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# Benefit-Cost Analysis of North Dakota's Garrison Diversion Unit: A Case Study of Conflicting Interest

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Federal agencies are generally required to justify the economic value of proposed water resources development projects with benefit-cost analyses. Responsibility for economic analyses lies principally with the proposing agency, under broad policies and procedures guidelines. The economic evaluation of the Garrison Diversion Unit in North Dakota was used as a case study to examine the ability of federal agencies to evaluate their own projects. A consistent tendency to overestimate project benefits and underestimate project costs was found. Revised benefit-cost ratios ranged from 0.44 to 1 to 0.77 to 1, depending on the discount rate employed.

The Reclamation Act of 1902 authorized the use of funds derived from the sale of public lands to survey, locate, and construct irrigation works in 16 western states [Holmes, p. 6]. Although legislation authorizing early reclamation projects generally required the demonstration of each project's economic value, the concepts and procedures of benefit-cost analysis did not appear until after the second World War [Holmes, p. 19].

Section I of the Flood Control Act of 1936 states that federal participation in flood control and watershed improvement is warranted "if the benefits to whomsoever they may accrue are in excess of the estimated costs." While this directive originally applied only to flood control and watershed improvement projects, the concept was soon adopted by all planning and development agencies involved in federal water resources projects [Holmes, p. 19]. Indeed, the language of the 1936 act was probably the genesis for the widespread application of

benefit-cost analysis by planning agencies both as a tool for determining economic feasibility and as a means of ranking alternatives. As Marshall notes, however, the application of the technique varied from agency to agency, often in a conflicting or contradictory manner. In general, the responsibility for economic analysis has rested with the agency proposing the specific project. While technical reviews of evaluation policies and procedures have been conducted periodically, ultimate evaluations of project benefits and costs have not been conducted by disinterested parties. This has led some [Margolis, Eckstein, Haveman, 1965] to question not only the theoretical propriety of agency evaluations, but whether judgments made regarding events in the future are made in an atmosphere of speculative neutrality.

This article examines the procedures and practices of the Bureau of Reclamation in estimating benefits and costs for the Garrison Diversion Unit in North Dakota. This project serves as a case study to evaluate the ability of a federal agency to conduct an economic analysis of its own project. Examination of these procedures and practices lends credence to the assertion that the primary pur-

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pose of such benefit-cost analyses is to justify projects rather than to evaluate them.

### **An Overview of the Benefit-Cost Procedure**

Literature on the theory and application of benefit-cost analysis with particular emphasis on water project evaluation is legion [Margolis, Eckstein, Hanke and Walker, Freeman Mishan, Haveman, 1965]. Bureau of Reclamation procedures were first formalized in the early 1950's in a document known as the "Green Book" [U.S. Department of the Interior, 1952], and the procedures and practices have been updated periodically in response to criticism of their theoretical and/or operational propriety. Briefly, a benefit-cost analysis seeks to estimate the degree to which society is better off as a result of project development. The Bureau of Reclamation's Principles and Standards has encouraged the inclusion of both primary or direct and secondary or indirect benefits. Primary benefits are defined as the increased value of goods and services produced resulting directly from the project. In the context of western water projects, the major primary benefit has traditionally been the value of irrigated crop production, though significant benefits of flood control, electric power generation, enhancement of recreation, wildlife and fisheries, and the provision of municipal and industrial water have been estimated. Primary benefits are evaluated at market prices where markets exist. Scant attention has been paid to cases where agricultural product prices have been supported by government programs, thus inflating free market value of their marginal benefit to society. Also often neglected is the fact that the additional output resulting from the project may depress prices for at least some commodities, decreasing farm income for a much larger segment of agriculture. Finally, recreational benefits claimed may not include the losses of recreation practices they displaced.

Secondary benefits are considered to be the net value of increased profits and income to firms and individuals who are not direct

recipients of project benefits. These profits necessarily arise as a result of technological economies of scale and the employment of previously underemployed resources (see Haveman and Krutilla and Margolis for a more complete discussion). While the concept of secondary benefits is straight forward in a theoretical sense, efforts to appropriately evaluate and include them have encountered major problems. Indeed, the Bureau of Reclamation is the only federal water project development agency that has, in the past, included estimates of secondary benefits, a practice which has been severely criticized [Margolis, Eckstein, Pearson, et al.; Freeman]. In fact, the criticisms of Bureau of Reclamation's estimation of secondary benefits became so intense that their inclusion has been terminated. In their place is an estimate of regional economic development benefits which are exactly offset by development losses in other regions (see, for example, U.S. Department of Interior, 1978).

Subtracted from gross irrigation benefits (the value of irrigated crops produced) are private crop production costs and losses of net returns associated with the previous use of the land. The resulting value is net irrigation benefits. In essence, the annual net benefit of irrigation is estimated as a residual that remains after *all* factors of production except irrigation water have been paid their opportunity cost. The residual per acre foot is then roughly the value of the marginal product of the irrigation water. Also included as project benefits are estimates of the net value of flood control, municipal water, recreation, flood control and drainage provided in conjunction with completion of the project.

Weighed against the benefits provided are the costs of project construction, operation, and maintenance. Estimation of public and private costs requires conjecture on future expenditure requirements. Hindsight suggests that Bureau of Reclamation estimates of future construction, operation, and maintenance costs be viewed with some skepticism [Haveman, 1972].

Finally, since benefits and costs occur over

time, it is necessary to discount their flows to arrive at a common basis for comparison. Until 1968, a discount rate of 3.125 percent was employed. In recognition that such a rate greatly underestimated the opportunity cost of capital, a rate approximating yields on long-term government securities has been used subsequently (for 1978, 6.625 percent). There are some who argue that even this understates the opportunity cost of capital [Baumol]. However, Congress has mandated that analysis-updates on projects authorized before 1968 be evaluated at the pre-1968 discount rate [Committee on Government Operations, p. 93].

### Case Study: Garrison Diversion Unit

The Garrison Diversion Unit is the sequel to the Missouri-Souris Unit authorized by the Flood Control Act of 1944. The irrigation project was only one part of a Missouri River Basin plan which included hydroelectric power, downstream flood control, and assured municipal and industrial water. Most of these benefits have accrued outside the state of North Dakota but required the inundation of approximately 568 thousand acres of river bottomland in North Dakota, of which approximately one percent was irrigated cropland, 35 percent dry cropland, and 64 percent was timber and pasture land [Leitch and Anderson]. Many people in the state feel that irrespective of the economic justification of the irrigation project itself, a political *quid pro quo* existed regarding irrigated land in exchange for the inundated bottomland (see, for example, Robinson (p. 465), Johnson and Goodman, Leitch and Anderson, U.S. Department of Interior, 1978 (p. 28)).

Part of the land proposed for the original irrigation project was found to be unsuitable, so detailed investigations of alternate sites were undertaken. An investigation of a 1,007,000 acre project was completed in 1957, and a report on the initial 250,000 acres was made in 1959. A Definite Plan Report was written in 1962 and revised in 1965. The 1965 plan served as the basis for Congressional authorization for a 250,000 acre project

in 1965. The 1962 report served as the basis for economic feasibility analysis until 1977. Funds for the project were authorized and construction began in 1967. Currently, the irrigation project is approximately 19 percent complete, but construction has been suspended pending resolution of legal objections and Canadian concerns over return flow water quality.

### Previous Benefit-Cost Analysis

The original economic analysis of 1962 served as the basis for subsequent versions adjusted primarily with indices of production costs and returns and reestimations of construction costs. The 1965 estimate of the benefit-cost ratio was 2.5 to 1 [Committee on Government Operations]. Succeeding revisions raised the ratio to 2.9 to 1 in 1977 [U.S. Department of Interior, 1977].<sup>1</sup> While examination of the practices used in previous analyses is instructive, examination of the Bureau's latest effort is the topic for the remainder of this paper.

### 1978 Benefit-Cost Analysis

In settlement of a suit brought by the National Audubon Society, the Department of the Interior agreed to prepare a supplemental irrigation project environmental statement by early 1978. Included in the statement is a substantial revision of the benefit-cost analysis. The analysis addressed the feasibility of a number of alternatives to the authorized irrigation project, though only the authorized 250,000 acres will be discussed here. While the draft statement contains little information regarding specific crop production practices, costs, yields, and returns, a variety of published and unpublished sources shed some light on these assumptions. Table 1 shows estimated annualized benefits and costs at the authorized (3.125 percent) and current (6.625 percent) discount

<sup>1</sup>These ratios are based on what the Bureau of Reclamation calls total benefits; that is, direct as well as the now discarded indirect or secondary benefits, evaluated at a 3.125 percent interest rate.

**TABLE 1. Annualized Benefits and Costs for the Garrison Diversion Unit, North Dakota.**

Item	Discount Rate	
	3 1/8 Percent <sup>a</sup>	6 5/8 Percent <sup>b</sup>
	----- \$1,000 -----	
<b>Benefits</b>		
Irrigation	42,864	29,943
Municipal Water	1,614	1,041
Recreation	1,727	701
Flood Control	412	0
Drainage	481	460
Total Benefits	47,098	32,145
<b>Costs</b>		
Investment	22,047	25,370
Operation and Repair	2,450	3,404
Total Costs	24,497	28,774
Benefit-Cost Ratio	1.92	1.12

<sup>a</sup>Total benefits and costs.<sup>b</sup>Remaining benefits and costs.

SOURCE: U.S. Department of the Interior (1978).

rates.<sup>2</sup> Annual irrigation benefits shown are based on the increased net benefits from irrigation (return to water) of \$235 per acre [U.S. Department of the Interior, 1978, p. 46]. The annualized value of construction costs is based on a total estimated remaining construction cost of \$622,218,000. Of this, approximately 90 percent or \$2,256 per acre is allocated to irrigation [U.S. Department of the Interior, 1978, p. 129].

### Analysis of Bureau Estimates

The data in Table 1 show that benefits claimed from sources other than irrigation are almost inconsequential relative to irrigation benefits. Economic justification of the project depends almost entirely on the estimated annual \$235 per acre increased net benefits from agriculture. Such a value suggests a marginal value product for irrigation water of about \$100 per acre-foot applied, based on approximately two acre

feet per irrigated acre. Alternatively, the annual increase in producer net income is approximately \$200 per acre (\$235 per acre net irrigation benefits less \$35 per acre charge for water). Capitalizing this value into a value for land at 6.625 percent interest suggests that irrigated land in the project area should be worth approximately \$3,019 more than dryland. For those who currently own land in the project, this would result in additional net income before labor income of \$54,000 on an irrigated farm of 270 acres. These values appear extremely high in comparison with past estimates of water values, land values, and farm income within and outside of North Dakota. A review of the assumptions and procedures used to obtain the \$235 increased benefits helps to explain the disparity. Table 2 summarizes projected crop rotations, yields, and prices received estimated by the Bureau for the project, and alternative estimates adapted by the author from published sources reflecting 1977 irrigated crop production and yields in the project area of North Dakota.

### Crop Rotations

The Bureau of Reclamation analysis crop

<sup>2</sup>The term "annualized" is used here to be consistent with Bureau of Reclamation publications. An annualized value is the annuity over the life of the project whose discounted present value is equal to the total discounted present value of the item in question. Annual values are undiscounted estimates of costs or returns expected to occur each year.

rotation is heavily weighted in favor of the higher value crops with 22.5 percent of the irrigated land in potatoes, 36 percent in sunflowers, and 19.5 percent malting barley. Agronomic considerations suggest a maximum of 25 percent sunflowers, so production of this level of sunflowers on a sustained basis appears unlikely without substantially increased production costs, exceptional management, and/or technological breakthroughs in disease control methods or genetic resistance [MIP Interdisciplinary Research Team, 1977, pp. 17-18]. Economies of size and the heavy investment in machinery and storage facilities required for potato production and the 160 acres per person acreage restriction may make potatoes infeasible for many operators.<sup>3</sup> It is also questionable whether the limited market for potatoes can accommodate an additional 56,250 acres without affecting market price or replacing existing acreage elsewhere in the state. Finally, the Bureau has assumed that all small grain produced under irrigation will be malting grade barley and sold at malting barley prices.

An alternative rotation is shown in Table 2

<sup>3</sup>The use of the 160 acre per person acreage limitation is currently under review. However, Bureau of Reclamation farm budgets were based on 270 irrigated acres per farm (two center pivot sprinkler systems).

for the project area. That rotation is based on the findings of a survey of irrigators in the project area for the 1977 crop year [Leitch and Anderson, p. 4] and an annual Extension Service survey of the state's irrigated land [Lundstrom]. A considerably greater proportion of forage and feed grain crops is indicated in comparison with Bureau of Reclamation estimates.

### Yields and Costs

The Water Resources Council's *Principles and Standards* (draft) appears somewhat contradictory regarding both projections of land use and yields. It says:

"Farm costs and returns, including... land use should be projected on the basis of historical trends to a point 20 years after the first year of the project... to approximate the average annual benefit over the life of the project" (p. 17).

However, it also says that:

"Projected crop yields for budgeting purposes should not exceed yield levels presently being attained in the project area... by the better farm managers. As a general rule, projected total farm expenses may be expected to increase by about the same percentage as projected gross farm returns" (p. 18)

**TABLE 2. Comparison of Bureau of Reclamation Estimates for the Garrison Diversion Unit and Current North Dakota Irrigated Land Use, Yields, and Prices.**

Crop (Units)	U.S.D.I. Estimates <sup>a</sup>			Current Levels		
	Percent of Irrigated Land	Yield	Price	Percent of Irrigated Land <sup>b</sup>	Yield <sup>c</sup>	Price <sup>d</sup>
Alfalfa (tons)	2.5	6	\$37.04	30	3.5-4.9	\$38.70
Malting Barley (bu)	19.5	90	2.88	--	55-66	--
Corn Grain (bu)	19.5	140	2.48	35	100-120	2.26
Potatoes (cwt)	22.5	350	3.79	7	235-300	3.74
Sunflowers (cwt)	36.0	27	10.30	8	16.1-21.0	10.19
Wheat (bu)	--	--	--	7	55-66	3.48
Pinto Beans (cwt)	--	--	--	5	18.0-23.2	16.12
Soybeans (bu)	--	--	--	8	33-40	5.87

<sup>a</sup>SOURCE: U.S. Department of the Interior (1978).

<sup>b</sup>SOURCE: Leitch and Anderson.

<sup>c</sup>SOURCE: "MIP" Interdisciplinary Research Team (1977) estimates for 1976 "normal management" range depending on soil type and location.

<sup>d</sup>SOURCE: "MIP" Interdisciplinary Research Team (1974) estimates adjusted by index of prices received to 1977 level.

Bureau estimates of yield appear to be consistent with published area "optimum management" yields but are well in excess of "normal management" yields [MIP Interdisciplinary Research Team, 1977]. The use of yields that are above current averages results in erroneous estimation of the benefit-cost ratio for two reasons. First, it overestimates benefits in the early years of the project which are weighted most heavily by the discounting procedure. This is the same period of time when novice irrigators are learning new methods and thus most likely to experience below average yields. Second, it requires either the assumption that crop production costs will not change as yields increase, or the estimation of additional production costs for those nebulous and nonexistent technologies providing the higher yields. Evidence suggests that production costs have not been adjusted upward with yield projections as the *Principles and Standards* requires.

#### *Prices, Returns, and Benefit-Cost Analysis*

Enterprise budgets have not been published by the Bureau for the project so it is impossible to assess the accuracy of production practices and costs. However, prices received appear to be reasonable. As mentioned before, the Bureau estimated increased benefits resulting from irrigation of \$235 per acre. In comparison, the estimated annual per acre returns to operator labor and irrigation water were \$87.58 more than dryland returns in the project area, based on the rotation, yield, and price assumptions in Table 2, and MIP (1974) estimates of current crop production practices and costs (adjusted with the index of prices paid to 1977 levels). Assuming two additional hours of operator labor per acre for irrigated land at \$3.50 per hour, increased benefits from irrigation would be approximately \$80 per acre under present conditions. Using the estimated return to water of \$80 per acre with Bureau estimates of nonagricultural benefits, costs of project construction, operation, and maintenance,

results in substantially lower benefit-cost ratios. At a 6.625 percent discount rate, annualized agricultural benefits are \$10,454,000 rather than \$29,943,000 and the ratio of benefits to remaining costs is 0.44 to 1 rather than 1.12 to 1. Using the interest rate of 3.125 percent, total annualized agricultural benefits are \$14,591,000 and the ratio of benefits to total costs is 0.77 to 1 rather than 1.92 to 1.

It has been suggested by some [Silvernagel, also by implication in U.S. Department of Interior, 1978, p. 46] that the return per acre represents the projected return to irrigation water 20 years into the life of the project (in 1977 dollars). Assuming that increased returns do reach \$235 per acre by the year 2010, claiming a \$235 return per acre from project inception still results in an overestimate of the discounted present value of benefits.<sup>4</sup> If returns begin at the current estimated level of \$80 per acre and increase in a linear fashion to \$235 per acre in year 20 and thereafter, using a 6.625 percent interest rate results in annualized agricultural benefits of \$21,489,000 instead of \$29,943,000 and a benefit-cost ratio of 0.82 to 1 instead of 1.12 to 1. The benefit-cost ratio using a 3.125 interest rate is 1.60 to 1 rather than 1.92 to 1.

#### **Repayment Capacity**

As part of the feasibility analysis a value called repayment capacity is calculated which is supposed to measure the ability of irrigators to repay project construction costs. Inasmuch as net agricultural benefits are the residual return to producers after paying all costs of production except water costs, repayment capacity should equal net agricultural benefits. Irrigators are the sole recipient of direct agricultural benefits, and as such, would theoretically be willing to pay up to the amount of direct agricultural benefits

<sup>4</sup>Benefits of \$235 per acre in 1977 dollars are assumed for the purpose of illustration. It is not conceded that this represents a reasonable or likely return to irrigation project water in year 20. The preceding analysis suggests that \$235 is neither reasonable nor likely.

per year for water. Using the Bureau of Reclamation estimate of agricultural benefits, irrigators would then be willing to pay up to \$235 per acre per year for water. However, repayment capacity as estimated by the Bureau of Reclamation is \$18 per acre annually, or 7.7 percent of estimated agricultural benefits [U.S. Department of Interior, 1978, p. 142].<sup>5</sup> Clearly, few would argue that irrigation is sufficiently remunerative to permit an annual charge of \$235 per acre for water. Yet, this is precisely what the estimated agricultural benefits of \$235 per acre imply. The differences between estimated agricultural benefits and repayment capacity are partially explained by the use of lower yield estimates and the inclusion of certain contingency costs when estimating repayment capacity [U.S. Department of Interior, 1978, p. 68]. The rationale for using different yields and not including contingency costs in estimating agricultural benefits is not explained, however.

Using an interest rate of 6.625 percent, the discounted present value of irrigator repayment of \$18 per acre annually over the project life is \$35,445,000 while the discounted present value of construction costs is \$347,563,000. Thus, the approximately 900 irrigators in the project area will receive a federal subsidy of approximately \$312,118,000, or \$346,798 each. Only approximately 10 percent of the costs of project construction will be paid by the primary beneficiaries.

## Conclusions

While a favorable benefit-cost ratio should not be the sole or perhaps even most important criterion on which to evaluate the merits of a project, at either interest rate, this irrigation project would appear economically infeasible if returns to irrigated agriculture remain at levels (in constant dollars) that have existed in the past. It is necessary to assume a rather dramatic and sustained food shortage

to estimate a real return to irrigation water which is nearly triple the current return. This is not to say that the Garrison Diversion Unit cannot be justified on other bases. Whether the project was promised to the state in return for losses suffered as a result of dams built on the Missouri River can only be determined by the judicial and legislative branches of government after an exhaustive review of the project's history. Attempts to justify the project on economic efficiency grounds alone, however, fail the test of economic reason.

Examination of the Bureau of Reclamation's benefit-cost analysis indicates that highly questionable assumptions have been used in their calculations. In comparison to present practices, crop rotations appear to be weighted heavily in favor of the higher value crops. Yield estimates are attainable under experimental conditions or with exceptional management, but greatly exceed yields currently achieved under normal management. Production costs do not reflect the high level of management and intensity of production that estimated yields would require. However, the Bureau of Reclamation has a vested interest in the construction of irrigation projects. An obvious conflict of interest exists when the agency responsible for building the project is also responsible for its justification. Benefit-cost analysis, like most economic analyses, involves a choice of expectations about the future from a range of values that reasonable people consider reasonable. When a conflict of interest exists, we can only expect the estimates to be at the optimistic end of the reasonable range, even when estimation practices are governed by stringent policy and procedure guides and directives. It is time that the public becomes aware of the manner in which water projects are justified and the distribution of the benefits and costs which accompany them.

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<sup>5</sup>Total cost of water is \$35 per acre, of which \$17 is allocated to project operation and maintenance and \$18 to construction cost repayment.



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