ECONOMIC ISSUES IN RESOLVING CONFLICTS IN WATER USE

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Completion R

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ABSTRACT

One central and recurring theme underlies the concern of many agencies involved in water development and allocation decisions in Colorado. That theme is conflict in the use of economically scarce water supplies and appropriate means of resolving such conflict. One key economic ingredient in resolving conflicts among alternative uses is the value of water. An extensive literature search indicates that policy makers are not being provided consistent, comparable estimates of the social and economic significance of water in alternative uses. The reason is that water resource analysts have apparently reached no consensus on a systematic framework within which to estimate water values in the absence of observed market prices. The explanation lies in the failure of analysts to fully appreciate problems associated with the physical characteristics of the resource which may lead to significant economic interdependencies, differences in the perspective taken in estimating water values, inadequately or inappropriately conceived concepts of use, variations in the techniques of analysis employed, and other factors. A conceptually consistent framework for valuing water is set forth. In addition two widely used analytical methods for valuing water are discussed. The residual imputation technique is found to be generally acceptable. However, the increasing reliance on valuation through the "value-added approach" should be discouraged.

TABLE OF CONTENTS

Economic Issues in Resolving Conflicts in Water Use

S. L. Gray and R. A. Young

Introduction

Water resource policy in the Western U.S. received its initial thrust from congressional action to promote economic development in the west. Early legislation, such as the Homestead Act and the Desert Land Act, provided land to settlers willing to develop the land for farming. Variations in water supply, seasonally and geographically, emphasized the need for water supply and storage facilities of a scale such that financial requirements exceeded the means of individuals and local and state governments. As a result, the Reclamation Act (1902) was enacted to provide supply and storage facilities in the west at low cost to the users. Under provisions of the Act, settlers were required to repay construction costs at no interest. The early federal legislative mandates placed major emphasis upon private and regional development with primary financial responsibility at the federal level of government.

Beginning in the 1950's and continuing through the 60's and 70's, a number of legislative and administrative attempts at developing a rational water policy were undertaken. <u>Bureau of Budget Circular A-47</u> (1952), <u>Proposed Practices for Economic Analysis of River Basin Projects</u> ("The Green Book," 1958), and <u>Senate Document #97</u> (1962), all provided statements of policies and procedures to be used in evaluating water development projects. While perspectives and objectives other than those reflecting the national interest were recognized in these documents, major emphasis was given to sound economic analysis of the benefits and costs of development from the national point of view.

Further emphasis was given to economic analysis of proposed water development projects in the Water Resources Planning Act (1965) which, among other things, called for reconsideration and refinement of benefit-cost practices and mandated periodic review of the national water situation. Still another attempt to improve water planning and development practices is found in the U.S. Water Resources Council's Principles and Standards . . . (1973) which replaced Senate Document #97 as the basic set of policy and procedures guidelines (see Federal Register, March 22, 1982). Also, the Carter Administration's stand on environmental protection and financial responsibility in water development, although badly mishandled and subjected to congressional override, represented an additional concern with establishing a rational, nationwide water policy.

Whether or not these attempts have been successful in meeting the ends they addressed is not of concern here. What is apparent, and important from our perspective and that of individual western states, is that the actions taken since the 50's, the exhaustion of sites for reservoir development and other developments appropriate for federal construction and, public awareness of sharply rising costs of federal projects have led to a gradual change and, in some instances, a reduction in the role of the federal government in the development of water resources. As a corollary, the role of the states in water developments and in setting water policy has expanded.

At the national level, the current concern with rapidly increasing energy prices and the availability of energy resources has tended to lessen the emphasis placed on water resources research.

In certain western states, however, the national energy situation compounds existing water problems and adds to the urgency of developing rational water policy. In states already facing serious conflicts among alternative water users, as is Colorado, pressure to satisfy national energy demands by developing abundant coal and, potentially, oil shale deposits is not an issue which may be treated independently from water. Energy developments, new or expanded, compound existing conflicts and increase the requirement for economic analysis of alternative water development and allocation schemes.

The existence of conflicts and the importance of economic analysis as an input in resolving them is, of course, recognized by agencies involved in state and federal water development and planning. A recent statement of priority water research issued in the State of Colorado (Technical Advisory Committee, Colorado Water Resources Research Institute, 1979) contained a list of more than 100 items. A large number of these items involved economic analysis to some degree and approximately one-fourth of them indicated economics as the primary discipline involved in the research. The research tasks in the latter group contained three common and interrelated elements: the call for an analysis of the benefits and costs of particular development and allocation strategies; a statement of the criteria upon which to base analyses of development and allocation schemes; and recognition of the need for empirically sound estimates of water value in alternative uses. These three elements support the contention of policy makers and economic analysts that the central feature of the state's water problems may be very briefly summarized as conflicts among existing and potential alternative uses. The focus of the State's water policy is then legitimately on resolution of conflict which is a problem of organizing human utilization of the available resource endowment.

Boulding (1980) states that there are three major mechanisms involved in this process — "prices," "policement," and "preachments." The first represents the results of the market system operation of free exchange and relative prices. The second represents the establishment and enforcement of property rights and public regulations governing resource use. The third represents the process through which human values are learned, transmitted, altered, and used in making choices.

Water has been governed by a combination of these mechanisms. However, in contrast to many other natural resources, the political and moral mechanisms have had the dominant role, and water administration falls largely in the political arena. There are good reasons for the lack of emphasis given to market prices as a means of allocating water among alternative uses and thus for continuation of allocation decisions made in a non-market context. Many of these reasons derive from the nature of the water resource. They are also suggestive of research tasks facing analysts charged with the responsibility of providing economic input into the decision process.

It is our intent, in the following pages, to: 1) sketch the general nature of the market system and the attributes of the structure of prices in a properly functioning market; 2) describe the nature of water in order to show why non-market allocation is, and will likely continue to be, the means of resolving conflicts in water allocation; 3) describe the nature of the economic problem and research input in the analysis of water allocation in the non-market context; and 4) critically evaluate alternative analytical techniques used in water valuation efforts.

The Role of the Market System in Resource Allocation and Evaluation

Any economic system must answer several questions: 1) What goods and services are to be produced? 2) What technology of production is to be used? 3) Who is to use the goods and services produced? The market solution to these problems is based on the premise of consumer sovereignty — the personal wants of individuals determine the allocation of resources, production, and distribution.

In the idealized competitive market model, the system will produce the desired (optimal) bundle of goods and services given the endowment of resources, production technology, consumer preferences and the distribution of purchasing power. Individual producers and consumers, acting within their own self-interest will, in accordance with Adam Smith's "invisible hand," arrive at an allocation of resources which cannot be improved upon. Firms, encouraged by prospective profit, buy inputs as cheaply as possible, combine them in the most efficient form and produce those things which have the highest value relative to cost. Consumers' tastes and preferences influence their expenditure patterns, thereby encouraging firms to produce the commodities people want. Prices are bid up for the commodities most desired, and producers allocate resources in the direction of greatest profits. The firms most successful in the process, producing desired goods most efficiently, are rewarded by profit and the unsuccessful are eliminated, so production occurs at least cost.

A second desirable property of the idealized market system is its ability to accommodate changes in conditions of production and patterns of consumption. New knowledge and technology are rapidly reflected in the prices which producers are willing to accept for their products. On the consumer side, changes in income and preferences soon show up in expenditure patterns. In short, in a properly functioning market economy conflicts among alternative resource uses would be solved by market determined scarcity values (prices) which direct resources and commodities to those use yielding maximum returns and to consumption yielding the greatest satisfaction. Market prices serve as the means through which conflicts are resolved.

<u>Obstacles to Market Allocation of Water and the Need for Value Estimates</u>

Markets in water, however desirable from a conceptual point of view, as a means to a more productive use of resources, are not yet common. (An important exception is found in the Colorado-Big Thompson project area in northeastern Colorado, where a relatively sophisticated market has evolved.)

Several reasons might be put forth to explain the relative lack of water markets. These are (a) physical (due to the nature of water and how it is used in production and consumption activities), (b) economic (which stems from the fact that, until recently, water has been in relatively plentiful supply), and (c) conflicting social values (in that material well-being is not the only yardstick used by society to measure success in water allocation).

Whatever the reason for the general absence of markets in water, the estimation of value in alternative uses remains an important task, because of the tendency toward under- or overcompensation of the parties involved in changing water use patterns. For example, the emergence of new energy developments located upstream of existing municipalities may impair the quality of water available for municipal use. The municipalities are undercompensated for this change in that they must incur costs to clean the water to a usable quality. Or, consider the situation in Colorado in which the courts have recognized the potential damage to water users external to a transfer of water between uses and have limited transfers to historic consumptive use. This action may well prevent transfers from low to higher valued use even though damage to the external parties to the transfer may be relatively minor. Third party interests are, in essence, being overcompensated. Resolution of conflicts in situations such as these is accommodated in the non-market context but the resource value question still remains (Howe, 1980).

Resource value has meaning only in relation to an explicitly defined objective(s) and value is measured as the contribution of the resource to that objective (or set of objectives) (Marglin, 1966). For example, one of the Department of Natural Resources and Division of Wildlife research priorities is to examine conjunctive water use options to maximize the value of output. The objective has been clearly specified and those options selected, at least on the basis of economic criteria, would be the ones contributing most to the stated objective. Another example is a stated priority research issue of the Colorado Department of Agriculture to examine appropriate efficiency criteria for agricultural and municipal water use. The objective, in this context, could be stated as the maximization of net returns to water in agricultural and municipal use. Again, the value of water in agricultural and municipal uses will reflect the contribution of the resource, in the two uses, to the objective function.

It should be noted that in public water resource management the objectives may not be expressed in the profit maximization motive often attributed to firms in the private sector of the economy. Certainly other objectives such as income distribution, environmental quality, and regional development represent legitimate objectives, often in their own right or as elements constraining an economic efficiency objective. Nonetheless, our discussion is limited in scope to the economic efficiency objective for two reasons. First, economic efficiency in the use of scarce water supplies is an extremely important social objective and efficiency values do have viable empirical content. Second, estimates of efficiency values provide an important means of assessing the trade-offs if alternative social objectives, e.g., income distribution, enter the objective function with weights greater than zero.

Water, in most cases, is a non-market good. Thus, the absence of observable market prices as indicators of values is the general rule. As a result, procedures for estimating the value of water can be interpreted as attempts to simulate market outcomes. Such attempts have been described, in economic literature, as attempts to determine the willingness to pay for the resource rather than do without it. This definition of value, i.e., the amount that a fully informed, rational resource user would be willing to pay for it (Marglin, 1966) is commensurate with market value. In more common usage, the term benefit in the benefit-cost literature is defined in terms of aggregate willingness to pay by the product users, and thus value in our definition is identical with benefit.

There are certain cases where a price is paid for water but this price, actually paid, differs from willingness to pay. Examples of this would include the allocation of water supplies by non-market mechanisms such as the water rights under the appropriation doctrine and the initial allocation of supplemental water supplies by the Northern Colorado Water Conservancy District. Willingness to pay may exceed the actual payments. Another very common situation in water resource developments is that in which the development adds large discrete increments to supply and where users are charged a single price for their increment. Revenues from the sale of water in these cases understate the true value of the resource and estimates of shadow prices are necessary in order to establish the true social value of the resource. However, there are a number of conceptual issues relating to the general problem of shadow pricing and specific to valuation of water which render the task difficult yet one which must be addressed if comparable value estimates are to obtained. We will not attempt a detailed presentation of the entire range of conceptual issues but will highlight those we feel to be of particular importance to Colorado.

Conceptual Issues in Valuing Water

The Accounting Stance and Allocative Criteria

There are three major viewpoints, or accounting stances, which can lead to differences in estimates of the value of water. First, in the private market context, the perspective of the individual is emphasized. In this context, the individual acts in accordance with his perception of gains and losses (benefits and costs). These gains and losses are associated with the individual's objectives, e.g., profit maximization, and are viewed independently of gains and losses occurring elsewhere. Two party transactions regarding the rental of water or permanent exchanges of rights to supplemental water through the Northern Colorado Water Conservancy District are examples of the individual perspective. A price (value) is agreed upon by parties to the transaction which reflects the individual assessments of gains and losses. In principle, exchanges will continue until they cease to be mutually advantageous to parties to the transaction. The private water user may, however, view benefits and costs much differently than do agents of the public who are charged with the responsibility for all members of the public.

Thus, alternative accounting stances are appropriate. In the water resources literature there are two major alternatives found: the regional accounting stance (state or river basin) and the national accounting stance.

The accounting stance adopted is an issue not only in assessing the impacts of water development schemes but also in determining the trade-offs involved in reallocations between uses. For example, the trade-offs, from a regional perspective, that are likely to be of major importance are the direct and indirect regional income changes, direct and indirect regional employment changes, and the hard to quantify, but potentially important, effects in terms of aesthetic amenities and desired economic mix of activities. While changes such as these may be significant from a regional perspective, their significance from the rational viewpoint may be much less. Consider a recent study by Howe and Young (1978) in which the direct and indirect income losses associated with transferring water out of irrigated agriculture in the Upper Colorado River Basin were estimated at $2.1 million per year. This loss was associated with phasing 8,800 acres in the Grand Valley and 10,200 acres in the Uncompaghre Valley out of irrigated agriculture. Consumptive water use reduction was estimated at 30,800 acre-feet per year for a regional income loss per acre-foot of water saved of $67. In addition, a reduction in salt loading of more than 76,000 tons per year was estimated. From the state or regional perspective the direct and indirect income (and associated employment) losses are quite significant and the state would likely oppose the acreage phase-out program. From the national perspective, however, the losses may not appear to be significant. The water saved and reduced salt loading will permit partially offsetting benefits in the Lower Basin. Howe and Young (1978) estimated that a one-ton reduction in salt loading would result in increases in agricultural yields valued at $8 per ton, or approximately $608,000, in the Lower Basin. Resulting estimates of the value of water from the two alternative perspectives are different and the conflict between agricultural and other uses will likely appear to be much more accute when the regional perspective is adopted. This difference in perspectives explains the conflict between state or regional authorities and the Federal government regarding appropriate means of handling water problems. Given the significant regional trade-offs which may occur in reallocations of this type, the state or region generally finds it to be in its best interests to turn to other ways of satisfying the needs of emerging water users, i.e., those provided from Federal funding.

The proposed increased responsibility placed on individual states for financing water projects may lead to an argument for adopting a regional accounting stance rather than the broader national viewpoint. The narrower perspective may, at first glance, appear justifiable. If the state finances its own water developments, and bears the financial burden of reallocation, why should economic benefit and cost considerations extend beyond state boundaries? Are the non-state (extraregional) impacts the responsibility of the state (region)? Economic literature distinguishes between two types of externality impacts and suggests an answer to the question of responsibility for such impacts (Mishan, 1976). These impacts are identified as pecuniary and technological externalities. The former refer to uncompensated financial impacts, e.g., an increase in the rates of factor hire, a reduction in the price of commodities because of increases in supply, and the like. The latter refer to uncompensated affects on the production (or satisfaction) functions of parties external to the development/allocation decision and would include such things as environmental degradation and the imposed costs of clean-up, loss of habitat for fish and wildlife, and losses associated with changes in the timing of available supplies. The literature suggests that pecuniary externalities are accommodated via normal market processes. It is the technological externalities which are worthy of concern and which are to be accommodated, for allocative efficiency, by some sort of internalization in the externality producing unit. We concur, for the most part, with this suggestion.

Regarding technological externalities, there appear to us to be two issues that suggest the state should adopt the broader perspective in analysis of water development schemes. First there is a question of moral responsibility for action affecting regions beyond state boundaries. It is our value position that this moral responsibility does exist. However, even if this value position is not widely shared, there is the second issue of legal responsibility. It may well be the case that the narrower perspective will prove to be more expensive to an individual state in the long run than would adoption of the national perspective in state policy. State practices which impose technological side effects on other regions will likely be met with stiff (and expensive) legal opposition. Consideration of these types of impacts should be internalized into the individual state's analysis.

If the national perspective is, in fact, adopted, private and/or regional objectives may not be the appropriate criteria upon which to base development and allocation decisions. Since the national viewpoint is much broader than either of these, some concept of net social value is suitable. In order to assure comparability in value estimates in alternative uses and between regions, it is imperative that the analytical perspective adopted be identified and that steps be taken to adjust estimates derived from different perspectives so that they are consistent and comparable.

The differences in accounting stance adopted by water resource analysts is one primary cause of differences in value estimates in alternative uses and geographic regions. Other causes include certain physical attributes of the resource, economic aspects of supply and use, and institutional factors.

Quantity of water available for use is the most often emphasized aspect of the water use and conflict situation. It is, however, only one dimension of the general development and allocation problem. Water supplies and uses vary in both time and space so that two other dimensions of the resource are immediately obvious — the timing and location of resource availability. In addition, water is found in varying qualities depending on the type of use and the nature of soils through which it moves. These four dimensions — quantity, quality, time, and location — are an integral part of the water problem and examples of conflicts in each dimension abound. The current struggle between Colorado and Nebraska over the South Platte River provides an example of conflict in the quantity, location and timing dimensions while the water quality dimension is exemplified in Weld County where conflicts between natural gas developments and water quality have reached a boiling point. Their consideration (or lack thereof) will have a significant impact on water value estimates in alternative uses and regions.

Physical Aspects of Supply and Use

Natural resource classification generally proceeds with a distinction drawn between non-renewable, or stock, resources and renewable, or flow, resources. Water, with a few notable exceptions, e.g., storage in underground aquifers in which withdrawals exceed recharge capacity, falls in the latter category. The physical mobility of water has caused its further classification as a fugitive resource. This general fugitive nature is responsible for a number of physical interdependencies among uses and attendant valuation problems. A particular concern is the definition of the unit of utilization.

It is common to distinguish between instream (non-withdrawal) and off-stream (withdrawal) and between consumptive and non-consumptive uses. Water "use" is a term which can be applied to withdrawal. It can also be applied to the quantity of the resource which is not available for subsequent re-use, i.e., to actual consumption. And it can be applied to instream uses. Generally, withdrawal uses are the major consumptive uses while instream uses are typically termed non-consumptive. However, in the former it is not likely that the entire quantity withdrawn is consumed. Certain uses, e.g., thermal-electric power generation, withdraw extremely large quantities but consume very little. In other cases, e.g., irrigated agriculture, consumption is a significant part of quantities withdrawn. In the latter case water use instream for hydroelectric power generation, instream flow maintenance for fish, wildlife, recreation and water quality improvement do not consume water in the same sense as does irrigated agriculture. However, storage for instream use can result in substantial evaporation and seepage loss. This is a consumptive use effect which is rarely taken into account in water valuation studies. In addition to this, the unconsumed portion, whether for instream or withdrawal use, may be altered significantly in the quality, time, and location dimensions.

In contrast to most other resources, the use of water for a given purpose at a specific time and location does not necessarily preclude its use for other purposes at a different time and location. This means that the total productive use of a unit of water may be many times greater than that at the initial point of use (Hirschleifer, et al., 1960; Hartman and Seastone, 1970).

Physical Interdependence and Economic Impacts

This indicates a major difficulty in evaluating water because water use cannot, in the majority of cases, be viewed independently of potential alternative uses. In most cases several alternative uses will exist within the same river basin and one use can affect others through any of the four dimensions mentioned previously. In Colorado, recognition of the potential significance of these interdependencies is reflected in part in the consumptive use limitation on transfers from one use or diversion point to another. This limitation explicitly recognizes the dependence of third parties on return flows from other uses as a major source of water supply. It may, as mentioned previously, also give too great a weight to third party interests and thus prevent some economically efficient transfers. Thus, there is a need for value estimates which take into account the physical interdependence among uses.

This is not a simple task, since the value of a particular unit of water (an acre-foot) in this context is the sum of the value marginal product in the initial use plus the value of the return flow in subsequent uses (Hartman and Seastone, 1970). This sum, in the systems context, is net of the positive or negative effects which are engendered subsequently in the system. The value of a unit of water to the whole system, rather than to a single use, is the relevant concept in the systems context. The system concept of value of water is very important in conflict situations within a river basin and also in consideration of reallocations between regions and river basins, e.g., transmountain diversions from Colorado's western slope to the eastern slope.

The Allocation Variable

The valuation problem posed by pervasive physical interdependencies in use is essentially one of identifying the appropriate allocation variable or definition of use of water. In some situations, evaluation may not require a measure of value per unit "used" in the traditional withdrawal or consumption sense. A case in point is instream use. A storage project with a primary purpose of storing water for irrigation, such as Horsetooth Reservoir, may create water-based recreation uses. So long as recreation demands are not great enough to create a conflict between recreation and the primary use, no value per unit of use is necessary. Project evaluation is a matter of summing annual recreation benefits and primary benefits. However, once competition between the two uses is established, the economics of the allocation decision requires that per unit values be established. This issue is one which few analysts have addressed and which is a priority issue in water research in Colorado.

Another problem posed by instream uses is that they do not withdraw or consume water in the usual usage of these terms. However, instream uses such as minimum flow, wildlife habitat, power generation and waste load assimilation clearly can foreclose other economic uses. Water released from storage to maintain minimum flow may, for example, preclude water for irrigation and municipal withdrawals. In such cases a conflict, or competitive relationship, exists and economic valuation requires a procedure for assigning value per unit of use.

Traditional offstream uses require some unit measure of use in the process of evaluating alternative allocations. The choice here is typically between withdrawal and depletion (consumptive use) but variations in annual precipitation, rates of percolation, interdependence among users, and the like preclude any definitive statement as to which is generally appropriate. Our contention is that the choice of the unit of "use" will depend upon the nature and extent of physical and economic interdependence and the perspective of the decision maker and that the definition of use must be applicable to both instream and offstream uses. Thus, we contend that a broad definition of water use is appropriate for decision makers and define use as any alteration in quantity, quality, timing, and location of supply for economic benefit.

Instream vs Offstream Values. Another conceptual issue which must be taken into account by policy makers and analysts in water resources is that of instream as opposed to offstream water value estimates. The problem here is that allocation decisions between instream and offstream uses based upon value estimates in the two general categories may be inappropriate unless proper steps are taken to insure comparability. Two examples will suffice to make the argument. First, water is a bulky commodity and thus is relatively expensive to transport to offstream points of use. Offstream value estimates which do not account for acquisition and transport will likely be inappropriate for comparisons among offstream uses and certainly for comparison between instream and offstream uses. In the former case, two uses which are not of equal distance from the initial point of diversion will have different transportation costs. If these costs are ignored a misallocation may occur because value estimates in the two uses are not comparable. An example would be two agricultural uses, similar in every respect except distance from the point of diversion. Lack of consideration of transport costs would likely result in value estimates which are equal between the two uses and thus an equal allocation of water between the two. If transport costs are included, the use closest to the point of diversion would be the more valuable use simply because transportation costs would be lower.

In the latter case, comparison between instream and offstream uses, the same argument holds. Failure to include transportation costs in the process of estimating values may give an unwarranted advantage to the offstream use. In order to be comparable, value estimates for offstream uses must be adjusted downward in an amount equal to the costs of transportation.

A similar argument applies to value estimates in cases involving variation in the quality of water necessary in alternative uses. The least common denominator in water value estimates is the unprocessed water in the supply source. Here, both processing and transportation costs must be deducted from site values for offstream use in order to have comparability between instream and offstream values.

Short-run vs Long-run Values. One final conceptual issue confronting water resource analysts and policy makers is that of short-run vs long-run values. The short run is characterized by fixity of certain resources and sunk costs of these fixed resources are ignored. In the long run, all such costs must be covered and thus short-run values may be significantly higher. Each concept is appropriate in certain cases. In-season choice of the quantity of water to be applied to irrigated crops would use the short-run values while public investment in water supply should use the long-run concept. It is, however, essential to avoid comparison of value estimates based on one concept with estimates based on the other. Care must also be exercised against using estimates based on one concept when the other is appropriate.

Comparability in Value Estimates. The issues raised above may be conveniently summarized according to a well-known precept in economics — comparable prices require comparability in terms of place, time, and form.

Specifying comparable shadow prices for water requires that values per unit which are conceptually equivalent in terms of quality, time, and location. This is, as pointed out previously, no easy task, and presents a significant challenge to analysts and policy makers charged with appropriate allocation of a scarce resource. It is our contention that most estimates of water values do not include adequate consideration of these factors and, as a result, in appropriate estimates are often employed and/or decisions are made in the absence of sound economic analysis.

Benefit Evaluation

The conventional economic appraisal of a water project attempts to determine the net change in gross regional product (GRP) available to the state (or region) as a result of the project. The key question is whether or not GRP will increase enough to pay project costs and still leave the state better off than it was prior to the project. The problem of benefit estimation in dealing with water projects is that of imputing a "shadow price" or value estimate in the absence of markets to perform the function.

Water valuation in practice uses several major approaches or techniques. These include: (a) the rare, but not completely absent, observation of market transactions; (b) derivation of value from statistically derived demand functions; (c) residual imputation and its variations; (d) alternative cost valuation; (e) user surveys. These techniques have been discussed elsewhere (Gray and Young, 1974; Young and Gray, 1972) and they will not be addressed in any detail here, with the exception of item (c) which is often used and, unfortunately, misused.

Residual Imputation

Shadow pricing using the residual imputation technique is a means of assigning resource value by allocating the total value of output among each of the factors used in production. The method is deceptively straightforward — if appropriate prices can be assigned to all inputs but one, and the quantities of all resources used can be identified, then the sum of the price-times quantity relations for the known resources can be subtracted from the total value of output. The residual is imputed to the remaining resource.

This technique rests on two major postulates (Heady, 1952). First, the market prices of all resources except the one to be valued (water) are equal to the marginal returns or value marginal product of the resources. Second, the total value of output can be divided in such a way that, if each factor is paid according to its marginal return, the total value of output will be exhausted. The method appears to be simple and straightforward. However, there are some important limitations on the technique which must be recognized.

First, one of the most important requirements is that all factors of production be identified and appropriately valued. If certain factors are omitted, the returns to the omitted resource are imputed to the residual resource and value estimates are inflated. This problem often emerges with respect to the management input and, say, family labor in a farm operation.

Second, even if all variables are identified and included in the imputation process there may be significant problems associated with the market's failure to appropriately assign prices to factors other than the one to be shadow priced. Errors in valuing these resources will, of course, lead to errors in imputing value to the residual resource (water). Similarly, distortion of true market prices via government intervention, as in the case of supports, will bias the residual imputation process.

In sum, residual imputation can be effectively used, particularly in situations where water is a substantial input in the production process, if the above shortcomings are recognized and are taken into account. Improvements in mathematical programming techniques and data bases have improved the residual imputation process for value estimation.

Regional "Value-Added Approach" to Value Estimation

The residual imputation technique and variation of it are commonly used in shadow pricing. However, there is one approach which appears similar in construct, and which its practitioners have presented as an appropriate method for valuing the generally unpriced water resource (Olson and Hibdon, 1980; Wollman, 1963; Bradley and Gander, 1968; Lofting and McGauhey, 1968). We, however, question its general validity.

This approach, which we term the "value-added approach," rests on the basis provided by the widely used Leontief or input-output model (Richardson, 1972). It is appealing, given the existence of a state or regional input-output model, because of its simplicity in formulation. Following conventional notation let:

X_{ij} = value of purchases from production sector i by sector j.

Z_j = value of primary purchases by sector j where $Z_j = V_j + M_j$ and V_j = total value added by sector j and M_j = value of imports by sector j.

X_j = total value of purchases by sector j or gross outlays.

The purchase transactions by any sector j, expressed in value terms, are

$$X_j = \sum_i X_{ij} + Z_j \tag{1}$$

$$X_j = \sum_i X_{ij} + V_j + M_j. \qquad (2)$$

The V_j element in (1) is usually a composite of the several primary resources: wages and salaries, profits (which will include rents to primary natural resources), interest, and certain taxes. We can now approximate gross regional income as

$$GRI_j = X_j - \sum_i X_{ij} - M_j = V_j. \qquad (3)$$

The value-added imputation process for sector j rests on the calculation of

$$\hat{P}_{w_j} = V_j/W_j \qquad (4)$$

where $\hat{P}_{w_j}$ = imputed value of water to sector j and w_j = units of water consumed by sector j. The imputation process is, at first glance, quite similar to that discussed in the residual imputation approach outlined above. However, there is one important difference and that is in the definition of value-added. Since value-added is generally an aggregation of the factors cited earlier, the residual in this case includes not only the contribution of water to the value of output, but the contribution of all primary resources. Attributing the value-added to water (4) implicitly assigns a zero shadow price to the other primary resources and thus ignores the fact that resources other than water are scarce. Assigning zero opportunity cost to other primary resources by implicit assumption is questionable and too often results in water value estimates which greatly overstate the true contribution of water to net regional output. The value-added imputation process can lead to conceptually correct results only if (1) extreme care is taken to disaggregate value added so that the contribution of all other primary resources is empirically identified, or (2) if the assumption that the opportunity costs of the other primary factors is zero is verified.

By way of driving home our point, we note a curious reversal of the meanings of costs and benefits can be seen to have occurred in the value-added approach. Expenditures for resources in the value-added element of the model have been transformed as if by magic from costs into benefits. For example, wages and salaries paid for scarce labor resources become, rather than a cost of production, a benefit of water resource development. But these resources must be paid for from revenues and a further surplus be available for the development of a water resource project to leave the region better off than it was without the investment.

Conclusion

While recognizing the return to the region's primary resources may be an attractive criterion to regional planning agencies, we challenge the general applicability of the approach. d'Arge (1970) in another New Mexico study has provided the most carefully reasoned justification of the value-added criterion for water allocation. He assumed water to be absolutely scarce relative to all other resources, applying a criterion proposed earlier by Kahn (1951). This is asserted to justify the implication that the social opportunity cost of labor and other primary resources is zero. If this is in fact true, then the maximum net social product derived from the scarce water resource would indeed be properly measured by value added. However, even if water is very scarce in the arid western United States, that fact does not appear to warrant the further leap to an assumption of zero opportunity cost of labor and other primary resources. Such a position is tantamount to assuming that a significant portion of the "associated costs" of a water resource project have no alternative uses during the life of the project. We believe this implicit assumption would be realistic for a state or regional planning agency only in the most unusual of cases (i.e., in a developing economy with high permanent unemployment). Thus, we judge it questionable that even a regional planning authority should ignore the alternative cost of primary resources other than water in its allocation decisions (although we readily concede that such assumptions often characterize the pronouncements and behavior of agenices of this sort)!

We conclude that a state or basin agency evaluating a water project on the basis of benefits measured in terms of a value-added concept will unfairly inflate the returns to a public investment program in comparison to the potential gains from alternative uses of the same investment funds. In what we feel to be the typical case, primary resources other than water are also scarce and valuable in alternative uses, in regional contexts as well as from the national and private perspective. If so, primary regional income per unit of water use as a measure of value results in estimates which may be several times too high from either the private or the national accounting perspective. Thus, the use of the regional value-added criterion appears appropriate only under quite limited conditions (if ever).

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