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64. This is a major constraint even in the oil-producing countries. The jobs in the petroleum industry drain off qualified manpower and leave a real shortage in water related fields. There is an acute need for trained manpower throughout the Middle East and this is being felt in all areas, including the field of water resources.

(c) Water use regulations

65. Because of the lack of water use legislation in most countries, there is a minimum of water use regulations in effect. What regulations are being applied are usually locally oriented and are based upon custom rather than law. Water being in short supply almost everywhere has caused over the years a system of regulation handed down from past generations. As a policy instrument water use regulations could go a long way toward solving some of the water problems prevalent today. It seems that self imposed regulations are used more for drinking water than for other uses. This probably comes from the old moslem customs of giving drinking priority over agricultural and other uses, since drinking water is the most critical in many areas. In many areas wasteful agricultural irrigation practices are allowed when it is known that water resources are declining toward dangerous minimums. The custom of hauling water by tanks is giving way to piping water into homes. Testing of water can now be done at central treatment points which should give greater control and regulation over such use.

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UN Water Conference, Mar Del Plata  
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PRICING AS A MEANS OF CONTROLLING THE USE OF WATER RESOURCES\*

Prepared by: J. J. Warford

March 31, 1976

I. Introduction

As urban and agricultural communities exhaust convenient sources of water for domestic, industrial and irrigation purposes, and have to go further afield for additional supplies; as sources of hydroelectric power become scarcer and more difficult to exploit; and as surface and ground-water pollution increases, unit costs of water resources can be expected to rise. This necessitates efforts to ensure that ever scarcer water resources are not used wastefully. An important means of doing this in an economy in which market forces are allowed to operate is to apply pricing policies that reflect, not the historic costs associated with supply of water-related services, but the real resources costs that are incurred as a result of additional consumption. If consumers are willing to pay prices reflecting real resource costs, it will be demonstrated that those costs are worth incurring, or, alternatively, that additional supplies will not be used wastefully.

This general objective is necessarily subject to a number of constraints. The choice of the appropriate pricing policy in any particular case will involve judgements about equity and income distribution, about its financial and fiscal implications, and about the cost of implementing the pricing system itself.

This paper will discuss the role of pricing in a number of contexts related to water resources, namely electric power (since pricing of hydro resources cannot be dealt with in isolation); water supply; irrigation; and water pollution. In each case, the costs which are relevant for the aim of influencing consumer behavior by pricing policy are the value of the resources which are made unavailable for other purposes by being devoted to the supply of water, whether for direct consumption or for the generation of power, or for irrigation. Sunk costs are thus irrelevant and it is the costs of future system expansions which matter; engineering cost estimates rather than historical accounting costs are

\* This report, prepared by J. J. Warford as a supporting document for the Conference at the request of the World Bank, expresses the views of the author and not necessarily those of the World Bank. The report should be considered complementary to the paper entitled "Policy options" (E/CONF.70/CBP/3).

therefore needed. The aim is to reflect these costs in the charges which affect user choices. Subject to problems of measurement, of income distribution, and of equity, this would require, for example:

- low charges when additions to capacity can be provided cheaply;
- an incentive to reduce the strength of industrial effluents when this would lead to savings in treatment cost or a desirably improved standard of treated effluent from sewage works;
- a greater incentive to reduce water or electricity consumption in summer in cases where capacity and hence costs are predominantly summer-use related.

The basic notion is thus that charges which vary with the use of the system should reflect the rate of change of system costs with respect to volume. This is what is meant by charges which reflect "marginal" costs. It will, however, be observed that because new water resource development projects are often large and complex, and because investment programs often combine the purposes of reinforcement, extension and replacement, a refined analysis of marginal costs may not be possible. But this need not deter planning engineers from deciding what sort of incentive structure would have to be provided by the charging system for it to convey a sensible message to users. Exact calculations are not required; the point is to reflect the approximate order of magnitude of the costs of system expansion in the charges which vary with the amount of use of the system. This notion of simultaneously informing and inducing beneficiaries to economize most when economy on their part would do most to save scarce resources is, however, easily confused with the entirely different notion of allocating costs between consumers. An example will make this clear. Suppose domestic water consumption is closely related to property values. Then a fixed charge related to property value would approximately allocate costs between consumers according to consumption. Yet the incentive effects would be zero, since no consumer would save money by using less water or be charged more if he used more. Thus whatever the fairness or unfairness of such charges, they would do nothing to realize the objective of influencing user behavior.

Practical implementation of the principle that efficient resource allocation is assisted by charging according to marginal cost is subject to a number of difficulties. Common to pricing of all water related activities are problems of allowing for income distributional consequences, financial and fiscal considerations, and treatment of price distortions in the rest of the economy. While the degree to which these problems arise varies to some extent according to the type of water use being considered, one other difficulty, namely, the set of practical problems of measuring the marginal cost of water-related activities; of charging beneficiaries in such a way that they are given an incentive to equate -- at the margin of use -- the costs of service they receive to the benefits they derive; and of excluding non-payers from using the service considered; allows a convenient distinction to be drawn between pricing as related to:

- (a) municipal water supply and electricity;
- (b) irrigation;
- (c) water pollution.

In the case of water supply and electric power, where it is relatively easy to identify users and to exclude non-payers from service, measurement -- or metering -- of consumption so that marginal costs can be attributed to users is the norm although as will be shown, there are a number of exceptions to this rule. On the other hand, metering (and therefore charging on the basis of use) of water for agricultural irrigation, has been, and probably will continue to be, the exception rather than the rule, largely because of the difficulty of excluding non-payers from supply. In the case of water pollution activity, the establishment of effluent charges confronts a peculiar set of problems; these include not only the difficulty of measuring the marginal costs to society that result from water pollution, but also the problem of attributing even the physical consequences of pollution to individual waste dischargers.

As used in this paper, the concept of marginal cost refers to "opportunity cost," i.e. the value of goods and services that are foregone because of the employment of economic resources. This is a particularly relevant concept in the water resources field, in which, for example, the opportunity cost of an additional thousand gallons of water used for irrigation might be the value of that water if it were instead used for residential consumption.

## II. Municipal Water Supply and Electricity

Application of economic pricing rules to hydroelectric power requires consideration of pricing of electric power in general. Since similar principles apply to the role of pricing in municipal water supply and electric power it is convenient to discuss the two sectors under one heading.

In practice, pricing of municipal water supply and electric power is generally dominated by financial considerations, in particular by the need to maintain tariffs at levels that will help finance the large capital requirements of continually expanding systems; and also by a questionable accounting approach to the design of tariff structures. Other objectives, however, also need to be incorporated into pricing policy to respond, for example, to the following kinds of questions: How fast should expansion be? How should output be divided, say, between industry and homes and between rich and poor? How can capacity be more fully utilized? The answers to these questions require a broader approach to pricing policy than traditional practice.

The traditional accounting approach is concerned with the recovery of sunk costs, whereas for efficient resource allocation it is the amount of resources currently used or saved by consumer decisions which is important. Prices are the amounts paid for increments of consumption and, social objectives aside, they should therefore be related to the increments of cost thereby incurred. If new consumers are connected to the system, or if existing ones increase the amount of power or water they use, it is important that prices should signal to consumers the costs of such changes in their consumption. Hence prices need to be related to the value of resources used (or saved), and the valuation of these resources (the estimation of their costs) requires a forward-looking estimate. The backward-looking estimate of the accounting approach creates the illusion that resources which can be used or saved are as cheap or as expensive as in the past; that is, that resources are as abundant or as restricted as in the past. On the one hand, this may cause over-investment and waste; and on the other, under-investment and unnecessary scarcity.

The traditional accounting approach to pricing is preoccupied mainly with average costs, so that large discrepancies often appear between the structure of prices and costs. This (1) generates large cross subsidies and (2) often results in prices too low when demand is high, and too high when demand is low. To promote better utilization of capacity, and to avoid unnecessary investments to meet peak demands (which tend to grow very rapidly), it is often useful to structure prices so that they vary according to the costs of serving demands:

- of different consumer categories;
- in different seasons;
- at different hours of the day; and
- in different geographical areas.

Another shortcoming of the traditional approach is that it considers "fairness" from the rather narrow point of view that consumers should pay for the share of accounting costs allocated to them. As just explained, these costs may very well differ from the costs which consumers are currently causing the economy, and such cost allocation involves (often arbitrary) judgements. However, the cost allocation per se is neither fair nor unfair; whether tariffs are fair depends on who is required to pay them. While questions of fairness and the need to raise sufficient revenue to permit system growth are relevant for tariff making, separate analysis of these aspects is necessary.

The foregoing suggests that if price is to be used to signal the economic justification of investment (social matters are discussed later), the traditional approach to tariff setting has to be replaced by one that allows price to reflect the cost of the resources used up in making additional consumption possible. This would permit consumers to reveal, ex post facto, whether the value that they place upon additional output at least equals the additional (or incremental) cost of a water or power system, thus signalling the justification of investment in additional capacity. This policy requires, inter alia, that differences in incremental costs attributable to different consumers or types of consumption should be reflected in the prices charged. This may include variations in costs of supply according to the geographic location of consumers, or to the time pattern of consumption.

If it is impossible, in practice, to establish price in the foregoing manner, economic justification of a project is made very difficult, the benefits of such investments normally being impossible to quantify by any other means than direct observation of consumers' willingness to pay. If price is less than the incremental cost of expanding a power or water system, there is no evidence as to whether or not consumers would pay for it if they were given the choice. On the other hand, if price is greater than incremental system cost, demand may be unnecessarily restricted, and the project smaller than optimal; how much smaller is however unknown. Moreover, even if on average, prices equal incremental system costs, project justification will not be automatically signalled by consumer behavior if differences in the cost of various types of consumption are not recognized in the tariff structure.

There are, however, a number of practical difficulties that confront us in attempting to rely upon pricing policy as a better means

of signalling the justification of investment. These include:

- (1) Cost of Implementation - Pricing itself may be costly. For example, the cost of special metering of domestic consumers to distinguish peak from off-peak electricity consumption may be greater than the benefits. Metering of domestic water supplies is often rejected on these grounds. Furthermore, price changes themselves may be difficult -- and costly -- to implement.
- (2) Fiscal and Financial Constraints - Public Utilities may be an efficient means of raising revenues for general governmental purposes. The gains from taxing them should therefore be weighed against or reconciled with the objective of using price to determine the justification of system expansion. Similarly, the financial viability of the public utility could conceivably be at odds with the approach to pricing described here, and reconciliation may be necessary.
- (3) Externalities - Benefits from incremental consumption may accrue to parties other than those who pay. As an example of such an "external" effect, the health of X may improve as a result of Y connecting to and using a public water supply or sewer system: Y's willingness to pay might therefore be expected to be an underestimate of the total benefit to society that results from his action.
- (4) Social Objectives - As the pricing concept is related to an effective willingness to pay, it depends in part upon the pattern of income distribution in a particular society. Thus, the very poor may lack an effective willingness to pay for water from a public supply, but they should not therefore be denied access to service. In other words, social objectives often are in conflict with the policy of allocating resources in accordance with willingness to pay, and appropriate adjustments to prices are necessary in these circumstances (in the absence, of course, of any measures to deal with the social objectives in more effective ways). Providing the service to the poor will then involve cross subsidization either by other consumers or by general taxpayers in the municipality itself or the country at large. Subsidies and taxes should be made explicit and justified in the overall assessment of the pricing policy for the service.
- (5) Shadow Values - In estimating the least cost means of developing water resources, and in estimating marginal cost, it may be necessary to substitute, for financial costs, the true economic costs to society. Economic and financial costs may diverge, for example, when labor that would otherwise be unemployed manage to command nationally legislated wage rates; where local currencies are maintained at artificially high exchange rates; and where

taxes and subsidies are significant elements of the cost of water resource development.

- (6) Forecasting Problems - Investment decisions will certainly be assisted by pricing according to marginal cost, differentiated by classes of consumer, etc. However, evidence as to consumers' willingness to pay a price for a service at a given point in time does not entirely remove the difficulties of predicting demand, which will in subsequent years be influenced by a number of variables, including changes in income, population movements and tastes. It goes without saying that forecasting of costs is an equally hazardous occupation.

Reconciliation of the various objectives of pricing policy -- efficiency in the allocation of resources, financial, fiscal, income distributional and other social goals -- may be a complex task. While tradeoffs between the various objectives may often be necessary (being reflected, for example, in tariff structures which allow poor consumers to obtain a basic supply of water for health purposes at a subsidized rate, while wealthier consumers pay more than cost), it remains true that pricing according to incremental or marginal cost remains the most direct and practical method by which reasonable resource allocation can be achieved. In a well functioning private sector, prices are determined by market mechanisms. In the public sector, prices are determined by regulation. However, by attempting to reflect the level and structure of costs in tariffs, utilities also can secure an efficient use of resources; where necessary, they can adapt those tariffs to achieve social goals and mobilize resources for expansion.

### III. Irrigation

Several methods of cost recovery for irrigation projects are employed, often in combination. Desirable forms are those that satisfy the following requirements: (i) they should have the power to discriminate between a project's direct beneficiaries and non-beneficiaries; that is, between water users and non-users; (ii) they should either guide the efficient allocation of resources, or be neutral or, at worst, interfere as little as possible in this regard; (iii) at least one instrument should have the capacity to permit progressive rates of charges, and the others should not be regressive to the point of cancelling the overall capacity of charges to be progressive; and (iv) they should be fair, in the sense of requiring users who are equally poor or equally rich to pay the same charge for the same benefit or service.

#### Discriminatory Attributes

Income taxes, taxes on consumer goods and most production taxes (taxes on farm inputs and outputs) tend to affect project users and non-users equally. Alteration of these tax rates for cost recovery purposes, therefore, would fail to put the burden of recovery on project beneficiaries. This limits us to considering the following types of charge:

- (a) Unit prices for water.
- (b) Charges against specific irrigation contracts; for example, charges per acre of crop irrigated (crop rates)

- (c) Betterment taxes against command land.
- (d) Any other production taxes, mainly indirect, which are highly discriminatory between project users and non-users; for example, a surcharge on marketings of output through project marketing boards.
- (e) Any discriminatory income transfers from project users to domestic consumers as a result of commodity pricing policies.

The first three types of charge are completely discriminatory. The fourth and fifth raise difficulties, however, because the few examples that arise are not always project-specific. If reasonably specific to the public irrigation sector -- as has probably been the case for instance with rice export taxes and related domestic pricing policies that favor consumers at the expense of producers in Thailand -- it is probably necessary to analyze the burden of general taxation within society as a whole, to see if this sector is being discriminated against overall; without such analysis, the relevance of the fourth and fifth instruments for water charge policy may still be unclear.

#### Efficiency Attributes

Contractual obligations to pay water prices and crop rates are entered into by users in return for specific arrangements for the supply of water. In contrast, obligations to pay land and other production taxes and discriminatory prices are linked only indirectly with water supplies. This helps to explain the varying potential of the five types of charges for influencing water use.

The most effective means of influencing water use through charges is to price it; this involves volumetric metering and, ideally, frequent market-clearing quotations (efficiency pricing) and related sales. A market-clearing price seldom has any relationship with any of the accountancy concepts of project costs, such as O&M costs, and it is difficult to determine without a market. Good conditions for pricing water at market-clearing rates arise in the disposal of surplus water from private pumping schemes and tubewells; where the volume of water delivered can be assessed fairly accurately public authorities might copy these practices in public tubewell and pumping schemes. But such conditions are seldom met anywhere in major canal schemes. Metering and sales at fixed, frequently nominal prices are found in major canal schemes in developed countries, but metering is rare in developing countries, partly because of the much larger number of meters required (smaller holdings). Nevertheless, even nominal prices for irrigation water serve some aspects of an efficiency objective; they offer users incentives to eliminate the conspicuous waste and over-watering that occurs when water is treated as a free good. If metering is too costly, some gains in efficiency are still obtainable, but currently not availed of in developing countries, from issuing users with negotiable rights to assured supplies in the event of water scarcity.

Crop rates can distort cropping patterns if their structure is not set properly. In certain cases, avoidance of distortions requires setting rates in proportion to the expected water consumption needs of crops. Crop rates may also deter irrigation altogether if their level is set close to the expected pay-off from irrigating a crop. Similarly,

land taxes, payable whether irrigation facilities are used or not, can affect water use if set high enough, but then only indirectly, by forcing out of business inefficient, inept irrigators. Hence, both land taxes and crop rates can contribute favorably to water management, under certain conditions, in the absence of efficiency pricing. For the most part, however, the real task of promoting water use efficiency, in the absence of efficiency pricing, falls to physical rationing; in fact, rationing is generally the sine qua non of most systems of public water distribution.

Indirect production taxes on water users are a potential cause of resource misallocation, because they tend to discourage the use of the factors taxed. <sup>1/</sup> Hence, the more effective these taxes are as recovery instruments, the more likely it is that they diminish a project's worth.

#### Distributional Attributes

Progressivity means that users having a large "capacity-to-pay" should pay proportionately more than others. By their nature, land taxes are the most robust means of effecting progressivity of recovery. Since a user's capacity-to-pay (net of other water charges) will be reflected in the value of his land, the most appropriate base for a land tax is the increment in the total unimproved value of command land attributable to the project. A distributionally neutral tax in this case is a flat percentage rate. Hence, a progressive tax schedule requires rates to increase directly with the size of the tax base. (Naturally, the impact of land betterment taxes on land values also needs to be anticipated in the tax formula; although not covered here, this impact is not difficult to analyze).

Because the potential of poorly constructed crop rates to misallocate water increases with their level, and because the area of a single crop is a poor measure of user wealth, crop rates are probably a poor vehicle for making charges progressive. In any case, legal responsibility for crop rates may fall on share croppers and tenants, not landowners. If implemented in pursuit of efficiency objectives, water prices offer no opportunities for progressivity. Rather, they favor owners of the most productive resources. Revenues and income transfers resulting from production taxes and pricing policies vary with the amount of input purchased or output sold. Although these taxes therefore bear only on traded surpluses and may be progressive in that weak sense, the impact of production taxes and pricing policies on user income distribution is judged rather neutral. As with water prices, however, recovery by production taxes or discrimination against users through pricing policies diminishes the capacity of all other instruments of recovery (for example, land taxes) to be progressive.

#### Fairness

Users also have a say in determining which policy instruments are effective. They generally resist charges that recover the same amount for unequal services, unless the justification for this is clear. For example, a common set of crop rates is usually legislated to apply to all public irrigation users irrespective of location. Yet the quality of irrigation services can and does vary widely within a command and between projects. Such charge systems are basically unfair, and this is one reason why crop rates tend to be fairly nominal. When significant

<sup>1/</sup> Land betterment taxes are an exception, because the supply of command land is not responsive to the tax.

levels of recovery via crop rates have been tried, they have frequently generated considerable political opposition from those treated unfairly.

Significant recoveries from irrigation projects may be possible only if (i) user charges that are linked to the amount of service provided, such as crop rates, reflect accurately the expected amounts and timing of water deliveries; and (ii) the tax base for charges that are independent of the amount of service provided, such as land betterment taxes, reflects accurately the size of potential rent conveyed.

#### IV. Pollution Control

Control of water pollution may be by means of a system of regulations and licenses to discharge wastes subject to certain standards, or by a system of charges related to the costs caused by the polluter, or by some combination of the two.

Under a system of effluent charges, a fee is levied on the use of publicly-owned environmental media for the disposal of wastes. The amount of the fee is based on the total load of the harmful pollutant discharged. This method has certain advantages over methods of control that call for uniform standards. For example, if a decision is taken to achieve a given level of reduction in effluents for some particular watershed, a unit effluent charge, at the proper level, will achieve the desired reduction at a lower total cost to the economy than a regulation calling for uniform reductions in levels of emissions or setting uniform quality standards. This is so because an effluent charge, unlike a uniform regulation, will induce the greatest reduction from those enterprises which can accomplish the reduction most efficiently. Self-interest in maximizing profits will lead each enterprise to invest in process changes or effluent treatment up to the point at which the cost of a unit reduction in effluent is equal to the amount of the charge. Producers with different cost characteristics will, therefore, respond differently. Uniform regulations, on the other hand, require a uniform response regardless of the cost to the individual enterprise.

International experience with effluent charge systems is limited. Several European countries, among them France, Holland, Czechoslovakia, the Federal Republic of Germany and the United Kingdom, which have employed license systems, have replaced or supplemented these systems with effluent charges, or are considering doing so.

Because absorptive/regenerative capacities, and, therefore, the harm caused, will be different for different water basins, an effluent charge should be set on a regional basis. The level at which the charge is set is critical. In principle, the rate per unit of discharge should be equal to the estimated cost to society of an additional unit of pollutant discharged. While the informational difficulties involved in achieving this result are immense, it should be noted that such an estimate would also have to be made to rationalize a system of regulation. While determination of an ideal level of effluent charge may be beyond the current state of the art, several methods have been proposed for arriving at rough approximations of the proper charge.

The question is whether an inexact level of effluent charge is more, or less, acceptable than an inexact effluent standard. With the "wrong" level of charges, the level of effluent production will be higher or lower than the target. The reduction that is achieved, however, is achieved by means of the "least cost" procedure. Furthermore, the

level of charges may be raised or reduced over time to bring results in line with the target. If a uniform standard is adopted, whatever the standard, it can be shown to be inefficient with respect to particular enterprises with differing marginal costs. Individually adjusted standards avoid the latter difficulty but, as noted above, the informational requirements and the administrative machinery necessary to set the individual standards and to avoid claims of discrimination may be overwhelming.

Where environmental pollution is excessive, and the first steps at improvement are being taken, the appropriate remedies for a particular industry may be obvious both to the regulatory agency and to the industry. In such cases, there may be no great difference in result between a system of individually specified standards and a system of effluent charges. As the desired level of environmental improvement rises, however, marginal costs typically increase in a sharply non-linear fashion and the case for a rigorous system of charges becomes stronger.

Finally, an advantage of an effluent charges system is that it may be a source of funds for certain environmental improvement works that are most efficiently carried out by the public sector. In the water pollution field, for example, economies of scale may be reaped in collective treatment works, while artificial aeration, sludge removal and low-flow augmentation would normally best be carried out by a public authority.

#### V. Conclusion

Common to the pricing of all water-related consumption discussed in this paper are problems of resolving potential conflicts between the various objectives of pricing policy. The role of price stressed here is that of influencing consumer behavior, of reducing "wasteful" use of water, or of achieving a sensible degree of water conservation. Generalizations about the practical feasibility of incremental cost pricing are therefore difficult to make, but estimation of incremental costs, either as a basis for establishing price, or as a benchmark by which to evaluate social or other goals is clearly an important element of water resource management.

## WORLD BANK

### AN APPROACH FOR SELECTION OF LABOUR- VS. CAPITAL-INTENSIVE TECHNOLOGIES FOR WATER RESOURCE DEVELOPMENT PROJECTS\*

#### I. INTRODUCTION

1. In recent years there has been an increasing awareness in most developing countries of unemployment and underemployment problems in rural areas. It is generally agreed that productive employment opportunities must be created in these areas for large segments of population to foster economic development with distributional equity. Efforts are being made at the national and international level to explore employment generation potential in several different sectors and subsectors. Attention has been particularly focused on civil works which generally account for a large and visible portion of government expenditure. Work now being carried out by the World Bank <sup>1/</sup> and the International Labor Organization <sup>2/</sup> is attempting to establish the technical and economic feasibility of alternative labor-intensive technologies for civil construction, with particular emphasis on the development and introduction of appropriate technologies. <sup>3/</sup>

\* This report, prepared by Inder K. Sud as a supporting document for the Conference at the request of the World Bank, expresses the views of the author and not necessarily those of the World Bank. The report should be considered complementary to the papers entitled "The promise of technology: potential and limitations" (E/CONF.70/CBP/2) and "Policy options" (E/CONF.70/CBP/3).

- <sup>1/</sup> The World Bank studies are being carried out within the framework of the Study of the Substitution of Labor and Equipment in Civil Construction (henceforth the World Bank Study).
- <sup>2/</sup> The ILO's work is being undertaken under the general auspices of the World Employment Programme.
- <sup>3/</sup> The term "appropriate technology" is invariably used in the literature to mean a technology that is optimum from a social point of view. It is generally implied, however, that it is a productive labor-intensive technology which is economically efficient compared with modern equipment-intensive methods. In this paper, all references to labor-intensive technology are presumed to mean appropriate technology.