SECTION 3.4

ECONOMIC ANALYSIS OF WATER RESOURCE DEVELOPMENT

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3.4.1. INTRODUCTION

Economic analysis of water resource development within the context of lake/reservoir management is concerned with the analysis of alternatives and the allocation of costs. Consider a dam and its reservoir. Economics plays a major role in the initial decision on whether or not to construct a dam, where to locate it, how to construct it, how big to build it, and how to operate the associated reservoir. The techniques of project analysis, usually some form of social benefit/cost analysis (B/CA) or cost-effectiveness analysis, are used to assess the initial design options.

Once built, however, a dam is a classic case of what economists call a "sunk cost"; the dam cannot be moved and probably has no alternative use other than impounding water. How the dam and reservoir are managed, however, is an important variable and economic analysis can play a useful role in this process.

A natural lake is also a fixed asset. Other than draining it, a lake is not easily changed, although its water can be polluted and degraded or used in various ways and at different rates.

However, whether man-made or natural, management of both lakes and reservoirs has many common features in terms of purpose of use and environmental effects. Although ex-ante economic analysis of major investments is primarily relevant to dams and their associated reservoirs, economic analysis of operation and maintenance is common to both reservoirs and lakes.

This section considers economic analysis of water resource developments including both dams/reservoirs and lakes. In particular, the environmental dimensions will be emphasized and how these aspects can be handled within an economic analysis. Broader issues of multiple objective analysis are covered in Section 3.1, Water resource management: planning and implementation.

3.4.2 ANALYSIS OF INVESTMENT DECISIONS

The economic analysis of major capital projects like dams is a well-developed technique. Whenever such major investments are undertaken it is important that careful estimates be made of expected benefits and costs. Dams are public investments made to serve multiple purposes including irrigation, water supply, flood control, navigation, and hydropower generation. Public decisions should be analyzed in a social benefit/cost analysis (B/CA) framework, rather than in a financial analysis of private return that is appropriate for individual decisions. The social B/CA uses measures of social costs and social benefits to analyze alternative projects, design formulations, or management strategies. This approach is therefore an integral part of the planning process as shown in Fig. 3.1.4 on planning and management activities. The mechanics of this approach are found in standard references including the UNIDO Guidelines (1972), Little and Mirrlees (1974), Squire and van der Tak (1975), Gittinger (1982), and Dixon and Hufschmidt (1986).

It is not possible to present the details of project analysis here. Dams are frequently mega-projects costing hundreds of millions, if not billions of dollars and often take years to plan, design and construct. Anticipated benefits may or may not be realized depending on changes in demand; prices of both inputs to the project and the desired outputs may change in the interval between analysis and project implementation.

Because of the long time horizon over which these projects are implemented, therefore, it is important that sensitivity analysis be carried out on key parameters to see how a change in a parameter will affect the economic viability of the project. For example, if a dam is designed primarily for hydropower generation, sensitivity analysis could be done on both the future price for electricity (higher? lower? than initially forecast) and on the future seasonal availability of water in the reservoir. These are commonsensical suggestions that are usually done as part of the analysis of any dam projects.

There may also be important environmental or resource effects associated with dams that need to be taken into consideration. These impacts can take place above the dam/reservoir, at the dam itself, or downstream. When they are beneficial these impacts should be included as benefits in the social welfare analysis of the project; when they are harmful they need to be included in the costs of the activity.

Environmental and resource impacts are important considerations both before construction begins, and in the management of existing facilities or lakes. A recent World Bank Technical Paper, Dams and the Environment: Considerations in World Bank Projects (1989), discusses the economic and environmental issues involved.

Fig. 3.4.1 presents the chain of main events related to storage dams and the environment. A number of upstream events are listed as "effect of the environment on the reservoir"; most of the impacts occur in the dam or reservoir/lake site or on the downstream "service areas", in this case irrigation, domestic and industrial water supply, and power.

Each of these effects or impacts has associated consequences (also indicated in Fig. 3.4.1). These consequences can frequently be valued in monetary terms, and hence economics enters the picture. The valuation of environmental effects of dams and their reservoirs is discussed next. Although some of these effects are unique to dams, many are also encountered in the management of lakes.

3.4.3 ECONOMIC ANALYSIS OF ENVIRONMENTAL EFFECTS OF STORAGE DAMS AND RESERVOIR/LAKE MANAGEMENT

A traditional economic analysis of a dam project includes the construction and operation, maintenance, and replacement (OM and R) costs as well as the expected benefits in terms of hydropower generated, irrigation water provided, flood damages averted, and water supplied for domestic and industrial use. In some cases, recreational and fisheries benefits may be important. In addition, there are associated environmental and resource costs and benefits that must also be taken into account.

The logic for a wider analysis has several dimensions. First, given the key position of a dam in a regional investment strategy and of a lake as a regional resource, it is prudent to safeguard such investments and resources by taking appropriate actions to prevent loss of direct project benefits -- the water and power provided by the dam or lake. Fig. 3.4.1 present environmental factors both caused by the dam and that affect its

STORAGE DAMS AND THE ENVIRONMENT

CHAIN OF MAIN EVENTS

EFFECT OF ENVIRONMENT ON THE RESERVOIR

EFFECTS	CONSEQUESCES
- Precipitation	- Run-off (for storage) with extreme events of floods & low flows
- Soil erosion	- Siltation of reservoir and outlet - Blockage.
- Pollutant & natural chemicals	- Deterioration of water quality
- Aquatic life & waterfowl	- Settlement on reservoir
- Evaporation	- Water loss
- Climate	- Low temperature water inflows
- Debris	- Outlet blockage.

RESERVOIR

EFFECT OF THE RESERVOIR AND ITS STORAGE FUNCTION ON THE ENVIRONMENT

EFFECTS	CONSEQUENCES
- Smaller variation in downstream streamflows	- More plentiful and reliable supplies of water; less flood damage; lower after-flood crop production; less flood plain fisheries; more/less estuarial salinity depending on topography. less bank erosion.
- Lower silt content of water	- Lower cost of water management; downstream erosion.
- Inundation of land	- Displacement of settlers; damage to fauna & flora, archaeology, and infrastructure; loss of land.
- Creation of lake/pond	- Recreation; new fisheries; better animal watering but disruption of migration routes; eutrophication.
- Creation of gravity head	- Command of irrigable land; potential power production.
- Lower flows downstream	- More esturarial salinity (in extreme cases).
- Temperature	- Better conditions for users (warmer water, less frazzle ice).
- Interception of river	- Interference with fish migration.
- Inundation of forests	- Poor water quality for potable purposes.
- Induced seismicity	- Induced landslides.
- Reservoir drawdown	- Dry season cropping/grazing.
- Subterranean leakage	- Rise in groudwater.
- Construction activity	- Economic development; environmental change.

SECONDARY EFFECTS ON "SERVICE AREAS" AND SYSTEMS DOWNSTREAM

IRRIGATION

EFFECTS	CONSEQUENCES
- Lower silt content in water	- Lower DAM cost; better water management leading to less water logging. - Changes in fauna and flora.
- More regular supply of water	- Adoption of perennial in place of non-perennial irrigation with better crop production. - Expansion of irrigated area. - Better control of some pests and diseases; less control over others.
- Additional water supply	- More waterlogging but, with good management, better salinity control.
- Gravity supply to irrigation system(where feasible)	- Lower energy consumption.
- Regulated river flows	- Lower pumping costs.

Note: Almost all storage dams supplement water supplies to existing run-off-river systems.

DOMESTIC & INDUSTRIAL WATER SUPPLY

EFFECTS	CONSEQUENCES
- More reliable supplies **	- Less failures and less rationing hence better public health control. - Better repulsion of salt intrusion in estuaries giving more sustainable rural water supplies.
- Lower biological quality *	- Higher treatment cost.
- Higher chemical quality *	- Lower treatment cost.
- Wider spatial availability of water **	- Less concentration of urban areas and industries.
- Poorer taste* **	- Higher treatment cost.
- Lower silt content **	- Lower treatment cost.

Note: * compared with groudwater
** compared with run-of-river

POWER

EFFECTS	CONSEQUENCES
- Non-thermal energy production	- Displaces fossil fuel and nuclear power and their associated environmental effect.
- Renewable energy source	- Sustainable production
- Lower cost of production	- Permits special industries such as smelting - Provides low cost domestic amenities.
- Simplicity of operation	- Less failure in regions with few skilled human resources.
- Lumpy investment	- Debt burden.

Note: Treats fossil fuel and nuclear power as the alternative sources to hydroelectric (excludes tidal wave, and other sources.)

Figure 3.4.1 Chain of Main Events for Storage Dams and the Environment (from Dixon, Talbot and Le Moigne, 1989) functioning. A number of these are adverse, such as a high rate of soil erosion in the upper catchment leading to sedimentation of the reservoir or lake, and degradation of water quality. There may also be second-order effects such as soil salinization or waterlogging in newly irrigated areas or the proliferation of human parasites in perennial irrigation areas made possible through water storage. These environmental impacts directly affect the generation of project benefits over time. Since most of these are costs they reduce the financial and economic attractiveness of the project.

Similarly, any direct environmental benefits, such as a new reservoir or lake fishery, a tourism industry, or the reduction of the suspended matter content of the water, should be counted as benefits.

Second, there may be important indirect effects created by the operation of the dam and associated reservoir/lake and associated environmental impacts. Fisheries, both downstream and in coastal areas, may be hurt by changes in water quantity and quality including a lowering of water temperature. If there are migratory fish species within the river (e.g. salmon, sturgeon), their productivity or very survival may also be affected. There can also be significant indirect environmental benefits of dam/reservoir or lake operation. Changes in stream flow after dam construction can result in reduced saltwater intrusion in coastal areas, depending on how water releases are regulated. When environmental benefits occur, they should be included in the economic analysis in the same way as environmental costs.

Third, there are important social impacts chiefly associated with dams. These include the major problem of involuntary resettlement for those people living in the reservoir area and the spontaneous voluntary movement of settlers into the watershed (reservoir basin) above the dam. In-migration is often accelerated by the improved access provided during dam construction. (There are even reports of new settlement in the proposed reservoir area in hopes of receiving compensation when it is flooded.)

Other social impacts are caused by changing economic patterns as a result of dam-induced developments, both upstream and downstream. The net effect of these factors may be to increase or decrease the economic returns from the dam project.

In order to conduct a wider, more environmentally sound appraisal of dam/reservoir or lake management projects, several conditions must be met. First, it must be accepted that environmental costs and benefits are real costs and benefits that must be included in the economic analysis. Under-estimating or ignoring environmental costs is no longer acceptable. Second, the identification of the likely environmental impacts requires the skills of a mix of disciplines.

Fourth, environmental effects change over time and monitoring is required, both to evaluate on-going activities and to identify potential problem areas and take appropriate action. Ideally, monitoring must start before construction to establish baseline data. See UNEP (1989) for a discussion of monitoring and evaluation for water resource development projects.

The tools of economic analysis are well developed for carrying out standard financial and economic evaluations of dam and lake management projects. In the past two decades, much work has also been done on applying economic analysis to environmental effects of development activities (Hufschmidt et al., 1983; Dixon et al., 1988). For some categories of effects, the analysis is quite straightforward; for others, the appropriate techniques are still evolving.

Consider the case of soil erosion and reservoir/lake sedimentation. The physical processes have been extensively studied; it is know that soil erosion and sedimentation are the result of both natural and man-made processes. The costs due to lost reservoir storage capacity are also very large if live storage is curtailed. (Most dams have dead storage built into the reservoir design for storage of sediment. In fact, sediment usually affects both live and dead storage. The important question is the distribution of sediment between the two.)

In a recent World Bank technical paper on reservoir sedimentation, K. Mahmood (1987) estimated the replacement cost for lost reservoir capacity of major world dams at some $6 billion per year. While part of this lost capacity is due to natural erosion, part is created by human activities. In addition, this annual cost is expected to increase over time. As Mahmood point out, "in many basins, additional sites are hard to find, and in general, remaining sites for storage reservoirs are more difficult, and, hence, more expensive to develop."

Environmental impacts may also be a major contributing factor to construction delays or even outright cancellation of projects. Just as a heavily sedimented reservoir imposes large costs on society, a delayed or canceled project can be equally costly in terms of project benefits foregone and lost capital investment.

A proper environmental and social analysis, therefore, can help assess whether or not the benefits are larger than the costs (including environmental damages). With this analysis, some proposed projects may not prove to be socially desirable. In that case, alternative projects or management strategies should be considered in the search to find the best way of supplying the desired water and power benefits.

3.4.4 ANALYTICAL TECHNIQUES

Recent work has expanded the list of environmental or resource impacts that can be evaluated in tangible (monetary) terms and included in the economic analysis. Many of the most useful approaches rely on changes in productivity that can be valued using market prices. Table 3.4.1 lists some of the environmental aspects of dam/reservoir projects, their economic impacts (both benefits and costs) and selected valuation approaches that can be used to value them. The table does not present an exhaustive list; it is merely indicative of where one can start.

As seen in Table 3.4.1, many of the environmental effects and their economic impacts can be valued using change in productivity techniques or preventive costs or replacement costs approaches. All of these approaches rely on use of actual expenditures (or in some cases potential expenditures) valued at market prices. With proper identification of the cause-effect relationships, there is little doubt that these impacts reflect real welfare changes -- either positively, in the case of benefits, or more commonly negatively, in the case of costs.

Other approaches used to value environmental benefits and costs rely on "surrogate markets" such as the travel cost and property value approaches. Health care costs and loss of earnings techniques may be used to value health-related effects. In all cases the aim of the analysis is the same, - to properly identify likely environmental benefits or costs arising from the dam project and incorporate them into the overall economic analysis of the project. The actual process of valuation of environmental effects requires their translation into monetary terms. Considerable literature exists on the valuation process; discussion of techniques and examples are found in Sinden and Worrell (1979), Krutilla and Fisher (1982), Hufschmidt et al. (1983), Dixon and Hufschmidt (1986), Dixon et al. (1988), and Dixon et al. (1989).

Table 3.4.1
Selected Environmental Effects and their Economic Impacts

Environmental Effect	Economic Impact	Benefit (B) Cost (C)	Representative Valuation Technique
Environment on Dams			
1. Soil erosion - upstream sedimentation in reservoir	Reduced reservoir capacity, change in capacity, change in water quality, decrease in power	B,C	Change in production, preventive expenditures, replacement costs
Dams on the Environment			
1. Chemical water quality - changes in reservoir	Increased/reduced treatment cost, reduced fish catch,	B,C	Preventive expenditures, changes in production.
2. Reduction in silt load, downstream	Loss of fertilizer, reduced siltation of canals, better water control	B,C	Replacement costs, preventive expenditures avoided.
3. Water temperature changes (drop)	Reduction of crop yields (esp. rice)	C	Changes in production.
4. Health - water related diseases (humans and animals)	Sickness, hospital care, death; decrease in meat and milk production	B,C	Loss of earnings, health care costs.
5. Fishery - impacts on fish irrigation, spawning	Both loss and increase in fish production	B,C	Changes in production, preventive expenditures.
6. Recreation - in the reservoir or river	Value of recreation opportunities gained or lost, tourism	B,C	Travel cost approach,
7. Wildlife and biodiversity	Creation or loss of species, habitat and genetic resource	B,C	Opportunity cost approach, tourism value lost, replacement costs
8. Involuntary resettlement	Cost of new infrastructure, social costs	B,C	Replacement cost approach, "social costs", relocation costs
9. Discharge variations, excessive diurnal variation	Disturbs flora and fauna, human use, drownings, recession agriculture	C	Relocation costs, changes in production.
10. Flood attenuation	Reduces after flood cultiva tion, reduces flood damage	B,C	Changes in production, flood damages avoided.

Source: Dixon, Talbot, Le Moigne (1989)

3.4.5 STARTING THE ANALYSIS

Among the hardest tasks for the economist or project analyst is to decide which of the environmental and resource impacts are important and how to measure them and include them in monetary terms. There is no "cookbook" answer; the analyst must think through each problem, identify important impacts, make decisions, and make all assumptions explicit. Among the various environmental effects of dam projects some general guidelines that should be of help in setting up the analysis follow:

Start simply with the most obvious, most easily valued environmental impacts. This may mean looking for impacts on the environment that result in changes in productivity and that can be valued using market prices. (Sometimes market prices are distorted and one has to make appropriate adjustment via use of shadow prices.) Table 3.4.1 listed categories of major effect dams/reservoirs and their economic impacts. Secondary effects may be very important, both ecologically and economically, but the analyst would do best to start with the effects that have directly measurable productivity changes that can be valued by market prices. Secondary effects can then be incorporated to the extent knowledge, data and resources permit.

There is a useful symmetry in benefits and costs: a benefit foregone is a cost while a cost avoided is a benefit. A reduction in dam height, for example, may mean that fewer people need to be resettled from the reservoir. This reduction in resettlement costs is a benefit of the decision. Of course, the reduced height also creates "costs" due to reduced hydropower, irrigation or flood control benefits.

All assumptions should be stated explicitly. This is particularly important in valuing effects on the environment because other analysts may wish to critically review the results and can only do so if the assumptions and the data are clearly presented. The analysis should be carried out in a with-and-without-project framework. That is, the analysis must compare the likely future situation without the project with what is expected to occur with the project. In many areas, existing forces are leading to growing environmental degradation (and poverty) and this process would continue or even accelerate without the project. In this case, the with-project situation must be compared to a deteriorating without-project scenario.

Given the wide range of potential valuation techniques, some of which are listed in Table 3.4.1, this section cannot present any in detail. Rather, brief reviews of two commonly used approaches are presented. The change in productivity approach uses market prices to value a change in production while the replacement cost approach is a cost analysis technique that uses estimates of potential expenditures to value an impact on the environment.

Changes in productivity

Techniques using changes in productivity as the basis for measurement are direct extensions of traditional benefit-cost analyses. Physical changes in production are valued using "economic" or accounting prices, usually based on market prices for inputs and outputs or, when distortions exist, appropriately modified market prices (i.e. shadow prices). The monetary values thus derived are then incorporated in the economic analysis of the dam or lake management project. This approach is based directly on neo-classical welfare economics. The benefits and costs of an action are counted regardless of whether they occur within the project boundaries or beyond them.

Several steps must be taken in order to use this technique:

1. Changes in productivity caused by the project have to be identified both on-site and off-site. In the case of dams, in addition to direct project outputs (e.g. hydropower, irrigation, water supply, flood control) there may be other indirect on-site effects such as the benefits of a reservoir fishery or a tourism/recreation industry. Changes off-site (both positive and negative) include various environmental or economic externalities. These off-site effects must be included to give a true picture of project impacts. Various lake management regimes may also result in impacts that can be measured using this approach.

2. Assumptions will also have to be made about the time over which the changes in productivity must be measured, the "correct" prices to use (e.g. shadow prices) and any future changes expected in relative prices.

The change in productivity approach can be used for various on-site and off-site effects: fisheries and draw-down cultivation in the reservoir or lake area, changes in crop production, and changes in fishery production, both in-stream and in affected coastal areas. Upstream environmental effects, such as changes in land use patterns and associated soil erosion/sedimentation will also affect the economic productivity of the reservoir or lake. These latter impacts may be difficult to measure for the "without project" scenario due to rapidly changing rural settlement patterns. These costs can also be valued by the change in productivity approach.

Replacement cost approach

The basic premise of the replacement cost approach is that the costs incurred in replacing productive assets damaged by a project can be measured, and that these costs can be interpreted as an estimate of the benefits presumed to flow from measures taken to prevent that damage from occurring. The approach can thus be interpreted as an "accounting procedure" used to work out whether it is more efficient to let damage happen and then to repair it or to prevent it from happening in the first place. With the assumptions given below, it gives an estimate of the upper limit of damages that can be ascribed to the project but does not really measure the benefits of environmental protection per se.

The assumptions implicit in this type of analysis are:

1. The damages are measurable;

2. The replacement costs are calculable and are not greater than the value of the productive resource destroyed, and therefore it is economically efficient to make the replacement. If this assumption is not true, it would not make sense from an economic perspective to replace the resource lost (although there may be social or political reasons to do so); and

3. Any secondary benefits (i.e. benefits other than those for which the project or management action was undertaken) associated with the preventive expenditures should be included as benefits in the analysis. For example, reforestation of an upper watershed to control erosion may result in development of a tourism industry or a new wildlife habitat.

In dam and reservoir projects this approach can be used to evaluate various environmental effects and alternative mitigation measures. The simplest example is the problem of resettlement. Resettlement of people displaced by a reservoir and construction site, whether rural farmers, residents of small villages, or inhabitants of larger urban areas, is a costly and difficult process. The costs of replacing lost facilities and recreating viable economic-social systems in another location are calculable. These are a form of replacement cost and should be considered in assessing the overall profitability of the project. The impacts of alternative dam heights and associated reservoir levels on replacement costs must be considered as well as the implication of dam height and reservoir levels on construction costs and generation of power, irrigation or flood control benefits. Although lakes are usually less variable in level, in some cases management actions can result in lowering or raising the lake level resulting in similar effects.

An instream fishery may be threatened by a dam that intercepts a natural migration path. In this case the replacement cost to protect and maintain the fishery may consist of fish ladders and other means to permit some degree of migration and natural biological cycles. These costs are then compared to the cost of allowing the fishery to disappear or suffer reduced productivity. In this example the dam project is debited with the amount of the replacement costs (if these are less than the value of the fish that would be lost) or the value of the lost fish (assuming replacement costs are larger than this).

In general, the replacement cost approach can be useful when an effect on the environment has caused, or will cause, resources to be spent on replacing a physical asset. When that asset is a road, dam or bridge, the technique is straightforward. When it is soil, water or aquatic life its application is the same but the problems of measurement are greater. The change in productivity approach can also be useful in these cases. When impacts on the environment result in measurable changes in the level of goods and services produced this approach can frequently be used to bring these "economic externalities" into the analysis.

3.4.6 ANALYSIS OF MANAGEMENT OF RESERVOIRS AND LAKES

In addition to pre-construction decisions and the explicit inclusion of environmental impacts, economic analysis serves a useful function in the analysis of management options. Whether a lake or a reservoir, there frequently is more than one user of the water (joint users), and decisions must be made on how to allocate costs over the various users (allocation of joint costs). This issue is discussed in some detail in Section 3.5.

Management to serve one purpose may well impose costs on another user. In the case of a reservoir that both generates power and provides irrigation water, it may not always be possible to meet both needs 100% throughout the year. If there has been a drought and the reservoir level is down, does one use the stored water to generate electricity or meet irrigation needs? There is no simple answer. Saving the water for one use rather than the other will impose economic costs on the affected sector. An economic analysis can compare expected productivity effects from shortfalls of either electric power or irrigation water. Depending on the economic situation, one option may be clearly preferred.

In Egypt several years ago, a major drought reduced inflows to the reservoir of the Aswan High Dam. In this case the decision was made that irrigation supplies were of prime importance and the reservoir was managed to meet agricultural needs. Power generation was reduced as a result of this action, but this decision was made after weighing the benefits and costs (social and political as well as economic) of each alternative.

Lakes present similar situations, particularly when there are several competing users for the available water. Recreation (including swimming) may be one important (if seasonal) use while lakes are also commonly used as a source of potable water, for cooling or power plants, for fishing, for navigation, and as a receptacle for industrial, agricultural or urban wastewater. Obviously conflicts arise and not all uses can be accommodated at their maximum level.

Economic analysis can be used to examine the implications of alternative scenarios. In general, the larger the lake, the more complicated the analysis. With increasing size of the water body there usually is an increasing number of inputs and outputs and increasingly complex ecosystem interactions. Knowledge of the physical system and of cause-effect linkages decrease rapidly with increased size and complexity.

Still, economic analysis may be useful to eliminate certain options. For example, if a lake (or a reservoir) is to be used for a potable water supply but is presently contaminated by industrial wastewater inflow (or natural run-off from agricultural or urban areas), two major options are possible. One is to reduce contamination of the water body by imposing stringent effluent control standards or by using physical means to prevent, or redirect, inflows. Alternatively, one can examine the costs of treating the water abstracted from the lake (or reservoir) to meet potable standards. As a result of an initial analysis the economically efficient option may become quickly apparent. If pollution control costs, for example, would be $100 million over a 10-year period and water purification costs were $10 million over the same period, one would probably choose purification. If the numbers were reversed, then control would be preferred.

Of course, the analysis becomes more complicated when the number of uses and users increases as well as the number of potential sources or pollution. In addition, even if the economic analysis points out the least-cost alternative, it does not specify whether that option is socially desirable or politically feasible. A multiple-objective analysis may be required to determine this. Governments frequently become involved as both analysts and regulators; taxes, fines or subsidies are commonly used to influence the actions of individuals and firms.

Economic incentives (and disincentives) can be powerful management tools in promoting changes in water use or water resource development. Pricing of water resources can help promote more efficient allocation of water. Although the traditional approach to water quantity problems has been supply augmentation, the use of economic policies to manage demand can be equally effective in helping reach a water supply/water demand equilibrium. (The use of economic analysis and water pricing to manage demand may have the additional benefit of raising revenue!)

3.4.7 CONCLUSIONS

Economic analysis of water resource development plays a useful role both in making investment decisions on design and construction of dams and reservoirs as well as in developing management options for existing lakes and reservoirs. Environmental and social impacts are associated with both project design and resource management and these impacts need to be taken into account in the economic analysis.

The theory and techniques of economic analysis are the same whether they are used for guiding investment decisions on new water resource developments, or developing management plans for lakes or reservoirs.

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