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ASSESSMENT OF THE ECONOMIC CONTRIBUTION OF WATER RESOURCES TO NATIONAL DEVELOPMENT

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The development of a country's water resources is important both as an input to the economic growth process and as an element of the basic needs package which most countries strive to provide for their population. As one of many economic inputs, water related investment should be subjected to the same strict investment criteria as are applied to other competing investments, and pricing policies should be grounded in the economic theories of efficient resource allocation. The social goal of providing adequate water and sanitation for everyone implies a major expansion in standpipe and low-cost sanitation facilities for most countries. Innovative design of tariff structures which cross-subsidize the poor and the packaging of water and sanitation with other basic needs delivery systems can be the keys to bringing the investment requirements down to manageable levels.

Introduction

1. The process of development has both social and economic dimensions. The two are linked, and reenforcing, in many important ways. At the micro level, as household income rises, a family can afford a better standard of living. At the macro level, however, there are numerous examples of countries where, although the average level of income has increased, income distribution has become more inequitable.1/ In some cases the absolute, as well as the relative, well-being of the poorest people declined as economic development progressed. The country's social fabric was placed under increasing strain by the worsening living conditions, particularly for the urban poor. The distribution of income is generally more scewed in developing countries than in industrial countries and a large proportion of their total population is often living in absolute poverty2/even in countries where the average income may be moderately high. For example, in the Philippines in 1971 the lowest 30% of households earned only 8% of the total income while in Japan the corresponding group accounted for 14% (in 1972).3/

2. The development and exploitation of a country's water resources plays an important role in both its economic and social development. Water is both an economic good and a social necessity. The first section of this paper discusses water's contribution to economic development. The second section deals with its role in meeting a country's social objectives. In the final section, the question of whether the economic and social contributions of water resource development are complementary or competing is discussed, and methods are suggested for integrating the achievement of both objectives.

Water as an Economic Good

3. Economic development can be viewed as the process of increasing the production of goods and services given a country's resource endowment. The endowment generally includes both variable resources, such as labor and capital, and fixed, or natural resources, such as land, minerals, water, etc. Combining these inputs in such a way (i.e., with such a set of technologies) so as to maximize total output is what constitutes economic efficiency. As an economy grows it often develops more sophisticated production chains leading from inputs to outputs.

4. A conceptual tool often used by economists to chart the economic growth process is an input/output (I/O) matrix. This is basically a table which lists the inputs, or factors of production, along the side and the outputs (by sector) across the top. A number found in a particular cell of the table is the coefficient which transforms an input into an output or, alternatively, breaks up an output into its constituant inputs. Thus if 0.5 is the number in the cell reading across from labor to agriculture, then for each unit of agricultural output one half unit of labor input is required.4/ Of course, most I/O tables are

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1/ For a summary and analyses of this phenomenon see ref. 1.

2/ As used in this paper the term absolute poverty refers to the state of those without access to the basic requirements of a healthy life including safe water, adequate nutrition and sanitation facilities.

3/ See ref. 2.

4/ Such a rigid relationship between inputs and outputs is an oversimplification, of course. Substitutions of one input for another are likely to occur if relative prices change. New technologies can completely change the production relationship. But in the short run, at least the orders of magnitude in an I/O table can provide a useful summary of how an economy functions.

considerably more disaggregated and would have many subsectors of agriculture and many skill classes of labor.

5. An examination of I/O tables for several developing countries was made in an attempt to determine through which sectors the contribution of water resources to development was felt. The countries which included water as a separate factor of production traced its influence through three main sectors: agriculture, power generation and transportation. Since for many developing countries agriculture is the dominant sector in the gross domestic product (GDP), water may play a major role in enabling GDP to grow over time. The examples of irrigated agriculture in Pakistan, India and the western United States are cases in point. Electric power, as an input to industrial development, is also an important sector in LDCs, particularly for the middle income countries. As compared with agriculture, however, power production is not as dependent upon abundant water resources since substitutes such as thermal generation are more readily available. Transportation is similar in that where, in a given country, navigable water courses do not exist other forms of transportation can be developed. In fact, the use of water-intensive methods of power production and transportation might not be the least-cost investment even where the water resources exist.

6. Despite these reservations, and despite the complexity of the economic growth process, one could hypothesize that there is a correlation between the abundance of water resources and the long-term growth potential of economies. In order to test this hypothesis in a broad way[1/] data were collected on the water resources and GDP growth rates of 26 countries. Six variables relating to hydrological characteristics of the countries were used as proxies for the abundance of water resources. The countries selected for these calculations were chosen primarily on the basis of available data on water resources. They included 5 African countries, 11 South and East Asian countries, and 10 Central or South American countries.

7. Three variables were used to try to capture the effect of water resources on agricultural development. These were the mean annual run-off, the total mean precipitation, and the mean annual rainfall. The first two of these can be related to irrigated agriculture, whereas the third could capture the water input for rainfed agriculture. In order to correct for differences in country size the first two were scaled by the land area of the country. Analysis of variance tests (also called F tests) were conducted using these three measures of water resources and the annual average real growth rate in GDP over the period 1950-1970.[2/] The F ratios produced are shown in Table 1 where F* is the hurdle value for significance. In no case was the result significant at the 95% confidence level. This does not mean, of course, that water resources are not an important determinant of agricultural production. However, it does indicate either that (1) the variables used in the analysis were not sufficiently sensitive proxies to capture the real effect, and/or (2) other determinants of agricultural production varied across the data sample and their effects outweighed those of differing water resources.

8. The analysis should be further qualified since the extent to which the mean annual run-off and/or the total mean precipitation is actually captured and utilized for irrigation is not fully known. The analysis of the potential effect of maximized utilization on the growth of GDP has not been attempted.

9. The effect of water resources on development of the transportation sector was tested using a dummy variable which took the value of 1 if a country had at least one navigable river in or on its boundaries, and zero if it did not. The statistic obtained from this test, as shown in Table 1, also was not significant at the 95% level of confidence.

10. Two measures of water's impact on power development were employed. The first was the installed hydro-capacity for power generation (in 1968) scaled by country's GDP. This scaling was felt necessary to correct for differences in total power requirements among countries of differing economic sizes. The second variable scaled the total installed hydro-capacity by the total generating capacity of the country. Thus it represented the percentage of total power generation supplied by hydrological resources.[3/] Again, neither F ratio was significant.

11. The negative results from these simple statistical tests should not be too surprising. A simple, one-dimensional test was used because of the paucity of comparable data on water resources, and because it could supply a first screening of any important correlations. However, the influence of all of the excluded variables in such a simple analysis is obviously considerable. In addition, such a test implies that the hypothesized correlation is monotonic whereas the presence of "too much" water (e.g., Bangladesh) could be just as detrimental to development as too little. The regularity of precipitation may be more important than its average level. For all of these reasons one cannot conclude much.

1/ In fact, the inverse hypothesis of no correlation is tested by the statistical method used.

2/ This period was chosen to represent a longterm trend, undisturbed by major wars or the petroleum price increases. A better dependent variable would have been the growth rate of the agriculture (and, later, transportation and power) sector alone, but such data were not available for many of the sample countries.

3/ The average percentage for the 26 country sample was 43%. It is possible that this measure could show a perverse effect if hydro resources are developed first and the faster growing countries have already moved to thermal investment.

Table 1. Analysis of Variance Tests on 20 year GDP Growth Rate

Independent Variable	Unit	Degrees of Freedom	F	F*
1. Mean annual runoff/unit area	$10^6 m^3/10^3 Km^2$	1,14	0.05	8.9
2. Total mean precipitation/unit area	$10^6 m^3/10^3 Km^2$	1,9	0.06	10.6
3. Mean annual rainfall	m	1,25	1.03	4.24
4. Presence of major river	1=yes,0=no	1,25	0.09	4.24
5. Installed hydro power capacity/GDP	megawatts/$10^6$$	1,25	0.01	4.24
6. Percent hydro of total installed capacity	percent	1,25	1.75	4.24

12. Another way of assessing the effect of water resources on a country's development is to look at the constraining effect of the lack of adequate water on economic growth. The degree of constraint can range from the absolute - parts of the Sahara and other desert areas - to partial or relative limitation of growth for water intensive activities such as irrigated agriculture, textile industries and the like. There are recorded cases where whole towns have been abandoned by the people because ground water sources were exhausted and no alternatives were available. There are no statistical data to measure these effects but there can be little doubt about their significance on economic development.

13. Another possible way to model the impact of water on economic growth is within the framework of single sector in a particular country. If we consider, for example, the effect of water on agriculture, it is likely that the basic economic laws of diminishing returns would apply. It is difficult to measure incremental returns, but it is likely that the first units of water input would have a very high return in productive output. New water sources in the Sahel or the first small irrigation canal bringing water to the Nile Valley would probably cause a dramatic increase in agricultural production. However, as more and more water is made available, the marginal increase in output attributable to increases in water inputs would diminish. Indeed, at some stage one would expect that further increases in water would actually have negative incremental effects.

14. What are the conclusions from this discussion of water's contribution to economic development? First, that water resources are not such a uniquely valuable input to growth that a simple statistical test can pick up their influence. Rather, it is likely that in areas of water scarcity the initial enhancement of water resources can bring dramatic returns, while future water development will show diminishing (although probably positive) returns. Thus a second conclusion is that the justification for investment in water resource development should undergo the same rigid economic analysis that is necessary for investment decision-making in other sectors.

Water as a Social Good

15. An article in a recent issue of Finance and Development described the social effect of inadequate water resources as follows:

> "Insanitary living conditions have debilitating effects which lower the productive potential of people as well as the quality of their living environment. The list of diseases related to deficiencies in water supply or waste disposal is terrifying; in many areas these diseases account for almost all infant death, a large proportion of adult death, and a very large proportion of adult sickness. In Bombay, over 40% of recorded deaths are related to inadequate water supply and sanitation. It is the poor, of course, who suffer most--those in the urban slums as well as those in the rural areas. They lack information on the real effects of insanitary conditions, their access to safe water and proper waste disposal is restricted, and they can afford neither to protect themselves from infection nor to cure it." (ref. 3)

16. Minimal levels of water and waste disposal services are a prerequisite to a healthy existence. Surveys carried out in both urban and rural communities in developing countries show an almost universal top priority placed on adequate water supply by the residents. (ref. 4) While waste disposal is not generally accorded such a high priority, medical research indicates that it is an essential complement to clean water for maintaining satisfactory levels of health. (ref. 5) In the recent past increasing research efforts have been devoted to the question of how to make clean water and adequate sanitation available at an affordable cost for those who currently lack such services. Recent work carried out by the World Bank has shown that water supply service provided through standpipes spaced at 100 meter intervals can cut water distribution costs by about a factor of four compared with full in-house services.. (ref. 6) Waste disposal can be accomplished in a technically feasible and socially acceptable manner at investment levels which are, at most, half those of conventional sewer systems. Further, economies in the provision of water and waste disposal tend to reinforce each other. The introduction of less water into an environment, through the use of standposts for example, lessens the need to dispose of large volumes of sullage through expensive sewer systems. The use of low volume flush latrines avoids the large water requirements of conventional flush systems.

17. A further finding of recent research in low-cost water supply and waste disposal is that the health and environmental impacts of such investments can be maximized through the addition of "soft-ware" components to the projects. Basic hygiene education, for example, can yield a high return when provided along with the introduction of new water and waste disposal facilities into a community. Indeed, the construction of the facilities alone, without any instruction in their proper use, can result in the failure of the community to receive full benefits. The example of clean water from a communal hydrant carried home in a dirty jar is well known.

18. As is true of water's contribution to economic development, its impact on social development is also likely to exhibit diminishing returns. Available medical evidence indicates that the health benefits achieved from the provision of the first 25 to 40 liters per capita per day can be very high (ref. 7), while consumption over the level of about 80 to 100 liters per day yields very little incremental health benefit. This implies that the optimum development of a country's water resources to meet social objectives would be to provide for a relatively low level of consumption for everyone, with additional supplies available for those able to bear their full cost. In urban areas

this can often be achieved through the extension of existing systems to supply standpipe service to outlying slum areas. New production facilities should be sized to accommodate such service expansion. With urban areas in developing countries growing at the present rapid rates it is especially important that at least basic service levels be provided for the additional population, the majority of which are urban migrants.

19. In rural areas basic water and sanitation facilities often consist of improved wells and latrines. Costs increase significantly when piped water must be provided and disposed of. While self-help labor can sometimes be used to reduce construction costs, the long-term financial requirements for building and maintaining the thousands of rural water supply systems needed in developing countries are very large.

Reconciling Economic and Social Goals

20. Water resource development is expensive. In a developing country where public funds are generally in very short supply, the decision to proceed with such investment must be made after particularly careful analysis. Trade-offs are necessary not only between irrigation projects and domestic water development, but also between irrigation and industrial or between domestic water and education or health projects. The two guiding principles for water resource investment should be; first, to undertake the least-cost investment which is consistent with the achievement of economic and social objectives; and second, to place as much of the burden of paying for that investment as possible onto the beneficiaries.

21. With respect to the first principle, investment criteria for economic analysis are fairly well developed. The usual decision rule is that a project with a positive net present value (and one which is higher than that of competing, mutually exclusive projects) should be undertaken. The application of this rule to lumpy investments such as those normally required in water resource development, and where benefits cannot be meaningfully quantified, however, is difficult. The problem of benefit quantification is the most intractable. While numerous attempts have been made to measure the impact of improved water supply on health, property values, agricultural production, etc. most studies have concluded that methodological problems compromise the results.1/ The inability to measure benefits means that cost-minimization criteria will generally have to be relied upon for investment choices. However, there is the danger that while a project may be the least-cost way of meeting a projected level of future demand, there is no guarantee that the demand is at the economically optimal level, particularly if the consumer is charged a price which is much lower than production cost. Thus in using cost-minimization rules to justify investment choices, it is important to cross-check demand forecasts, production costs (long-run marginal costs) and consumer income for consistency.

22. The second principle for investment decision-making relates to tariff policies and cost recovery. The important issues in cost recovery for water supply and waste disposal projects are discussed in considerable detail in the paper by Mr. Maurice Mould on "Financing Water Resource Development." The only point which should be reiterated here is the resolution of the conflict between designing projects for maximum cost recovery from the users and providing the basic minimum services to the poorest portion of the population at affordable cost. The design of a tariff structure which cross subsidizes from larger users to smaller users is a nearly ideal solution to this problem. Since, as explained in Mr. Mould's paper, economic efficiency requires pricing water at or near its marginal production cost, there is good justification for charging marginal cost to industrial and large residential consumers. Since marginal costs are generally higher than average financial costs for water and sewerage services, such a pricing policy often generates sufficient revenue to permit charging a very low price to small volume users who are usually the poorest section of the population.2/

Conclusion

23. The development of a country's water resources is important both as an input to the economic growth process and as an element of the basic needs package which most countries strive to provide for all their population. The meagre statistical base available on worldwide water resources does not permit economic linkages to be precisely established, but it appears that agriculture, power, and transportation are the three sectors whose development can be most affected by water resource availability. As one of many economic inputs, however, water related investment in those sectors should be subjected to the same strict investment criteria as are applied to other competing investments. Water charges for irrigation, for the generation of power and for navigation should be set at levels which not only recover investment costs but also reflect the increasing scarcity (and therefore the increased future investment cost) of the resource.3/

24. The social goal of providing adequate water and sanitation for everyone to enjoy a healthy existance implies a major expansion in standpipe and low-cost sanitation facilities for most countries. In urban areas the potential for an economically efficient redistribution of income through appropriately designed tariff structures should be explored. In rural areas self-help

1/ See ref. 8 for a summary of studies undertaken.

2/ For additional ellaboration of this point see ref. 9.

3/ An exception to this policy should be made when local price distortions in competing products (such as diesel fuel for electric power or railroads for river traffic) would result in an economically inefficient utilization level if marginal costs were reflected in tariffs.

construction and the packaging of water and sanitation services with health education or other basic services with existing delivery networks may hold the best promise.

25. Most of these solutions require a creative blend of technical, economic and behavioral science expertise. The diversity of conditions in developing countries precludes all but the most general policy prescriptions. In the end it will be up to the planners and engineers in the developing countries themselves to find the proper trade-off between economic and social goals and to determine the role that investment in water resources will play in achieving them.

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