AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.

July 19 Draft

UNIVERSITY OF CALIFORNIA
DAVIS

AUG 24 1979

Agricultural Economics Library

RETURNS TO PUBLIC IRRIGATION DEVELOPMENT AND THE CONCOMITANT COSTS OF COMMODITY PROGRAMS

William E. Martin

Department of Agricultural Economics
University of Arizona, Tucson

An Invited Paper to be Presented to the Joint Meeting of the
American Agricultural Economics Association and
the Western Agricultural Economics Association
Pullman, Washington
July 28 - August 1, 1979.

RETURNS TO PUBLIC IRRIGATION DEVELOPMENT AND THE CONCOMITANT COSTS OF COMMODITY PROGRAMS

William E. Martin

Development of agriculture, and associated agricultural problems, have had a prominent place in congressional deliberations virtually throughout the history of the United States (Benedict). Early policy stressed land development, and the Reclamation Act of 1902 was in such spirit. It was "An Act Appropriating the receipts from the sale and disposal of public lands in certain States and Territories to the construction of irrigation works for the reclamation of arid lands." With later modifications of policy to provide greater sources of income for works construction, Congress continues to support the Bureau of Reclamation's water development, output increasing activities.

Yet, since 1929, with time out for war, the federal government also has effected commodity programs designed to reduce the supply of major agricultural commodities so as to maintain product prices "at levels that would be above the market price in a free and reasonably normal market situation" (Benedict, p. 517). Such a situation would tend to strike most economists as peculiar (inefficient). Howe and Easter estimated the annual costs of commodity programs directly related to reclamation irrigation in the range of $83 million to $179 million during the period 1944 to 1964 (p. 143). Some of the "facts" generated by these apparently contradictory policies are the subject of this paper.

In the past two decades resource economists, including myself, have severely criticized Bureau of Reclamation project evaluation procedures. Young summarized these criticisms and concluded that if we explicitly adopt a national accounting stance such that benefits and costs are evaluated from the point of view of the whole nation ("to whomsoever they may accrue . . ."), and if we assign a dominant role to economic efficiency in our assessment, "there would have been only a very few, if any, projects initiated in the past two decades which would have met the B-C criterion" (p. 9).

I will not dwell on all the criticisms, but there is one issue that is of particular importance to returns to irrigation development and associated costs of commodity programs. Water development projects traditionally are evaluated outside of a general equilibrium context, and it is assumed that each single project will have no effect on commodity prices. While the elasticity of demand for agricultural output may be close to infinite for the Bureau's smallest, 221 acre project, it could not be infinite over all of its 9.3 million irrigated acres. It is because of the existence of downward sloping demand curves that there could be a rational economic reason for simultaneous irrigation development and agricultural income support programs if questions of welfare and distribution are considered. Thus, in this paper, I first develop a simple conceptual framework of the costs and benefits of public irrigation development, then examine some of the relevant empirical data, and finally draw some rough conclusions as to our country's relative economic rationality.

A Conceptual Framework

Traditional B-C analysis has looked only at the producer side of the issue. As in figure 1A, demand has been assumed to be infinitely elastic while irrigation development shifts supply from S_1 to S_2. There is no consumers' surplus before development and none created by development. Producers' surplus is assumed to increase from area a to area a + b through development. Area b would be available for producers to repay project costs. Consumers

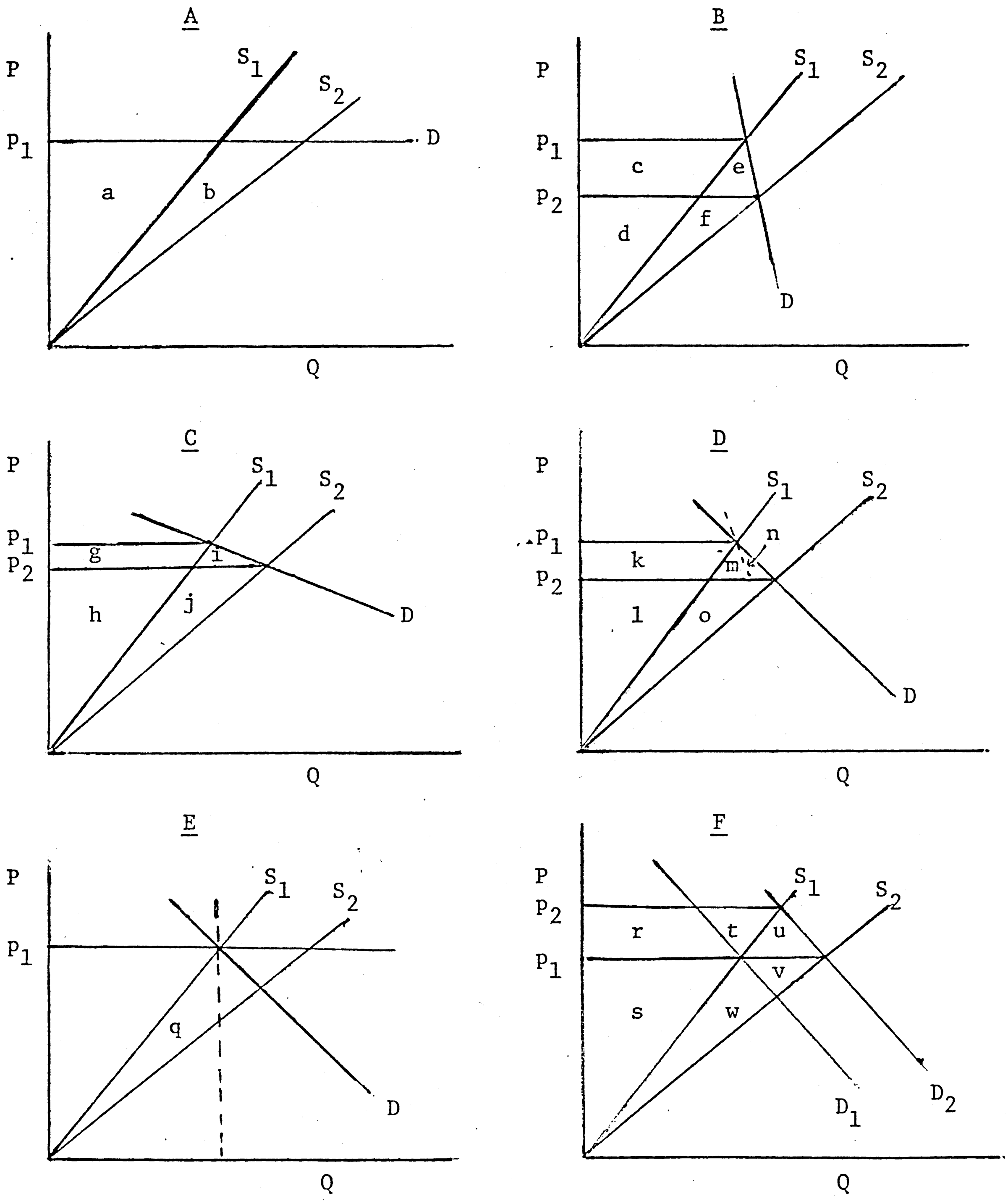

Figure 1. Changes in Consumers' and Producers' Surpluses Resulting from Irrigation Development (Hypothetical).

would have no interest in the whole process if they were not usually required to provide a subsidy.

In fact, the situation is as shown in figure 1B. Given a downward sloping demand, project development will create additional consumers' surplus equal to c + e. Producers lose c to the consumers, but gain f. The water is there on the farm, f - c may or may not be positive, but the water will be used, output will increase and c + e is always positive.

A distributional problem is created. As with b in figure 1A, f in figure 1B accrues to the recipients of the new water and is available to repay project costs. The loss, c, comes from all producers, old and new. Even if all loss comes from producers outside of the project development area, f is smaller than b and repayment ability will be smaller than computed under the assumption of constant prices.

As is evident from figures 1B and 1C, the relative gains to consumers and gains or losses to producers depends on the elasticity of demand. With an inelastic demand, gains to consumers (c + e, figure 1B) are large and losses to all producers are probable. With an elastic demand, consumers gain less (g + i, figure 1C) and all producers have a chance of a net gain (j - g). Producers in the project area have a chance at project repayment, since j (figure 1C) is not too much smaller in size than b (figure 1A).

A caveat is required on the measurement of consumer gains. If we assume that consumers have a right to their original position (p_1, figure 1D) rather than their subsequent position (p_2), and that the income elasticity of demand is not zero, the more accurate concept of gain is that of compensating variation (Hicks; Currie, Murphy and Schmitz) rather than simple Marshallian consumers' surplus. For a price fall, compensating variation is the maximum consumers' willingness to pay to achieve the subsequent equilibrium condition. Because of income effects, this amount is less than simple Marshallian consumers' surplus. Compensating variation is shown as k + m in figure 1D, less than consumers' surplus by n. Willig argues that for small changes in consumers' surplus for goods with an income elasticity in the range of $\pm$ 1.0, n is negligible.

We thus have a case for a consumer subsidy to producers where an irrigation project lowers the prices of agricultural products. While we may be sacrificing national economic efficiency, the consumer should be willing to pay up to a maximum of k + m (figure 1D) to gain the distributional effects of increased quantities at lower prices. This amount will be larger where the project produces products for which there is an inelastic rather than an elastic demand. The subsidy could be in the form of zero interest on irrigation project repayment charges--past and current practice under reclamation law or through direct support payments on the commodities. ("Current projects are subsidized to over 80 percent of costs, if the interest on a normal repayment period is factored in" (Young, p. 13)). However, it is important that output be allowed to increase and prices allowed to fall. If the original price is maintained through production controls (figure 1E) there is no consumer gain to provide a subsidy. While there is a total gain in producers' surplus of q, since all producers must be limited if the project is to produce, project farmers will gain at other producers' expense. In this case it is hard to argue that either efficiency or distributional equity would be served.

We may go farther in the argument for a consumer to producer subsidy if we allow demand to shift to the right as would be expected with population growth. Assume an original position at the intersection of S_1 and D_1 (figure 1F). With demand projected to rise to D_2, consumers should be willing to pay up to r + t to avoid the price rise. (See Burns for surplus estimation with shifts in demand.) If prices actually rise to p_2 with the shift in demand, consumers could pay r + t + u to regain their former position of p_1. Of course, the anticipated or actual shift in demand, with the accompanying growth in producers' surplus of r + t should create pressure for irrigation expansion by producers under a market solution. However, project costs could exceed w + v - r - t or there simply could be market failure (Young, p. 3).

Public Investment in Irrigation Development

Bureau of Reclamation facilities do not comprise the entire investment in U.S. irrigation. In fact, Bureau of Reclamation facilities serve only 9.3 million acres while "other project facilities" serve 13.3 million (USDA, 1979). ("Other" projects include BIA and Corps of Engineers projects as well as state and private development.) Private on-farm facilities serve another 22.7 million acres for a net farm irrigated acreage of 45.3 million out of 367 million acres in "planted crops and fallow" in the United States (pp. 28, 39). But the net value of the capital investment in Bureau projects in 1975 was $8.960 billion out of $9.005 net federal investment, with other group projects valued at only $2.370 billion. Private individual facilities were valued at $4.640 billion (p. 27). Thus, in terms of federal investment, Bureau projects comprise 99.5 percent of value. In the context of the issue of federal commodity programs versus federal irrigation development, I will concentrate on the acreage in and output from Bureau projects.

U.S. and Bureau of Reclamation Acreages

In Table 1 U.S. acreage and Bureau of Reclamation acreage are compared by crop. Of the cereals, barley and rice are the only crops with Bureau acreage exceeding 1 percent, with 6.1 percent of U.S. barley and rice acreage each. Total cereal acreage on Bureau lands is less than 1.1 percent of the U.S. total. Bureau lands are 6.6 percent of U.S. alfalfa acreage, but probably less than 1 or 2 percent of total forage acreage. Thus, we find that while forages and cereals are grown on 62 percent of all Bureau lands (37 percent and 25 percent, respectively) (USDI, 1978a), they are but a percent or two of U.S. forage and cereal lands.

Field crops are a different matter. Twenty-four percent of the dry bean acreage is on Bureau lands, 30 percent of sugar beet acreage, 10 percent of cotton acreage and 72 percent of all hop and mint acreage. But with soybean acreage negligible, total miscellaneous field crop acres on Bureau lands are less than 2.4 percent of the U.S. total.

The speciality crops--vegetables, fruits, seeds and nuts--are the major crops on Bureau lands when compared to U.S. acreage. Vegetables are on only 9 percent of Bureau lands but account for close to 18 percent of U.S. acres. Fruits and nuts are on 8 percent of Bureau lands but account for 21 percent and 32 percent of U.S. fruit and nut acreage, respectively. Seeds are but 2 percent of Bureau lands but approximately 11 percent of U.S. seed acreage.

To summarize, lands currently irrigated by Bureau of Reclamation projects are only 2.5 percent of total U.S. cropland, but they contain a significant percent of vegetable, fruit, nut, seed and miscellaneous field crop acreage, as well as a significant acreage of barley, rice and alfalfa.

Table 1. Total U.S. and Bureau of Reclamation Cropped Acreage, by Major Crops, 1977.

Crop	U.S.[a]	Bureau of Reclamation[b]	Bureau of Reclamation as a Percent of U.S.
	------------1000 acres------------		
Cereals			
Barley	10,586	647	6.1
Corn	82,680	646	0.8
Oats	17,793	86	0.5
Rice	2,261	139	6.1
Rye	2,652	1	0.0
Sorghum	16,994	96	0.6
Wheat	74,804	595	0.8
Other	?	116	-
Total	>207,770	2,327	<1.1
Forage			
Alfalfa	27,085	1,791	6.6
Other Hay	33,408	242	0.7
Irrigated Pasture	?	987	-
Other Forage	?	432	-
Total	>60,493	3,452	<3.4
Miscellaneous Field Crops			
Dry Beans	1,395	335	24.0
Cotton	13,694	1,476	10.0
Hops and Mint	116	83	71.5
Sugarbeets	1,277	379	29.7
Soybeans	59,080	8	0.0
Other	?	33	-
Total	>75,562	1,784	<2.4
Vegetables			
Potatoes	1,349	257	19.1
Melons	322	67	20.8
Other Vegetables	>2,786	470	<16.9
Total	>4,457	794	<17.8

Table 1 cont'd.

Crop	U.S.[a]	Bureau of Reclamation[b]	Bureau of Reclamation as a Percent of U.S.
	------------1000 acres------------		percent
Fruit			
Citrus	1,163	154	13.2
Major Deciduous	1,657	427	25.8
Minor Fruits	108	42	38.9
Berries	45	2	4.4
Total	2,973	625	21.0
Nuts	471	152	32.3
Seeds	>1,587	175	<11.0
Total Cropland[c]	367,000	9,310	2.5

a. USDA, Agricultural Statistics, 1978, various tables.

b. USDI, 1977 Land and Water Resource Accomplishments, 1978a, Table 4.

c. ESCS staff, Natural Resource Capital in U.S. Agriculture, Tables 6 and 17. These estimates are for 1975. Individual crop estimates do not add to total because of different sources and missing acreage estimates.

The Incremental Output from Federal Investment

More important than mere area is the productivity of the irrigated lands. In Table 2 is shown the 1977 production of major crops grown on Bureau lands, the index for yields from wholly irrigated lands as compared to unirrigated lands, and the implied increment in production due to irrigation on Bureau lands as a percent of 1977 total U.S. production. Also shown is total Bureau production as a percent of total U.S. production.

Two assumptions are crucial to the estimates of the increment from irrigation. First, it is assumed that cotton, dry beans, vegetables and melons, and orchards would not be grown in the absence of Bureau irrigation. Thus, for these crops total production is equal to incremental production. Second, for all crops it is assumed that no other irrigation water was available; that is, that the Bureau was required to develop full water service rather than merely supplemental water service. Both assumptions obviously cause an overestimate of the increment from irrigation, since 54 percent of all lands irrigated by the Bureau receive supplemental rather than full water service (USDI, 1978a).

Given these caveats, we see that the greatest increases in production caused by Bureau water are for vegetables, melons, orchards, and dry beans. Other significant increases are for cotton, rice, barley, alfalfa and potatoes. The increments in corn, oats, sorghum, wheat and soybeans are each 1 percent or less.

Now let us examine recent participation in the major commodity programs. In Table 3 are shown the quantities of commodities pledged to the commodity credit corporation under the commodity loan programs, as percents of total U.S. production for the years 1972 to 1977. (Flaxseed, honey,

Table 2. Increments in Production from Irrigating Bureau of Reclamation Lands, 1977.

Commodity	1977 Bu Rec Production[a] (1,000s)	Index for 17 Western States[b]	Implied Dryland Production (1,000s)	Increment from Irrigation as Percent of 1977 U.S. Production	Total Bu Rec Production as Percent of 1977 U.S. Production
Barley	49,914 bu.	205	24,348 bu.	6.1	12.0
Corn	59,346 bu.	181	32,788 bu.	0.4	0.9
Cotton	1,663 bales	256	c	11.6	11.6
Dry Beans	6,374 cwt.	309	c	39.1	39.1
Oats	5,908 bu.	153	3,861 bu.	0.3	0.8
Sorghum	6,259 bu.	193	3,243 bu.	0.4	0.8
Soybeans	263 bu.	126	209 bu.	negligible	negligible
Wheat	44,776 bu.	187	23,944 bu.	1.0	2.2
Rice	7,978 cwt.	d	0	8.0	8.0
Alfalfa	–	230	–	5.8[e]	10.2
Potatoes	–	179	–	9.9[e]	22.5
Vegetables and Melons	–	318	c	26.9[e]	26.9
Orchards	–	214	c	25.6[e]	25.6

a. USDI, 1978a.

b. USDC, 1974 Census of Agriculture. Compares irrigated with nonirrigated.

c. Dryland acreage in the West is minimal.

d. No dryland acreage.

e. Based on index and relative acreage.

naval stores, peanuts, rye, and tobacco--not produced on Bureau lands--are excluded. These commodities, along with storage facility and equipment loans comprised 16 percent of the 1977 loan program.) If we take these quantities as a rough measure of farmer and Congressional perception of excess agricultural production, we might compare them with production increments associated with public irrigation investment. These increments, developed in Table 2, are also presented as the last column of Table 3.

A portion of all of the cereal grains has consistently gone under loan during this recent 6-year period. In 1977 10.8 percent of the barley crop was pledged while the public irrigation increment was 6.3 percent. Only 0.5 percent of corn production was pledged--but the irrigation increment was 80 percent of that amount. Oats and sorghum were each pledged at about 6 percent of production even though the irrigation increment was minor. Less rice was pledged in 1977 than the Bureau increment, but large quantities had been pledged in previous years. Wheat was heavily under loan (20 percent) even with only a 1 percent public irrigation increment.

The two commodities with the largest production increment from public irrigation investment, dry beans and cotton, while pledged in earlier years, apparently were clearing the market at "satisfactory" prices in 1977. No beans were pledged in 1977 although the irrigation increment was 39.1 percent. Only 0.3 percent of cotton was pledged while 11.6 percent of U.S. production was attributable to public irrigation investment.

Costs and Benefits

How might these data be interpreted? Clearly the grains have generally been and continue to be in "excess" supply relative to Congressional

Table 3. Quantity of Commodity Pledged to the Commodity Credit Corporation[a] and Increment in Production from Irrigation on Bureau of Reclamation Lands as Percents of Total U.S. Production.

Commodity	Year 72	73	74	75	76	77	Increment from Irrigation 1977[b]
	percent						
Barley	10.1	3.7	2.3	2.5	4.9	10.8	6.1
Corn	7.5	4.6	1.6	2.5	4.4	0.5	0.4
Cotton	14.2	13.6	21.4	8.4	9.0	0.3	11.6
Dry Beans	5.3	0.4	0.5	0	0	0	39.1
Oats	4.6	1.6	0.6	0.6	0.8	6.5	0.3
Sorghum	3.7	2.0	0.6	1.2	2.9	5.9	0.4
Soybeans	7.1	8.0	2.9	0	1.7	.0	negligible
Wheat	9.2	3.5	2.0	2.3	22.1	20.1	1.0
Rice	26.8	20.6	8.2	16.7	20.2	4.6	8.0

a. USDA _Agricultural Statistics 1978_.

b. Table 2.

intent. But irrigation development seems not to be a major culprit, except perhaps with barley. The problem would exist even without public irrigation development. On the other hand, irrigation investment to grow these crops is obviously unnecessary. The problems with cotton, dry beans, and soybeans seem to be lessening. At least with dry beans, one might see a need for having developed production. Still, overall one could hardly argue the necessity of public water development from the point of view of the U.S. producers of these commodities. That the commodity programs exist is enough evidence that water has not increased net income. Benefits, if there are any, must be on the consumers' side. A consumer should be willing to pay to have larger quantities with lower prices. Unfortunately, the mechanism for subsidies generally has not allowed the consumer to receive full benefits.

Consumer benefits surely have been achieved with investment in water for fruits, nuts, vegetables and melons, potatoes and perhaps even alfalfa. While many of these crops with the exception of alfalfa have been under marketing orders, with the obvious intention to restrict output and raise prices, the very magnitude of their position in total U.S. production suggests a positive benefit. The problem is, of course, that even though demands for most fruits and vegetables are more elastic than for the basic commodities, they still are inelastic. Therefore, a downward shift in supply tends not to benefit consumers greatly--perhaps not enough for project and producer subsidy.

Let us work backwards to see what consumer benefits would have to be if the federal water projects were to be beneficial. The 1975 Bureau of Reclamation gross real investment in irrigation project facilities was $9.1 billion (USDA, 1979). This value "represents the estimated cost of reproducing all existing irrigation . . . works at unit costs prevailing in [1975]" (p. 43). If consumers were to receive the full value of the irrigation investment, an annual total return of $910 million would be required if the investment were evaluated at an interest rate of 10 percent. With a 1975 estimate of "number of people eating from civilian food supplies" of 211 million (USDA, 1978a, p. 552), the required annual per capita consumer's surplus would need be only $4.31. Given the large amounts of vegetables, fruits and nuts that are incremental in Bureau of Reclamation Project acreages, I do not find a $4.31 consumer benefit unbelievable.

In fact, annual per capita subsidy costs of Bureau project construction have been at most about $3.50 in 1975 dollars. I make this estimate as follows. Given the 1975 estimate of $9.1 billion for reproducing all existing irrigation facilities, and assuming amortization at 10 percent for 50 years (the normal payback period), total principal and interest would equal $45.891 billion. North and Neely estimate that current projects are subsidized to about 80 percent of costs, when the interest in the normal repayment period is included. Eighty percent of the total is $36.713 billion or $734 million per year (of which only 20 percent is principal). With a 1975 population of of 211 million, the annual per capital subsidy would be $3.47. Of course projects have been constructed over the past 75 years. In any given year only a portion of the 153 projects actually would be under repayment.

However, because of commodity programs for cereals and field crops, there is the additional cost of government payments to farmers. Since World War II, total payments have varied from 0.6 percent (1974) to 7.9 percent of total farmers' cash receipts from marketings on a national basis (USDA, 1978b). In 1969 a per capita consumer contribution of $19.06 is implied, in 1974 the contribution was only $2.52, and in 1977 the contribution rose again to $8.47. The problem here for consumers is that they are paying for the privilege of not having higher quantities and lower prices on cereals and field crops. Thus, the costs must also be absorbed by any benefits to vegetables, fruits and nuts.

What might be the total incremental benefits to these crops? Per capita food expenditure in 1977 was $1,136 (USDA, 1978c). Ten percent of this expenditure was on fruits and vegetables (USDL). Given a price elasticity of demand for fruits and vegetables of around -0.75 (George and King, p. 49), and assuming an increment in U.S. production of fruits and vegetables of 26 percent (Table 2), the incremental consumer's surplus attributable to public irrigation would be $34.26 per capita. Perhaps Bureau projects really have been worth the associated commodity program costs.

The data presented have summarized the past and presented the current status of public irrigation investment and commodity programs. What of the future? I cannot help believing that because the less expensive project sites have already been developed, future development will be slight. People slowly are beginning to realize that water naturally runs downhill and to reverse that phenomenon requires energy. For example, Arizona's Salt River Project, the first construction activity of the Bureau, is a major producer of electrical energy. Currently, the Central Arizona Project is under construction. It will require a quarter of the output from the three 750-megawatt coal-fired units of the Navajo Generating Station to lift the water more than 2,000 feet uphill (University of Arizona).

Let us examine the recent trends in construction activities and the crops grown on these new irrigated acres, as a possible clue to the future. The 20 years for which Young suggests negative benefit-cost ratios should serve. Since 1960, in the last 27 percent of the Bureau's history, 35 percent of its 153 projects have come on-line, but these projects irrigate only 10.6 percent of its land. Since 1970, 15 percent of Bureau projects began producing on only 3.4 percent of Bureau land. Apparently we are not running out of projects, only land on which to put them. Further, while between 1960 and 1968 acreage developed with full water service was 1.3 times that developed with supplemental service, since 1970, 4.4 times as much supplemental service has been developed than full service (USDI, 1978b). Supplemental service may well reduce fluctuations in crop yields, but surely develops a smaller production increment than full service development. I suspect many of the supplemental-water projects are so called "rescue" projects such as the Central Arizona Project, where the marginal cost of not having the "rescue" water is very small (Kelso, Martin and Mack).

Finally, we may ask what crops are being grown on these newer project acreages? Economists, including myself, have generally argued that projects should be evaluated in terms of the MVP's of the lowest valued crops--the grains and forages, and that higher valued crops--fruits and vegetables--would be grown in any case if a market were available. From an efficiency point of view the correctness of this argument seems clear. However, the data show that since 1960, the total Bureau land increase of 10.6 percent was associated with a 10.9 increase in project vegetables, a 23.4 percent increase in project nuts, an 8.7 percent increase in project fruit and 9, 11.5 and 10.6 percent increase in project cereals, forages and miscellaneous field crops, respectively. In other words, all crops tended to increase proportionately to land in projects. In the years since 1970, the 3.4 increase in Bureau lands include a 21.7 increase in project nuts, a 5 percent increase in project fruits, a 4.6 percent increase in project vegetables, almost proportional increase in project forages and field crops, but only a 1.4 percent increase in cereals.

These data, however, could be misleading. An increase in project fruits or vegetables need not mean a net increase in fruit or vegetable acreage of the same size--especially on supplemental-water projects. As shown above, recent projects are mostly supplemental. Still, one might suspect a positive distributional effect toward consumers.

Conclusions

While it is clear that recent public irrigation development projects are economically inefficient from a national accounting stance, logical economic arguments can be made, at least for past projects, on the basis of distributional gains to consumers. Such gains are probable even in the face of the costs of our national commodity programs. The gains could be substantial if output were not restricted, and any farmer income support were handled through direct income payments.

Arguments for future development are much weaker. Low cost project sites no longer exist. Projects now use energy rather than develop it. Alternative uses for water in high MVP uses are growing. The increments from the development of supplemental water are not as large as from the full service projects that made the deserts bloom rather than merely "rescuing" marginal acreages. If the intent of Congress remains to provide inexpensive food to consumers while supporting producer incomes, new directions in both water development policy and farmer support policy are clearly necessary.

REFERENCES

Benedict, Murray R. Farm Policies of the United States. New York: The Twentieth Century Fund, 1953.

Burns, Michael E. "A Note on the Concept and Measure of Consumer's Surplus," American Economic Review, 63 (1973):335-344.

Currie, John Martin, John A. Murphy and Andrew Schmitz. "The Concept of Economic Surplus and Its Use in Economic Analysis," The Economic Journal, LXXXI (1971):741-799.

George, P.S. and G. H. King. Consumer Demand for Food Commodities in the United States. Giannini Foundation Monograph No. 26, University of California, Berkeley, March 1971.

Hicks, J. R. "The Four Consumer's Surpluses," Review of Economic Studies, 11 (1943):31-41.

Howe, Charles W. and K. William Easter. Interbasin Transfers of Water: Economic Issues and Impacts. The Johns Hopkins Press, Baltimore, 1971.

Kelso, Maurice M., William E. Martin and Lawrence E. Mack. Water Supplies and Economic Growth: An Arizona Case Study. University of Arizona Press, Tucson, 1973.

North, Ronald M. and Walter P. Neely. "A Model for Achieving Consistency for Cost Sharing in Water Resource Programs," Water Resources Bulletin, 13 (1977):995-1005.

University of Arizona. Arizona Energy: A Framework for Decision. Research Report for the 28th Arizona Town Hall, March 1976.

U.S. Department of Agriculture. Agricultural Statistics 1978. Washington, D.C., 1978a.

U.S. Department of Agriculture, Fact Book of U.S. Agriculture, Misc. Publication No. 1063, Washington, D.C., November 1978b.

U.S. Department of Agriculture. Working Data for Demand Analysis. ESCS Revision of March 1978c.

U.S. Department of Agriculture. Natural Resource Capital in U.S. Agriculture. ESCS Staff Paper, March 1979.

U.S. Department of Commerce, Bureau of the Census, 1974 Census of Agriculture, Irrigation and Drainage in Farms, Vol. II, Part 9. Washington, D.C. June 1978.

U.S. Department of the Interior, Bureau of Reclamation. 1977 Water and Land Resource Accomplishments, Summary Report, Washington, D.C., November 1978a.

U.S. Department of the Interior, Bureau of Reclamation. 1977 Water and Land Resource Accomplishments, Statistical Appendix 1, Washington, D.C., November 1978b.

U.S. Department of Labor, Bureau of Labor Statistics, Consumer Expenditure Survey: Integrated Diary and Interview Survey Data, 1972-73. Bulletin 1992, Washington, D.C., 1978.

Willig, Robert D. "Consumer's Surplus Without Apology," The American Economic Review 66 (1976):589-597.

Young, Robert A. "Economic Analysis and Federal Irrigation Policy: A Reappraisal." A paper presented to the Western Agricultural Economics Association, Bozeman, Montana, July 1978.

FOOTNOTES

William E. Martin is professor of agricultural economics at the University of Arizona, Tucson.

Arizona Agricultural Experiment Station Journal article No. 3030.

The author benefited from conversations with Russell L. Gum and Dennis C. Cory.