxes on landowners within the district.

As argued in the introduction, economic rents are captured when the costs of obtaining and using a resource are lower than its value in use. Let us suppose that a farmer has an annual entitlement of water of three acre-feet per acre. His average per acre-foot cost is $20, and its value in use is $30 per acre-foot. As defined above, annual economic rent captured by the farmer is $10 per acre-foot, or $30 per acre of irrigated land. Total water rent could be calculated by multiplying the per acre rent by the number of irrigated acres operated by the farmer. From our discussion thus far it must be obvious that the annual income of our farmer is materially influenced by the magnitude of the water rent.

His asset wealth position may likewise be affected by rent. If the water entitlement were an appropriative right that could be separated from any particular parcel of land, the water right itself would be worth the discounted present value of the flow of economic rents. If the entitlement were a riparian water right that was attached to riparian land, the flow of economic rents would become capitalized in the value of the land itself. If the entitlement were a 20-year water contract with a public water agency, the contract would take on a value reflecting the present value of the discounted flow of rents over the contract period. It follows that the wealth value of
the annual water rents is influenced by the type of property right incorporated in the entitlement. The conclusion is that income and wealth effects on farmers resulting from water use are a function of the magnitude of economic rent and the nature of the property right in the use entitlement. The pricing and allocation policies of the water districts described above are crucial elements in determining what water costs and how much it is worth.

Let us first discuss some of the water pricing policies utilized by the districts and analyze their allocative and distributive effects. In allocating a fixed quantity of developed water, allocative efficiency requires that the marginal value of water consumptively used be equal, net of the costs of transport, and assuming that marginal values include both private and social benefits and costs. In the development of new water, economic efficiency requires that benefits from the proposed project exceed costs and that development is permitted to proceed only so long as the marginal benefits received from water supply exceed the marginal opportunity cost of the resources needed to bring forth the new supply. The district and agency policies analyzed below somehow prevent the users of water from seeing the relevant cost or value, and therefore the user decision in water allocation are not economically efficient. Given the elasticities of demand for irrigation water presented earlier and the derived use values, a low marginal cost for water means that farmers will want to use more of it than if the marginal cost were higher. In fact, if water were free to move among prospective users without restriction and prices were free to seek equilibrium levels, water prices should vary among users only by the cost of moving it from one user to another. This is the way the market works for other more mobile inputs such as machinery, energy, and fertilizer. Those users who can
earn high economic rents in its use will bid it away from lower-rent users by offering a price higher than the rent earned in the less valuable use. Thus, one way of judging whether or not water misallocation is occurring is to look at the distribution of water prices among water districts net of transport costs.

Recall once more the substantial differences in water price among water districts in Kern County (Table 3). The intriguing question is why do these pricing policies vary so much? There appear to be two important reasons, both related to the sources of water supply available to a given district and what they cost: (1) Since a district is nonprofit, it must capture sufficient revenues to meet its total financial obligations (most of which are tied up in water costs which it incurs as a wholesaler) and at the same time sell the water available; and (2) many of the districts have sold bonds in order to create distribution facilities and these instruments are easier to sell if the financial backing is in the form of fixed charges that are not dependent on direct water sales.

There are several aspects to the first point. Since (1) most districts may sell water only to farmers inside the district boundaries, (2) they may expect future use to be greater than present use and (3) running out of water is costly, they tend to contract for "large" surface supplies, especially if they are cheaper than expected costs of pumping groundwater. If the district has a large supply compared to its demand, the marginal cost (the variable water toll) must be kept low so that the quantity available can be sold. If the resulting low toll generates insufficient resources to meet repayment obligations, then the fixed charge or the land tax will need to be relatively higher. Of course, the reverse situation would call for high variable tolls
(marginal costs) if surface supplies were short and the district is faced with the need to pump expensive groundwater. Since the districts have varying expectations of future demand, different groundwater alternatives and different financial obligations, the mix of fixed charges and variable tolls are highly variable among districts.

This relationship between revenues generated and variable water tolls can create financial problems for the district. If demand for water were highly inelastic, an increase in the variable toll would not reduce the quantity demanded very much, and the toll would be an effective instrument in raising revenues for the district. If, however, as the above review of elasticities indicated, demand elasticity approaches unity and may sometimes even exceed it, increasing the water toll may not increase revenues at all. The increase in price would be more than offset by reductions in the quantity demanded. No wonder several of the districts rely heavily on a fixed charge. If they must increase revenues to cover their costs, that would seem to be their only alternative.

The water costs to the district are also obviously crucial in determining the variable toll charged the farmers; if the costs are low the water toll will be low. Those with the low tolls, Buena Vista, Delano-Earlimart, Kern Delta, North Kern, Shafter-Wasco, and Southern San Joaquin, either get the bulk of their supplies from old rights to the Kern River at very low costs or from the Central Valley Project (CVP), where ability-to-pay pricing procedures have produced low contracted rates for very long periods of up to 40 years. Those districts charging high rates generally receive higher cost state water and/or are heavily dependent on expensive groundwater.

It would appear that the economic rents captured by the water users are highly variable, given this evidence from Kern County. Even though demand
studies have not been made in each district that would reveal what the use value of water is, similarities in cropping patterns would suggest use values that are not as disparate as water costs. If economic rent is defined as the difference between per unit water value and cost, the upshot is that high cost districts would be capturing lower rents than low cost districts.

Of course, over the longer run if higher annual economic rents are "secure," they would tend to get capitalized into higher land values. Wealth gains would be captured by landowners. If the land were sold to new owners, the favorable economic rents attributable to water procurements would be offset by higher land costs, ceteris paribus. Thus the original landowner would capture the bulk of the benefits of the higher water rents.

Unfortunately, no systematic studies have been made of the land market in Kern County that would establish empirically the relationship between water rents and land prices.

This policy of combining variable tolls with fixed charges may be perfectly sensible as viewed by the district's management that must raise revenues to cover cost. It may not be socially optimal if efficient water allocation is a significant policy goal. If quantities demanded were free to adjust so that the marginal value of water would be equal to the variable water toll, then great variation in the toll implies great variation in the marginal value of water among users. This, in turn, suggests that water reallocation from uses and users of low value to high value would increase water's economic productivity.

There is substantial empirical evidence that water values are highly disparate, even within agriculture. Noel, Gardner, and Moore (1980) published a Yolo County, California study of conjunctive use of groundwater and surface
water, allocated by several water agencies. The groundwater aquifer was partitioned into six basins which differed in pumping costs and surface water costs. An economic-hydrologic linear quadratic control model was used to estimate the marginal values of irrigation water in the six basins. The range was large--from $2.44 per acre-foot in an area near the Sacramento River where surface water is plentiful and cheap and the pumping lift was less than 20 feet, to $61.13 in another area scarcely 25 miles away, where water is pumped from more than 100 feet. This disparity in values suggests that large economic gains could be captured by water transfers from areas of low value to areas of high value. These transfers do not occur because of institutional impediments that result from the mish-mash of water law and administrative practices that are used at the water district, state, and federal levels. The most significant of these will be discussed below.

A common pricing policy, particularly by districts in the Sacramento Valley, is to impose a fixed per acre water charge which varies by crop. As a typical example, one irrigation district which sells large quantities of water to rice farmers, announced water rates, effective February 7, 1980, as: $17.25 per acre flooded for rice; $12.10 per acre irrigated for sugarbeets and tomatoes; $10.35 per acre irrigated for pasture, clover, ear corn, alfalfa, and orchard; and $6.90 per acre irrigated for general crops (barley, vine crops, wheat, milo, other cereal grains, and silage corn). The announcement also specifies that the regular rates apply to three irrigations (except for rice). Water quantities delivered are not measured. Lands outside the district may be supplied with water if prior agreement has been made with the irrigation district's board of directors, but per acre water charges outside will be twice the announced per acre inside charges.
Such a policy violates the requirements of economic efficiency. Since the water charge is not related to the quantity applied or consumptively used, at the margin the water cost is zero. A sugar beet grower would pay the same flat rate to apply 45 inches of water as for 35 inches per acre, a rice grower could get 10 acre-feet for the same total cost as six. (Of course, other costs involved in irrigation, such as the irrigator's wage, however, may constrain water use.) Under this pricing policy there is little incentive for conserving water by careful irrigation practice.

Another problem with the fixed per acre charge is that some crops bear higher water costs than others per acre-foot used consumptively. Alfalfa and pasture in the area consumptively use about 48 inches of water annually, rice about 56 inches on average. Most of the other crops use much less. In the example cited above, it is apparent that growers of alfalfa, pasture, and probably rice are receiving economic rents much higher than they would if water were priced at equal per acre-foot rates for all crops. Tomatoes and sugar beet growers appear to be capturing smaller water rents than if per acre-foot prices were equal. If the fixed per acre charge were replaced with an economically efficient per acre-foot toll that was the same for all crops, it is likely that substantial shifts in cropping patterns would ensue. This question should be researched to determine the extent of the current misallocation.

One of the reasons commonly given for pricing water on a per acre basis is the difficulty and cost of determining how much is delivered to a given farmer. This is especially true for surface water diversions and for riparian users of water courses. Still, meters, weirs, and other measuring devices are available, and there is little doubt that their implementation would permit a more efficient pricing policy.
Land or water taxes, imposed on all landowners in a district to raise district revenues, are even farther removed from direct water use than per acre charges. Nearly all districts allocating water in California have legislative authorization to levy taxes and many do, especially those selling urban water. In an efficiency sense, it makes little difference to water use decisions whether taxes so raised are used to pay off fixed indebtedness or to cover current operations and maintenance costs. In either case the amount of the tax is divorced from the quantity of water used and thus has no impact on water allocation at the margin. High cost water that may not be economically justified in the sense that benefits exceed costs may be paid for by spreading the costs among district taxpayers, some of whom may use little or no water. The tax may be an effective instrument for raising district revenues, but it is inefficient as a mechanism for producing efficient new water development, for allocating water to its highest valued uses, and for providing incentives to economize on the amount of water used.

In its allocative effects, perhaps the most pernicious of all pricing practices commonly utilized in the water districts and by the water agencies is so-called price averaging. Some hypothetical numbers will permit us to see how averaging works, why it promotes uneconomic water development, and how economic rents are affected. Suppose an existing supply of water delivers 3 acre-feet per acre to the district's farmers and the average cost is $10 per acre-foot, the price which the farmer pays. Suppose the average value of this water is $20 per acre-foot, which means the farmers are capturing a rent of $10 per acre-foot. Let us assume a new supply source might be made available to the district which would double the water supply and which would cost $25 per acre-foot. If the average value of existing water can be taken
as the marginal value, it is apparent that the farmers would not want the additional supply if they had to pay $25 per acre-foot. This would be the end of it and the new water would not be developed. What the district commonly does, however, is average the old and the new water costs; in our example, this average is $17.50. This is still below the average value of water so there is demand for the new supply. The effect of this price blending is to distort the true supply price of the new water. The upshot is that uneconomic supplies get developed and per acre-foot rents are diminished.

To make matters even worse, the district might use this practice to expand its acreage. In this case there would be a transfer of rent from the farmers on the original acreage to those on the new. Not only does uneconomic water get developed, but it is allocated to new land that otherwise would not be producing crops. Empirical analysis is also needed to quantify this type of misallocation.

A vivid example of price averaging and its effects on water rents is provided by a proposal by the Bureau of Reclamation. The separable costs assigned to irrigation for new agricultural water supplies forthcoming from the proposed Auburn Dam have been estimated at approximately $63 per acre-foot. (Agricultural water users do not pay interest charges on the capital costs of constructing new projects). For the sake of argument, let us assume that this figure is a true representation of the marginal supply costs of the new irrigation water. Only if water is worth $63 per acre-foot is it economically efficient to develop it. Repayment capability budgets of the

---

Bureau, however, suggest that, in general, farmers could not afford such high water prices. Current Bureau prices in California are far lower—generally from $2.50 to $15 per acre-foot.

What is proposed is to spread the costs of the new water over all users of federal water, existing users as well as new users. Some of the existing users are far removed from Auburn Dam and the area of intended use. By averaging the cost in this fashion, the water rates to all existing users would rise by $3.25 per acre-foot. Short of a law suit, existing users would have no say in the matter; the new rates would simply be imposed. The upshot is that economic rents would be reduced by $3.25 per acre-foot on all existing users.

The efficiency implications are indeed ominous: (1) almost any project, regardless of water costs, could be justified and paid for by this mechanism, and (2) the increase in price to all users may drive water costs above its worth and cause previously economic production to be uneconomic and thus misallocate resources. The equity implications are no less objectionable: the imposition of the equivalent of a water tax without the consent of the affected irrigators.

Policies of both the Department of Water Resources of the State of California, which administers the State Water Project, and the Bureau of Reclamation, which administers the federal Central Valley Project, differentiate between contracted (entitlement) water and surplus water. Entitlement water is contracted for long periods of time and usually well in advance of delivery, and the supply agency must plan to meet the requirements of these contracts. Because of random climatic variables and the need to provide a firm supply of entitlement water, the quantity in the entitlement is
less than is available in all but the dry years. For state entitlement water
the rules specify that the water price must cover the pro-rata share of the
fixed capital costs of the project as well as the variable costs of delivery.
In the federal case, the water price on contracted water is usually determined
by an ability-to-pay rule.

Because contracts are long-term instruments and growth in use is assumed,
in the early years of the contract the contractors are often unable or
unwilling to take all the water available. As stated above, year-to-year
variation in precipitation affects the supply as well. For these reasons,
some water is usually available as "surplus." Surplus state water is sold at
the variable costs of delivery which depend on how far the water must be
transported and how much it costs to pump it through the system. Federal
surplus water is also sold below contracted prices and has been used to
replenish groundwater aquifers in years of plentiful supply.

An interesting example of surplus water allocation is provided in Kern
County. The Kern County Water Agency is a water broker for several of the
water districts discussed earlier. For most years in the last decade it has
been receiving large quantities of state surplus water because the
Metropolitan Water District in Southern California has not been using its full
entitlement. Perhaps it soon will, however, as 650,000 acre-feet of Colorado
River water now flowing to Southern California might be lost to Arizona
beginning in the mid-1980's. In the meantime, the question that concerns us
here is how the Kern County Water Agency decides who should receive the
"cheap" surplus water and thus capture the economic rents. The price
averaging process among districts is a mechanism whereby the agency can spread
these "goodies" around.
The water law in California presents some obstacles as we look for possibilities for developing markets to efficiently allocate water. Individual water users do not themselves own the water rights—the water companies and often districts do. In California, the federal Bureau of Reclamation and State Department of Water Resources are permittees of the State Water Resource Control Board, which has ultimate jurisdiction over water rights. Contractors of these agencies technically do not hold any permanent water rights beyond their contracts. They are given options to purchase water from the districts on terms specified in the contract. For its part, the district is bound by contract to supply water so it isn't really free to negotiate the sales of water rights or even water rentals unless it has surplus available. In the case of State Project water, any changes in contracts or in points of diversion must be approved by the Director of the Department of Water Resources. This type of administrative approval is likely to be difficult to obtain. The ultimate water users are powerless to make any transfers at all. The most they can do is simply forfeit their use of water, but usually they are committed by contract to take a certain amount. The result is an inflexible and inefficient water allocating system.

This complicated milieu of water allocation by the water districts in California is no doubt what led researchers of the Rand Corporation to argue that the treatment of water rights is one of the most crucial factors in achieving efficiency of water use and that title to water should be passed from the water district to the water user, thus providing full economic incentives to transfer water to parties valuing its use more highly (Phelps, et al., 1978).
Conclusion

One might interpret the foregoing discussion as being pessimistic that much can be done to improve the efficiency of water allocation in California. That would be an erroneous interpretation. Water policy is dynamic and responsive to economic pressures, and the next decade is likely to bring many changes in the rules of water pricing and allocation. These changes will probably have a significant impact on the economic rents captured by water users.

Water users themselves are taking significant steps to improve water mobility in time and space. Market-like arrangements are developing in many situations where conditions are conducive. Some districts that have capacity are storing water for other districts, both above and below the ground, at terms mutually acceptable. Within districts, some farmers with relatively inexpensive groundwater are selling their surface water to other farmers who have either expensive groundwater or none at prices which benefit both parties. These developments are immensely encouraging and should be supported by effective legislation and administrative policies.

At the federal level the 1902 Reclamation Act that restricts the acreage receiving federal water under one owner to 160 acres is likely to be replaced by legislation that is much more liberal. Bills being considered by the Congress would expand the restriction to 960 acres of owned land. The question of whether or not additional acreage may be leased is being hotly debated, as is the issue of whether or not to require owner residency on or near the land. Some versions of the proposed legislation would require irrigators to pay the full supply cost of federal water utilized on acreages over 960 acres, including an interest charge on the capital stock. The
impact on the economic rent earned by water could be substantial. What water is worth per acre-foot is related to the size of farm if economics of size exist. Rents will no doubt be less if water prices are increased more than the value of water increases in use. When land receiving subsidized water is rented, it is not clear a priori whether the lessor or the lessee captures the water rent. It would depend on the characteristics of the land rental market and who has market power.

At the state level also there are changes pending. The electorate will decide in June of 1982 whether or not to build the Peripheral Canal to move water around the Sacramento-San Joaquin Delta to the San Joaquin Valley and to Southern California. This and other costly state projects must be funded by water sales. Water prices, and thus water rents, will be affected. Even if no new water is developed, water prices will be much higher as new contracts are negotiated in 1984 due to increases in energy costs. My guess is that in most situations water prices set by administrative fiat will increase faster through time than the value of water and therefore economic rents will decline. Also, the quantity of water demanded will decline substantially as farmers adjust by using less water on a given crop, use more water-efficient technology, and shift to more water-efficient and higher-valued crops. This probably means that the state will encounter greater difficulties than at present in finding contracting buyers of irrigation water.

Those irrigators who have either riparian private water sources with firm rights and can get water cheaply will continue to capture large water rents and their land prices will continue to escalate relative to those irrigators who must pay the higher water prices.
References


