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THE INCOME DISTRIBUTIONAL IMPACTS OF ALTERNATIVE IRRIGATION RETURN FLOW CONTROL POLICIES

by

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INTRODUCTION

Economics is concerned with the description of alternative states of the economy in terms of various criteria of efficiency and equity. However, an examination of the public and academic economists' evaluations of many policy proposals reveals that efficiency is the primary criterion applied in policy analysis, particularly with respect to natural resources. Explicit attention to equity or the distributional impacts of policy have been subsumed in the estimation of aggregate benefits and costs irrespective of distribution. While it is true that distributional analysis is hampered by a lack of precision in the specification of equity criteria, we argue that such analysis should occupy a more critical role in policy evaluation. In particular, distributional analysis, whether of income or wealth, is a comprehensive socio-economic evaluation of public policy that includes the identification of who benefits and who pays. Such analysis has implications for the need for and design of compensating programs such as cost sharing. Distributional analysis may also indicate the existence of synergistic and/or antagonistic effects between proposed and operating policies and programs. The purpose of this paper is to report the income distributional impacts within a San Joaquin Valley irrigation district from the implementation of two alternative water quality policies to manage irrigation return flows.

Several possible empirical approaches can be applied in assessing the distributional impacts of natural resource policy. The basic underlying contention is that the institutional environment that defines property rights in resources and the public policy toward those resources affects the distribution of income. Distributional effects, whether resulting from the direct application of economic incentives in the form of taxes or subsidies or resulting indirectly from restrictions on resource supply or use, may be represented by a single index number such as the Gini coefficient (Hansen and Schwartz), as net impacts upon classified groups (Collins) or as an estimated function for the Lorenz curve itself. Each of these approaches has merit. In this analysis, both the Gini coefficient and the gross impact by income group are used to represent the income distribution resulting from each alternative policy. Despite the fact that there does not exist a unique correspondence between Gini coefficients and income distributions, they are useful comparative summary measures of distributional impacts.

The Federal Water Pollution Control Act Amendments of 1972 (PL 92-500) outlines broad water quality goals for the nation and establishes mandates for each state to control point and nonpoint sources of pollution from all man-made activities. Pollution from irrigation return flows was originally classified as a point source and subjected to the National Pollution Disposal Elimination System Permit Program. However, in 1977 the Clean Water Act reclassified irrigation return flows as a nonpoint source and as such subject to the procedures outlined in Section 208 of PL 92-500. Section 208 requires that nonpoint sources of pollution be identified and that procedures for control be specified as "Best Management Practices" (BMP). The specification of BMP's and a schedule for implementation are to be a part of the Areawide Waste Treatment Management Plans which must be submitted to the

Environmental Protection Agency (EPA). Section 303 of PL 92-500 requires that the state adopt a continuing planning process that is consistent with all provisions of the Act. This process is designed to insure that the initial plan formulated under Section 208 remains effective under changing economic and environmental conditions. In addition to its planning responsibility, each state must prepare an estimate of: (1) the environmental impact; (2) the economic and social costs necessary to achieve the objective of the act; and (3) the economic and social benefits.

Determining the distribution of benefits and costs by socio-economic or geographical group of specific BMP's is an important criteria in evaluating a Section 208 plan. Two policies that could be specified as BMP's to reduce irrigation return flows in the San Joaquin Valley were evaluated for changes in water quality and income distribution. These policies were evaluated by simulating farmer's decisions and estimating irrigation return flows using data from the Central California Irrigation District (CCID). CCID is located on the west side of the San Joaquin Subbasin. Cotton, alfalfa, sugar beets, beans, rice, corn, orchard crops and melons are the principal crops grown on the 145,000 irrigated acres comprising the District. Farmers in the District used an average of 3.66 acre-feet of irrigation water per acre in 1976. Water costs to the farmer included a fixed assessment of \$2.15 per irrigated acre and a variable charge of \$2.50 per acre-foot of water delivered. Approximately 15 percent of the District's water supply is groundwater. Surface and subsurface irrigation return flows are collected and disposed of in the San Joaquin River.

METHODOLOGY

The alternative water quality policies were evaluated in the integrated land and water resource analytical system presented in Figure 1. Specific policy impacts were produced in the water quality subsystem whose principal analytical components consist of two location-specific models sequentially linked to simulate spatial and temporal changes in agricultural production and water quality. The linear programming model derives optimal cropping patterns, water and fertilizer use for 126 subregions encompassing 2.78 million acres in the San Joaquin Subbasin. These subregions were defined such that the soils in each subregion are homogeneous with respect to yield characteristics, response to fertilizer, management and land treatment measures. These subregions range in size from 1,498 to 78,711 acres with a mean size of 22,081 acres. The solution to the LP model is constrained by water supply, processing capacity, crop rotation requirements, risk and the amount of irrigable land.

The results of the LP model serve as data inputs to the physical model. This model is partitioned into three interdependent submodels that analyze the hydrology, salinity balance and nitrogen of the soil profile on the same spatial and temporal basis as the LP. The submodels estimate the effects of irrigation water and fertilizer use on the water depths and the quantity and quality of irrigation return flows. The costs for collection and disposal of return flows and the costs for installing tile drainage to relieve high water tables are calculated by the physical model and used in updating the LP model. Solutions from the models are derived annually to simulate adjustments from

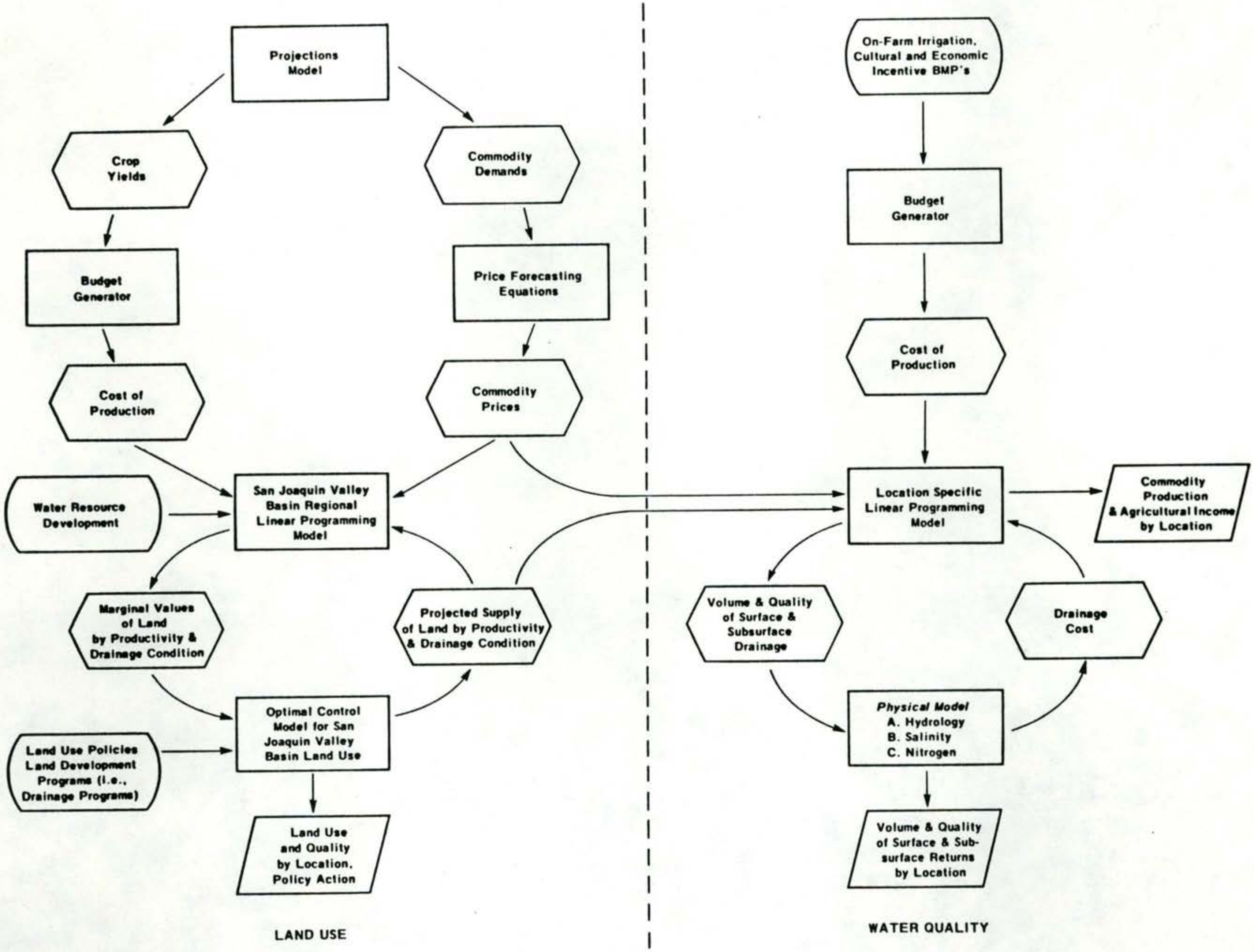


FIGURE 1. INTEGRATED LAND USE, WATER RESOURCE AND WATER QUALITY ANALYTICAL SYSTEM

policy changes affecting irrigated agricultural practices. This analytical system is discussed in more detail in Horner and English.

Procedure

Cropping patterns, returns to land, farm management and risk and the quantity and quality of irrigation return flows in CCID were estimated by the analytical system by subregion. The size of farms in each subregion within the district were determined from District water delivery records. Returns were adjusted to reflect economies of size of operation (Moore; Moore and Hedges). Firms were then grouped by income class and Gini ratios were determined for a base situation and two policy alternatives.

Policy Alternatives

The two policies evaluated to reduce irrigation return flows are: (1) implementing a $22.00 per acre-foot price for surface water and (2) requiring water management practices and methods that result in an increase in on-farm water use efficiency of 30 percent. Increasing the price of water to account for the negative externalities associated with irrigation return flows is an indirect approach that is mandated by the nature of the nonpoint pollution problem. If return flows were a point source problem, the effluent charge would be a direct approach to internalize these externalities. Water prices in the West vary because they are established by water agencies and districts to allocate diversion and distribution costs to water users. This pricing structure results in greater water diversions, production, incomes and return flows than would occur under higher water prices. (Howe and Orr; California Department of Water Resources). Increasing the price of irrigation water is as effective as an effluent charge system in reducing environmental damage if diversions are proportional to the pollution caused by return flow disposal. Howe and Orr contend that sufficient correlation exists.

The water management policy assumes the present price structure and that water conservation practices would be imposed on the area. An example of such practices could be canal and lateral lining, tail-water recycle, irrigation scheduling and more efficient water delivery systems. As a result the water use efficiency was assumed to increase by 30 percent.

RESULTS

The average returns to land, management and risk per farm firm and the amount and quality of irrigation return flows for the base and two policies are presented in Table 1. Average returns decrease slightly as a result of imposing the water management policy. This is due to a slight shift in the location of processing tomatoes outside of CCID to other subregions within the subbasin. Total regional acreage of tomatoes is constrained by the size of local processing facilities. Some areas outside of CCID were constrained by water supply. Thus, when the water management policy increased the effective supply of water, tomato acreage was increased in these previously water short areas. However, average returns were decreased by 34 percent under the policy of increasing surface water prices.

The environmental degradation potential of irrigation return flows within CCID was reduced under both policy options. In the case of the water management policy, reduced pumping of groundwater would result. Consequently, the average quality of applied irrigation water

Table 1

Average Returns to Land, Management and Risk and Amount and Quality of Irrigation Return Flows by Policy

	Base	Policy: Water Management Policies (BMP)	Policy: Increased Surface Water Prices
Returns to land, management and risk per farm firm	$ 43,768	$ 42,522	$ 28,783
Irrigation Return Flows (AF)	164,000	151,000	103,000
Salt Load (tons)	329,000	58,000	213,000
Salt Concentration (PPM)	1,836	356	1,897

increases, the amount of water lost to deep percolation decreases and the quality of tailwater and subsurface drainage improves. However, the characteristics of the return flows differ substantially under the two policies. The total volume of return flows is reduced by 37 percent under water pricing and the salt concentration remains about the same as in the base situation. The reduction in salt load would be about 35 percent under these conditions. The average quality of return flows that would result under the water management policy is sufficiently high for recyling within agriculture or disposal within potential standards. The substantial reduction in salt load is the result of reduced volumes of return flows, better quality irrigation water and the reduced amounts of subsurface return flows.

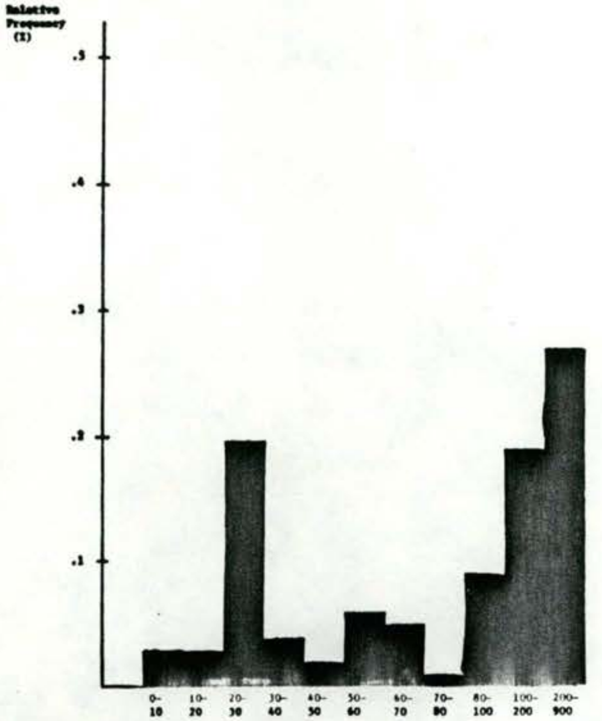
Results of the Distributional Analysis

The income distributional impacts of the two alternative policies to control irrigation return flows and salt loading will be described according to their overall impact, the impacts by income class and the impact by income quartile. Table 2 presents the basic income distributions for the base, best management practices, and water pricing options. In addition, Figures 2-4 detail the relative frequency of total income by income class according to the three alternatives analyzed. Similarly, Figures 5-7 present the same information for the number of farms by income class.

The BMP policy, when compared against the base condition, has the overall impact of increasing the percentage of income concentrated in the lower end of the distribution and decreasing that in the upper portion (Figure 3). The largest changes in distribution by income class were a 4 percent loss in total income share in the \$50,000 - \$60,000

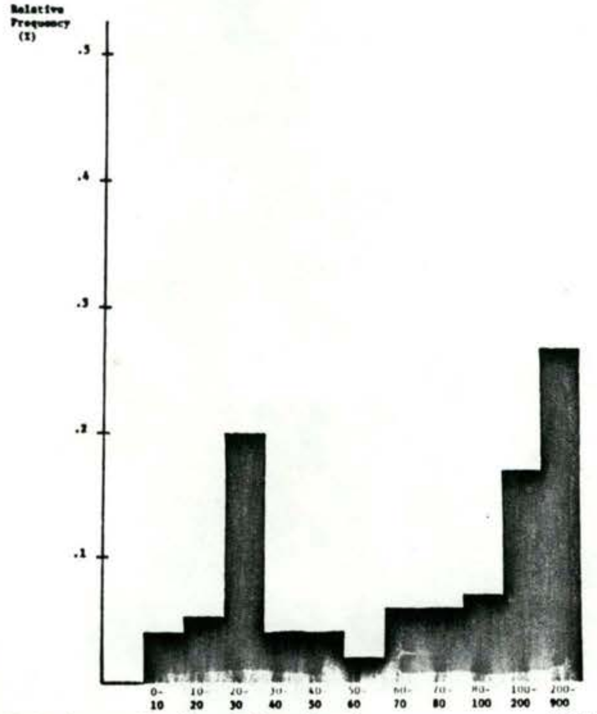
Figures 2-4. Relative Frequency of Total Income by Income Class Under Alternative Water Quality Policies

Figure 2.



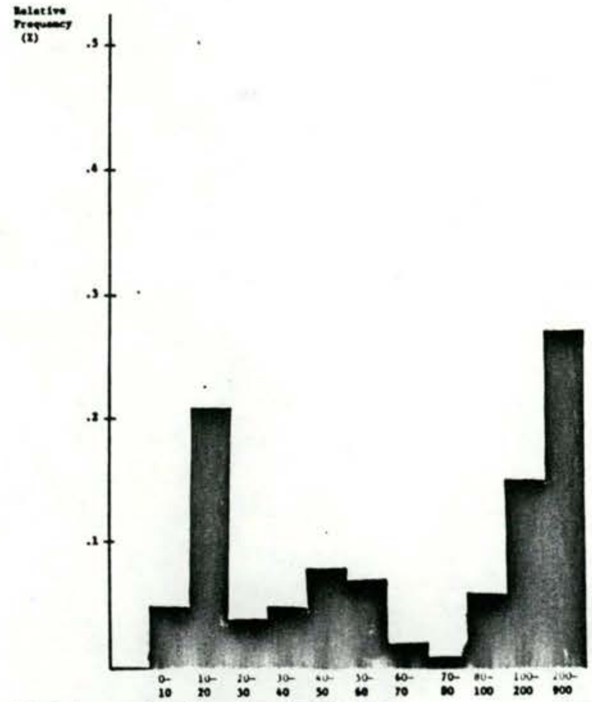
Relative Frequency of Total Income by Income Class With No Policy.

Figure 3.



Relative Frequency of Total Income by Income Class Under Best Management Practices.

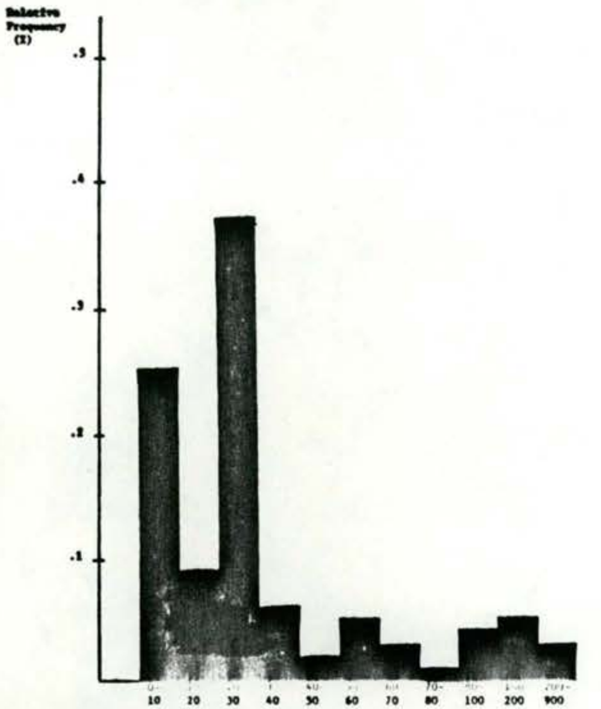
Figure 4.



Relative Frequency of Total Income Earned by Income Class Under High Water Prices

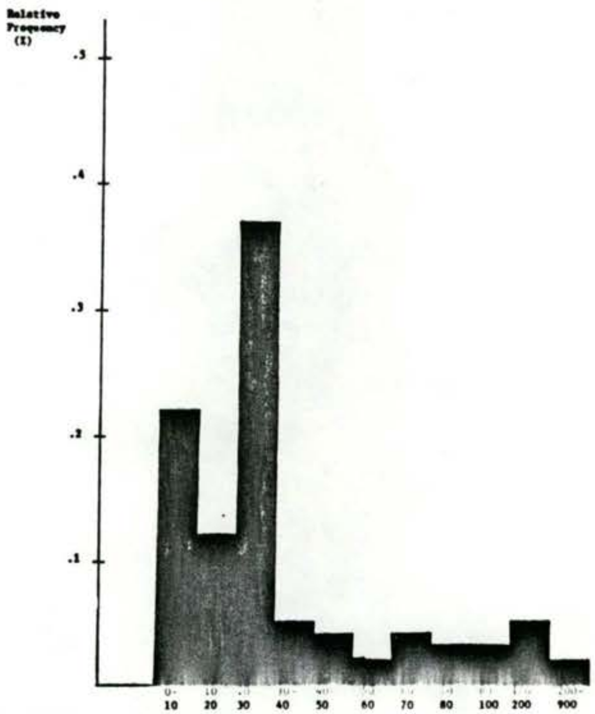
Figures 5-7. Relative Frequency of Number of Farms by Income Class Under Alternative Water Quality Policies

Figure 5.



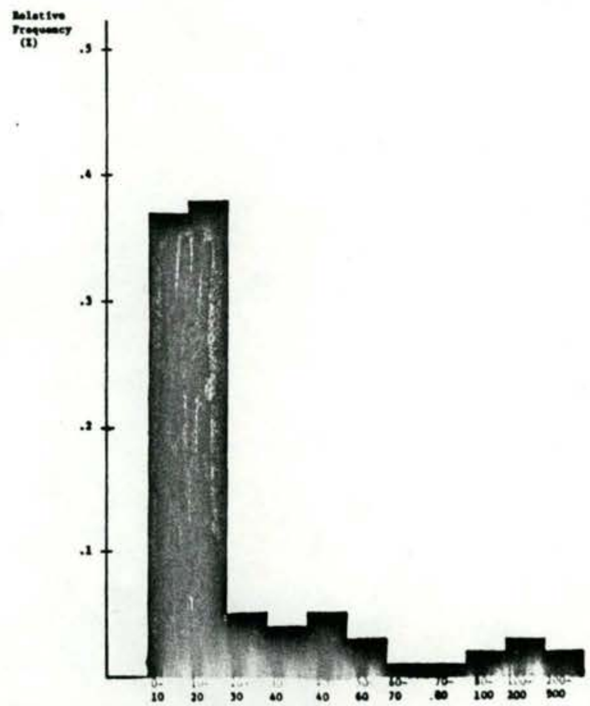
Relative Frequency of Number of Farms by Income Class With No Policy.

Figure 6.



Relative Frequency of Number of Farms by Income Class Under Best Management Practices.

Figure 7.



Relative Frequency of Number of Farms by Income Class Under High Water Prices

Table 2

Income Distributions Under Alternative Water Quality Policies

Income Range	Base: Number of Firms	Base: Cumulative Percentage of Firms	Base: Cumulative Percentage of Income	Water Management Policy (BMP): Number of Firms	Water Management Policy (BMP): Cumulative Percentage of Firms	Water Management Policy (BMP): Cumulative Percentage of Income	Increased Surface Water Price: Number of Firms	Increased Surface Water Price: Cumulative Percentage of Firms	Increased Surface Water Price: Cumulative Percentage of Income
Under $ 10,000	184	.25	.03	163	.22	.03	268	.37	.05
10,001 - 20,000	63	.34	.06	84	.34	.07	272	.74	.26
20,001 - 30,000	269	.71	.26	269	.71	.27	33	.79	.30
30,001 - 40,000	41	.77	.30	37	.76	.31	31	.83	.35
40,001 - 50,000	16	.79	.33	27	.80	.35	36	.88	.43
50,001 - 60,000	33	.84	.39	12	.82	.37	24	.92	.49
60,001 - 70,000	25	.87	.44	31	.86	.43	5	.92	.51
70,001 - 80,000	5	.88	.45	25	.89	.49	4	.93	.52
80,001 - 100,000	32	.92	.54	23	.93	.56	13	.95	.58
100,001 - 200,000	38	.97	.73	37	.98	.73	25	.98	.73
Over 200,000	19	1.00	1.00	17	1.00	1.00	14	1.00	1.00
Gini Coefficient		0.61			0.59			0.65	

range and a 5 percent gain by the $70,000 - $80,000 class when compared against the no policy alternative (Table 2). Other changes were of a smaller order of magnitude and distributed throughout the range of classes. In examining the impact upon firm numbers as distributed by income class (Figure 6), it can be seen that the general trend is an evening out with numbers shifting toward the middle from each end of the distribution. The greatest specific changes in firm numbers were 3 percent losses and gains in the $0 - $10,000 and $10,000 - $20,000 classes respectively. The lowest income firms have benefited from the BMP policy. In addition, there was a 3 percent decrease in firm numbers in the $50,000 - $60,000 classification. The Gini coefficient under the BMP option relative to the no policy option declined from 0.61 to 0.59. Thus, according to this measure the income distribution was improved.

The distributions of income and firms by income class under the BMP policy option can also be summarized by aggregating the eleven ranges of income into quartiles. Each of the quartiles would then correspond to the following income spreads: I, $0 - $30,000; II, $30,000 - $60,000; III, $60,000 - $100,000; and IV, $100,000 upward. The changes in income and firm number distributions from the base no policy condition resulting from the implementation of BMP's to improve irrigation efficiencies are summarized in Table 3. The third quartile, ($60,000 - $100,000), is most heavily impacted by the imposition of BMP's. Firms in the upper end of the second quartile have benefited enough from the reduction in their total water bill through improved irrigation efficiency that they moved into the third quartile. Due to cropping pattern changes in the solution to the programming model with the BMP

Table 3

Net Changes in Relative Frequency by Quartile as a Result of BMP's

Quartile	Income Change	Firm Number Change
I	+0.01	0.00
II	-0.03	-0.01
III	+0.04	+0.02
IV	-0.02	-0.01

policy imposed, firms in the fourth quartile actually lose money and 1 percent of them move down into the third quartile.

The second policy alternative is high water pricing. The overall impact of this option on the relative frequency of income by class is almost an exact displacement of the distribution one class leftward relative to the base condition (Figure 4). Firm numbers in all but three classes have been reduced with the greatest concentration of firms occurring in the two lowest income classes (Figure 7). Under this policy, the Gini coefficient has increased to 0.65 thus the income distribution is worsened compared to the base. The specific impacts by class are much greater than under the BMP policy. Income in the $10,000 - $20,000 range increased by 18 percent since firm numbers for this class also rose by 18 percent (Table 2). Also heavily impacted was the $20,000 - $30,000 class which lost 16 percent of income and 22 percent of the firms. Firm numbers in the $0 - $10,000 class also rose by 12 percent bearing out the conclusion that the heaviest impacts accrued at the lower end of the income distribution.

Examining the impacts by quartile of the water pricing policy further emphasizes this result (Table 4). The only quartile to display relative improvement under this policy option is II, but this is the result of firms in the lower end of the third quartile having income reductions of sufficient magnitude to displace them into the upper end of the second quartile. As has been previously indicated, the heaviest impact is in the first quartile.

In comparing the impacts of the alternative policies to control irrigation return flows, it is important to examine the cumulative distributions presented in Table 2. In the base condition, 79 percent

Table 4

Net Changes in Relative Frequency by Quartile
As A Result of the Water Pricing Policy

Quartile	Income Change	Firm Number Change
I	+0.04	+0.08
II	+0.06	0.00
III	-0.06	-0.05
IV	-0.04	-0.03

of the firms had 33 percent of the income with an average per firm income of $18,275. Under the BMP option, 80 percent of the firms occupied the range $0 - $50,000 and had 35 percent of the income which averaged $18,603 per firm. However, under the water pricing policy, 79 percent of the firms were concentrated in the $0 - $30,000 income range and these shared only 30 percent of total income. The average per firm income under this policy declined to $10,925.

As a further comparison of the relative impacts of the policies, it is useful to consider the more detailed description of quartile data presented in Table 5. It shows firm numbers, the average percent of total income share per firm and the average per firm income by quartile and policy. While the average percent income share per firm in the first quartile shows little change across policies, the number of firms and average per firm income change drastically under the water pricing option. Firm numbers rise and average per firm income drops. Quartiles II and III are again quite similar for the base and BMP alternatives. However, water pricing produces a higher average percent income share per firm. This is the result of the displacement effect discussed earlier in this section, i.e., firms shifting down into the next lower income quartile. In the highest income quartile, average per firm income drops across policies with the lowest level occurring under water pricing. In conclusion, then, the policy of BMP's to control irrigation return flows beneficially affects the income distribution among firms in the study area and would thus be favored under the equity criteria employed in this paper.

Table 5

Distributional Impacts by Quartile by Policy Alternative

	No Policy			BMP Policy			Water Pricing Policy		
Quartile	Firm Numbers	Average % Income Share Per Firm	Average Per Firm Income	Firm Numbers	Average % Income Share Per Firm	Average Per Firm Income	Firm Numbers	Average % Income Share Per Firm	Average Per Firm Income
I	516	0.00050	15,866	516	0.00052	16,031	573	0.00052	10,851
II	90	0.00144	45,694	76	0.00132	40,694	91	0.00209	43,613
III	62	0.00242	76,791	79	0.00241	74,297	22	0.00409	85,349
IV	57	0.00807	256,076	54	0.00815	251,252	39	0.01077	224,745

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