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IMPLICATIONS OF U. S. EXPERIENCE FOR WATER RESOURCE PLANNING IN EGYPT

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1. Introduction

The history of Egypt is inextricably tied to the Nile. The river is the lifeblood of the country, providing many economic services as well as being a unifying force for the nation. The multiuses of the waterway for such activities as navigation, hydroelectric generation, fisheries, recreation, municipal and industrial uses, and irrigation emphasize the need for a systemwide approach to water management. All of the authorized water available from the Aswan High Dam (55.5 billion m^3) was being used by Egypt in 1974, but it is believed that the quantity of water would not be a constraint in the foreseeable future if delivery systems were made more efficient, irrigation methods were based on a comprehensive water management program, and there was more recycling of drainage water.[1] Although the quantity of water may not be a systemwide constraint, there may be problems between and within sectors as to the amount, timing, and quality of the water provided. It appears that water quality could be more of an issue than water quantity for the next 20 years.

1.1. Water Quantity and Quality

Both the quantity and quality of the resource at any point is highly sensitive to changes throughout the river basin, especially points upstream.

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[1]Egypt is expected to have 64.5 billion m^3 available by 1985 (USDA).

It is a linear system, so water quality can be severely deteriorated by many sources. The river has been used as a dumping ground for effluents, and its carrying capacity for certain materials will soon be exceeded. There have been significant increases in the types and amounts of algae and coli bacteria as well as greater turbidity and more oil spills. In urban areas, sewerage is provided without charge, and there have been no major prohibitions on the types of effluents allowed. This is a classic externalities problem. Inadequate treatment facilities for both municipal and industrial wastes have resulted in large quantities of effluent-filled water not being returned to the system.[1] The aphorism, "one river, one problem," is quite applicable. Since agriculture accounts for most of the consumptive use of the Nile waters, that sector's efficient use of the resource is critical.

Egyptian agriculture historically depended on the annual flooding of the Nile River to provide irrigation water, the leaching of salts from the soil, and the deposition of nutrients from the silt. With very low average rainfall, irrigation is essential to the growing of crops.[2] The farmers along the river developed their cultivation techniques through centuries to adapt to the available resources, but the inherent uncertainties surrounding the extent of annual flooding substantially limited the potential productive capacity of the Nile Valley.[3]

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[1]It is estimated that improved treatment would result in an additional one billion m^3 being available for reuse by the year 2000 (USDA).

[2]Average rainfall is near 0 inches at Aswan to 8 inches in Alexandria (USDA).

[3]The average annual maximum and minimum daily flows of the river recorded at Aswan were 750 million and 50 million m^3, respectively (USDA).

1.2. Water Distribution

Recent changes, especially the land reform movement and the completion of the Aswan High Dam, have radically altered the methods of agricultural production.[1] The year-round availability of water meant that more crops could be grown and more land could be used for agriculture. Irrigation allowed uniformity of both quantity and quality of output. Since a wider variety of crops could be produced, farmers had the potential to respond more readily to changes in the market demand for crops. Perennial irrigation became the primary method, while traditional basin irrigation was largely discontinued. This expanded the multiple-cropping capabilities on all lands. However, traditional methods continued to be used to bring water to the field. A network of low dikes formed small basins into which water is delivered by small ditches. Draft animals supplied most of the power for both field and harvesting operations. There are several major problems inherent with such methods. Most farms are less than 5 feddans (approximately 5.2 acres), and the fields are crisscrossed with drainage ditches which precludes the use of large machines. Also, the amount of water actually delivered to the crop may be quite uneven depending on the amount of flow and uneven ponding depth. Irrigation practices did not keep pace with the rapidly changing needs, and the impact of the ensuing problems occurred much sooner than predicted. Irrigation efficiency is only about 50 percent which is quite low for a river system such as the Nile.[2]

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[1]It became possible for Egypt to control the daily flows from their share of the 84 billion m^3 average annual flow. Flow patterns could be regulated to meet policy goals (USDA).

[2]A well-planned irrigation system is expected to be about 80 percent efficient (USDA).

The lack of an adequate drainage system contributed to the loss of productivity due to rising groundwater levels and increased soil salinity on about 80 percent of the old lands.[1] Unfortunately, as the drainage systems are completed, there will be a marked increase in salinity downstream. Drainage water with high-salinity concentration is pumped directly into the sea resulting in large pumping costs and the loss of a great deal of water from the system.[2] Many of the drainage problems have been magnified due to poor water and soil management practices. There were no agricultural extension workers at the village level which slowed the transition to more appropriate techniques. As the quality of water deteriorates, it is expected that farmers will shift their cropping patterns away from water-consumptive plants, such as sugarcane, as well as away from crops sensitive to saline water.

1.3. Government Policy

The government in the past has made the cropping pattern compulsory, but there have been recommendations that individual farmers be allowed to choose the pattern based on economic incentives and the quality of the land. The government price controls on crops presently distort such incentives. It appears that the current policy is to provide inexpensive food supplies to the urban population at the expense of farmers. Agricultural prices are geared to help the government raise revenues. In 1978, the net economic transfer from

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[1]"Old lands" refers to the Nile Valley downstream from the Aswan High Dam to Cairo and the Delta downstream from there (USDA).

[2]In 1974, about 6 billion m^3 of saline drainage water was pumped into the sea (USDA).

cotton-producing farmers to the rest of the economy was estimated to be LE373 million per year.[1] The farmer received less than 60 percent of the international price for wheat in that year.[2] Policymakers must clearly understand the trade-offs between production efficiencies and social programs. The economic effects of price controls and crop quotas on government objectives should be compared with different combinations of market and nonmarket activities.

Without the deposition of silt, nutrient losses must be replaced with fertilizers. There has been chronic overuse of these chemicals which has contributed to water degradation.[3] The amount of fertilizers to be used on a crop is determined by the government and allocated by the cooperative system.[4] Overfertilization implies that the farmers obtain chemicals outside the official distribution system which, in turn, may indicate a lack of confidence in the decision-making process. Proper irrigation, drainage, tillage, and fertilization techniques could increase yields substantially in the old lands.[5] These areas, which are primarily Class I, II, and III lands, offer the largest opportunity for productivity gains.[6]

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[1]Approximately $954.8 million (World Bank).

[2]World Bank.

[3]World Bank.

[4]Cooperatives have not been farmer-oriented organizations. They enforce crop rotations to assure a quota supply and provide a means of collecting payments in kind for inputs.

[5]It is estimated that yields could increase as much as 30 percent for field crops and 500 percent for some vegetables (USDA).

[6]The productivity classes are based upon the economic and agronomic properties of land according to soil-profile properties, availability of water, present productivity, and the cost of management.

Currently, agriculture is the largest sector in the Egyptian economy.[1] There is a need for a more coordinated infrastructure to support productive rural development. A marketing system, a credit market, and a price structure for both inputs and outputs are needed which offer the proper incentives for the efficient use of resources and disposal of wastes. Currently, resources are diverted from agriculture to industry. The proportion of agricultural public investment as a proportion of total public investment has fallen from 25 percent in the 1960s to 8 percent in the 1970s. Of this amount, 31 percent will be spent on drainage problems and 28 percent on reclamation.[2]

The results from the development of new lands have been very disappointing. Only half of what was reclaimed is cultivated, and half of that is below the point where variable costs are covered.[3] The main problem surrounding these projects is that the soil is primarily of Class IV which has severe limitations for crop production.[4] Coupled with inefficient irrigation practices and inadequate drainage leading to salinity and waterlogging, the less fertile soil is not likely to produce yields comparable to those from the old lands. Such factors restricting the addition of good cropland serves as a primary constraint for the horizontal expansion of productive farming.

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[1]Agriculture contributes 30 percent to GNP and employs 45 percent of the labor force (World Bank).

[2]World Bank.

[3]More government jobs have been created than long-term employment for farm families (World Bank).

[4]Of the undeveloped land studied to find suitable new acres for irrigation, only 13 percent was found to be Class I or II (USDA).

1.4. Ministry of Irrigation

The Ministry of Irrigation is known as the "master of the tap." It controls releases downstream of the Aswan High Dam and is responsible for the planning, construction, and operation of the major distribution system throughout the country. The large capital expenditures needed to build, operate, and maintain the canal system have been handled by central planning. Concentrations of capital and technical labor are not available at the local level. However, distant bureaucratic control of distributional arrangements can be inconsistent with the objectives of farmers to control their own destinies. Local control is needed for efficient distribution to the laterals and to the individual farms.

Water is provided by a rigid system of distribution; rotation requires that the farmer receive the water at fixed intervals which does not necessarily coincide with the consumptive needs of the crop. This method of distribution also locks the farmer into a surface system of irrigation which precludes switching to such technologies as sprinkler or drip. At present, there does not seem to be an institutional mechanism through which small landholders can take responsibility for the repair of the distribution and drainage system. The flow in a canal can be greatly reduced without the yearly removal of silt, water plants, and debris. Before the land-reform movement, large estate owners would assume the responsibility for maintenance if it were not done by the central government.

1.5. Water Rights and Pricing

The operation and maintenance expenses for the delivery or drainage systems are not tied to the price of the water. The only price that a farmer pays for water is the cost of lifting it from the canals to the farm ditches. Rights for the quantity of water are not assigned so that, once the water is flowing in the lateral, any farmer can use as much as they can remove. This has resulted in widespread "overirrigation" of up to 40 percent.[1] The farmer at the end of the ditch could well find himself without water. Also, there are no rights designated for the quality of the resource, so downstream irrigators are not compensated for the damage caused by upstream uses.

1.6. Groundwater Reserves

In addition to the Nile River, Egypt is blessed with extensive groundwater reserves. The Western Desert region is underlain by a substantial aquifer system.[2] Pumping, however, has proven to be very costly. High pumping costs can severely restrict the variety of crops that can be profitably irrigated. There are also problems associated with extensive groundwater mining such as falling water tables and subsidence.

The Nile Valley and Delta groundwater reservoirs are recharged primarily from seepage from the Nile River, canals, and irrigated fields. Consequently, surface contamination can directly affect the quality of the groundwater resource. Presently, there is a great deal of inefficient loss of surface water to the groundwater supply, but much of this water could be recaptured for use through proper management. The vastness of the groundwater reserves adds significantly to the total water stock of Egypt, but this resource has not been efficiently exploited.

Traditionally, wells were drilled to supplement the river water during periods of low flow. The demand for such wells has fallen since the opening of the Aswan High Dam. Groundwater is presently used for domestic water and to supplement the supply in outlying canals.[3] However, domestic use is often

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[1]USDA.

[2]The New Valley is thought to have a potential recovery of 234 billion m^3 with a low concentration of dissolved solids (USDA).

[3]In 1974, only about 350 million m^3 of groundwater was used (USDA).

inhibited due to the brackish or high mineral content of the well water.[1] The greatest potential for groundwater use is to reduce the salinity concentration in downstream waters and to ensure adequate flow in the peripheral ditches.

2. The U. S. Experience

The average farmers in western America work larger plots than their counterparts in Egypt. They also depend on machines rather than animals to do their heavy work. Despite the seeming differences between modern and ancient agricultural practices, there are many similarities between the two countries. Water played a crucial part in the development of the western United States. This relatively recent experience can serve to illustrate many of the problems in Egypt as well as some of the possible solutions.

The U. S. experience with irrigation has resulted in a variety of distribution systems, each one of which has evolved from differences in geography, weather patterns, and the cultural conditions of early development. The range of operating systems from which a community of irrigators could choose in order to gain its objectives was determined by available technology. The common thread among them, however, was that continual operation of irrigation distribution systems proved to be more successful when performed by farmers' cooperatives. Each system involves complex relations among individual farmers which can lead to conflicts. In most instances, conflicts have been effectively resolved especially when the controlling organization has had the confidence of the farmers. There seems to be a direct correlation between the strength of a local irrigation organization in developed regions and the community's success in stabilizing growth. Limits to growth offer security to

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[1] World Bank.

the members and have been typically accomplished by imposing water rights based on prior appropriation in some form. There is a recognized trade-off in the community between equality of all acres and the priority of these acres in terms of time of initial irrigation. The desire to have a policy which fulfills both equity and efficiency goals is often not satisfied, however.

The beginning of irrigated agriculture in states such as California, Colorado, and Utah forced the abandonment of the English code of riparian rights which had worked well in the temperate East. Water rights in the West were based largely on prior appropriation. Water was an emotional issue, so rational discussion was often difficult. This is expressed eloquently in the poem by K. E. Boulding:

> Water is far from a simple commodity,
> Water's a sociological oddity,
> Water's a pasture for science to forage in,
> Water's a mark of our dubious origin,
> Water's a link with a distant futurity,
> Water's a symbol of ritual purity,
> Water is politics, water's religion,
> Water is just about anyone's pigeon,
> Water is frightening, water's endearing,
> Water's a lot more than mere engineering,
> Water is tragical, water is comical,
> Water is far from the pure economical,
> So studies of water, though free from aridity
> Are apt to produce a good deal of turbidity.

Despite such problems, systems of water allocation were developed to meet the irrigation needs of the West.

2.1. Illustrative California Experience

To illustrate the experience of the United States in specific terms, we shall briefly examine the Kings River area of California. This area was developed by land speculators using the colony method of settlement.[1] Corporate capital was used to acquire water rights, build diversion dams, canals, and a system of laterals, and control structures to supply irrigation water to each tract of land. An important feature of the colony system was the permanent transfer of water rights to small tracts. Since profits were made primarily in selling the developed land, the private companies were not interested in administering the irrigation system. Hence, an irrigation system evolved which was controlled by a public irrigation district with the ability to raise operating funds on the basis of assessed valuation (even of those lands not irrigated with that water). The state certified the tax-exempt bonds issued to cover capital expenditures. The water was also apportioned on the basis of the valuation with the owner then having the privilege of selling some or all of his entitlement. This alienation of water from the land was felt to make the system more equitable. The district was given the right to refuse service to users who wasted water willfully or carelessly because of defective ditches and structures or because of inadequate preparation of their land for irrigation, but this right was seldom exercised.

A rotation schedule was prepared at the beginning of each irrigation season with some districts being more rigid than others in the scheduling. Farmers would supplement this supply with groundwater pumped from the reservoirs beneath the basin. The overmining of groundwater was recognized as a serious problem; therefore, the canal districts were held responsible for

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[1]For a complete description of the Kings River area, see Maass and Anderson, _. . . and the Desert Shall Rejoice_, MIT Press, 1978.

recharging the subterranean reservoirs.[1] Although supervised by district ditch tenders, farmers themselves controlled the gates opening onto their fields.

2.2. Experience of Western United States

Another result of the California and Colorado experiences came from the area settled by homesteaders. The many owners of small farms found that a mutual irrigation company satisfied their needs. The primary benefits of this system stem from the efficiencies of having local control of the resource. Members of the representative bodies, administrative officials, and often their employees were irrigators with knowledge of local requirements. Farmers owned shares of stock in the company, and important issues were decided on the basis of one vote per share. Each share also represented a basic allotment of water which reflected the seasonal status of water supply. The stock could be freely bought, sold, and rented since it was considered personal property and not tied to the land. Individual stockholdings were not necessarily proportionate to the amount of land owned. There was an annual assessment for the basic allotment of water to pay for operation and maintenance of the system. The basic allotment could be withdrawn whenever the farmer demanded it. This provided full delivery to all users. The amount of surplus water and its price (about 125 percent of the price of the basic allotment) were known to the farmer so he could plan the irrigation pattern best suited for his land and crops. He could also choose the crops which would be most profitably produced with the available water supply. Differences in topography, soil characteristics, and crop requirements account for varying water needs.

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[1] In many areas of the United States, the unpleasant consequences of unregulated groundwater depletion are encouraging the development of responsible groundwater regulations.

The limitations of this institutional design are that the supplies can be drawn down during peak growing seasons and that there can be large water losses in the system with water provided by demand rather than on a rotation system. Much of the water lost, however, does serve to recharge the groundwater reservoirs. By allocating small quantities of water to each share of stock, there was greater flexibility in the ownership of rights and in the delivery of water.

In Utah, the Mormons emphasized proportionate sharing and limited water rights to beneficial uses only. The system used was very similar to the mutual irrigation companies with assigned shares of water treated as private property. One difference was that the water rights were divided into two classes. Ditches with primary rights had acquired those rights prior to the time that the sum of rights equaled the ordinary low-water flow of the stream. Secondary rights were held by later ditches. Rights were equal within classes, but there was a substantial distinction between them. Those with secondary rights usually had an alternative source, such as groundwater, which was more costly to obtain.

Individual irrigation companies have developed modifications of the basic system with respect to time priority, canal operation, and headgate control. Growth limitation based on time priority was accomplished in several different ways: water was refused to anyone outside a clearly defined irrigation area, land to be irrigated was registered, and/or a prohibition of the extension of any part of the physical canal system. Based on the time the water rights were granted, land could be classed in three ways: lands to be irrigated regularly, those to receive excess water, and those to remain dry. A less-rigid system would give new lands water rights but less water per unit than older lands. In some organizations, water allocation was authorized only when there was sufficient demand to justify operating the canal. Headgates could be locked and controlled by officials in order to maintain efficient deliveries. Some areas used a time-variable method of apportionment in which the allotment of water per share varied with either the time of year or the flow in the stream which spread the costs of drought.

There are many basic procedures for the allocation of irrigation water: rotation, shares, farm (time) priorities, demand, turn, crop priorities, and market. The first four have been described above in the context of the U. S. experience. Irrigation by turn is the distribution system presently used in Egypt. This system only works well with abundant water and has been abandoned in drought-prone parts of the world because of the inherent inequities and inefficiencies. Crop priorities have been used on a limited basis in Colorado and Utah. When there is insufficient water available for all crops, priority crops are watered first on all farms. The priorities can be based on meeting either economic or social goals such as building foreign trade or achieving food self-sufficiency.

The last procedure mentioned above is the market allocation of water. Under this system, all water users bid each period for the water needed to irrigate their crops. It is thus assumed that water would be allocated to the highest value uses each period. This is the only system which would place a proper economic price on a unit of water. Unfortunately, the market procedure has been unpopular with irrigators of many communities. Government policies have effectively allowed a chronic underpricing of U. S. irrigation water, and the farmers are understandably hesitant to give up their benefits.

3. Water System Planning and Economic Incentives

The efficient use of water depends on the institutional design and the environment for economic incentives. In most areas, irrigation water remains underpriced. Such a policy may have made sense when the objective was to encourage the use of an abundant input to develop other resources. However, that objective is no longer valid. At this time, much of the return to a landowner per acre can be attributed to the water received for irrigation. This amounts to a direct water subsidy which is borne by the taxpayer. The federal government was very active in developing water projects in the past, but its role has been declining. Although local benefits may be high, the economic and social returns to the investment may be quite small.[1]

Technologies for increasing productivity is the domain of hydrologists, agronomists, chemists, and biologists. Economic analysis, however, can indicate the incentives needed for the farmer to make the necessary physical changes a reality. Soil conservation policies related to water use should be evaluated to ascertain the optimal level of investment for that resource. Another source of productivity gain which should be explored is the use of fresh water in conjunction with drainage water to expand the usable supply of irrigation water.

There will always be inconsistencies between water policies and those of other agencies. A classic example occurred in America after World War II. The federal government substantially augmented projects increasing the availability of irrigation water while the U. S. Department of Agriculture was

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[1]Agricultural water supply projects repay only 19 percent of real project costs.

trying to reduce national output and acreage. Such counterproductive policies need to be effectively integrated.

Systems Analysis was developed to aid in river-basin planning in the United States, but none of the basins studied were as extensive or as complex as that of the Nile River. Application of such methods to Egypt would be a huge task but one with the potential for large gains. A comprehensive plan would have to incorporate the multiuses of the river water and the linkages among all of the sectors. Tracing the quality of the water and recognizing the trade-offs involved is essential for such a linear system. The quality of both surface and groundwater should be evaluated with respect to alternative water rights schemes. It would be valuable to study the effects of an implementation of effluent charges on industrial and municipal dumping of waste water in the Nile River. There are dynamic feedback effects which must be considered when planning long-term investments as well as trying to meet short-term goals.

Economic analysis can also indicate ways of achieving certain social goals which may not be compatible with a pure efficiency criterion. Differing policy recommendations should be evaluated in a manner that the decision-maker could readily understand the trade-offs inherent in the choices. There are many techniques available for water modeling including dynamic programming and simulation, but more basic information on the system is necessary before detailed analysis can begin.

In the short run, the emphasis should be on the evaluation of present agricultural techniques, the condition of the land, and the design of the water distribution and drainage system. Any long-range planning must be done with the recognition that favorable economic environments must be provided for efficient farmers. Given proper economic incentives and the dissemination of information on agricultural techniques, productivity will surely increase. Central or regional planning is necessary to design a water delivery and drainage system which would take advantage of the availability of both surface and groundwater. More local control is necessary, however, in order to evaluate canal rotation patterns in terms of the actual water requirements in the area. A cooperative which is not as tightly linked to the central government might well gain the confidence of the farmers and become more effective. A more effective agricultural-extensive organization would offer the technical expertise necessary to implement the new methods. The entreprenurial skills of leading local farmers should also be used to benefit the whole community. A code of water rights could be instituted, and a system of water-quality management could be fostered.

It is essential that the social and economic goals of the government be clearly defined. The agricultural sector is affected by many policies and cannot be studied in isolation. The huge capital expenditures needed to complete and update the Egyptian irrigation and drainage system emphasize the need for central government involvement. Also, centralization is recommended in order to protect the quality and quantity of the water stock from misuse by any sector. Clear goals and cooperation among agencies is essential.

Once the system is in place, however, it is recommended that control pass to local institutions for actual implementation. These institutions could be modifications of some of those which evolved in the United States. The essential requirements for such systems would be that water rights be clearly defined for both quality and quantity of the resource and that the individual farmers have confidence in the irrigation organization.

3.1. Efficiency Versus Equity

Major agencies have made conflicting recommendations to Egypt with regard to improvements in agricultural policy. As an example, the USDA stresses the need for the new lands to be farmed only be the most expert farmers in large units in order to achieve adequate production. The World Bank, on the other hand, encourages new projects in order to improve income distribution and to generate employment through the settlement of small farmers. The recommendations differ because the goals differ. The USDA uses an efficiency criterion while the World Bank expresses more concern for equity issues. Both, however, recognize that it will take a long time before investments (public or private) in reclamation will bear fruit.

By observing the workings of any agricultural system, it is obvious that efficiency is seldom the sole criterion for implementing policy. In agricultural policy analysis, issues of equity are crucial and cannot be neglected. Unfortunately, there is no single widely accepted measure that can be included in an optimization model for the purpose of resolving equity issues. Due to this problem, many public-sector planners have argued that this problem must be solved by the political process rather than by applying an optimization model.[1] Brill argues that most public-sector problems are characterized by a multitude of local optimum and comparable objectives—the common rubric problem. He goes on to argue that:

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[1]Brill.

> "Parametric analysis would often be required to guarantee obtaining the best solution even if all objectives are known and quantifies. In reality, however, it is impossible to capture all the important elements of planning problems within an optimization formulation, and truly optimal solutions are likely to lie in the inferior region of a multiple objective mathematical analysis instead of along the non-inferior frontier."

In the case of many agricultural public agencies, the multiple objectives include such loosely defined measures as increased income of farmers, increased consumer's welfare, improved distribution of income, self-sufficiency, price stability, improvement in balance of payments, decreased public expenditures, stable flow of supply, and the like. In the face of such multiple concerns, the continued use of single-attribute objective criterion functions will result in analyses which fail to deal with actual policy problems. Such an approach will assume an air of unreality that public decision-makers will rightly reject. Hence, if we are concerned with operational implementation, we have no recourse but to deal explicitly with multiple objective criterion functions.

There is little doubt that there will be conflicts among the multiple objectives. The definition of a multidimensional objective function neither creates nor resolves such conflicts; instead, it identifies them. The identification of the conflict is, of course, an important first step in their resolution. As Steiner argues, however:

> "If objectives were genuinely multidimensional and not immediately comparable, some solution to the weighting problem is implicit or explicit in any choice and that solution reflects someone's value judgement. Put formally, we now accept in principle that the choice of the weights is itself an important dimension of the public interest. This choice is sometimes treated as a prior decision which controls public expenditure decisions (or at least should) and sometimes as a concurrent or joint decision—as an inseparable part of the process of choice."

The relative importance placed by the decision-maker on the goals will determine the resulting policy. All of the important goals might not be in the objective function because some of them can be included in the form of constraints such as a minimum level of income.[1]

3.2. Multiobjective Policy Analysis

Work on several aspects of the multiobjective policy problem is presently in progress. A synthesis of several of these recent approaches is what is needed for the effective evaluation of the trade-offs inherent in water and agricultural policy alternatives. To Keeney and Raiffa, for example, the central aspects of choosing policies when faced with multiple objectives are how to define an appropriate measure of each objective and how to resolve conflicts among objectives. They enforce comparability among alternative objectives in terms of their contribution to utility. The resulting scalar measure has been defined as a multiattribute utility function. Construction of such functions involves several critical factors such as (1) structuring the objectives, (2) defining performance measures or attributes for each objective, and (3) measuring the scaling constants or weights associated with various attributes. Although there are still problems associated with these factors and others, the approach is operational. The strengths of the Keeney and Raiffa framework are the assessment process and the explicit treatment of uncertainty.

In a more positive vein, revealed preference has been widely employed to determine the weights associated with various objectives. In the context of

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[1]The constraint structure must also capture the essential elements characterizing the behavior of agricultural firms and the principal properties of agricultural markets.

water resource policy, the work of Maass and Eckstein treats weights as being generated by the decision process. Both express the view that administrators and project analysts should not abrogate the weighting process and bury the choices within a single measure of benefit.

Rausser and Freebairn argue that, in the environment of public policymaking, the importance of the bargaining process and the resulting compromises between different political groups, the range of preferences of these groups, and the lack of an explicitly stated unambiguous value concensus provide the basis for the construction of several criterion functions. They argue that these functions should reflect the extreme viewpoints and preferences of various decision-makers actively involved in the policymaking process as well as the preference sets lying between these extremes. A parametric treatment of the resulting set of preferences would, of course, provide decision-makers with rational policy outcomes conditional on the representation of policy preferences. The results obtained from such an approach should contribute to the efficiency of the bargaining process in reaching a consensus, should serve each policymaker (i.e., each legislative member) individually, and should serve to make quantitative analysis based on historical data effective for many policymakers even though the composition of a legislative body might change.

A cooperative game framework is utilized by Zusman; it is both theoretically and empirically an elegant formulation of the political process. One of the more interesting aspects of the Zusman framework is that it enables quantification of power exertion of interest groups on public bureaucrats and the responsiveness of those bureaucrats to the exertion of such power. This approach presumes that interest group power issues are settled by the various groups first dividing up whatever gains may accrue according to their relative strengths—power determines relative shares which neutralizes all antagonisms—and then, and only then, all interest groups striving jointly to maximize total gains. In operational applications of this approach, it is likely that the "cost of power" and "strength functions" are not well defined and that both measure "relative clout" of different groups rather than actual exertion of power.

Another conceptual framework is that of Downs, Stigler, and Peltzman. The key feature here is that the government is concerned with maximizing political support—the probability of reelection or, in the case of appointed officials, the probability of reappointment. Governmental bureaucrats are viewed as being interested primarily in votes and only secondarily in their welfare. What counts is not simply aggregate benefits and costs but, also, the distribution of benefits and costs among those who benefit from policy and those who lose. As in the Rausser and Freebairn and Zusman frameworks, interest groups play a major role in the determination of trade-offs and weights assigned to various objectives.

A synthesis of these approaches should incorporate the best features of each. The Keeney and Raiffa prescriptive approach can include uncertainty and the weightings of goals, while the Zusman framework allows the incorporation of interest groups, the costs of their acquiring power, and the associated strength functions. The other approaches include the realities of bureaucratic decision making and the bargaining power of interest groups. The determination of the "weights" entering the multidimensional criterion function governing the trade-off among alternative individual attribute utilities would be a crucial part of the new approach. The weights may be viewed as functions of the "cost of power" à la Zusman; hence, consistent with the Zusman framework, the relationship between the weights and the cost of power can be regarded as the "strength functions." In this sense, the effects of exertion of power on trade-offs made by policymakers reflect the process of political interactions. The distribution of benefits derived from alternative policies and the costs of interest-group organization can be included as determinants of the cost of power. This approach provides a complete revealed preference method for estimating the effects of power exertion on policy and for identifying the actual exertion of power. There is little doubt that a high payoff exists for approaches of this sort which integrate prescriptive with substantive positive analysis.

The integrated approach suggested here would have several advantages over traditional firm or industry models. The dynamic aspects can show both long- and short-run effects and the distribution of income under each alternative. In the final analysis, major benefits from modeling public policy problems depends critically upon the sound judgment and experience of the public decision-makers and the analysts involved. Only through such judgment and experience will it be possible to balance the value of simplicity with the cost of complexity. Given the appropriate balance, the principal benefits of quantitative modeling will be achieved. These benefits include (1) forcing the users or public decision-makers and the analysts to be precise about perceptions of the system they are attempting to influence (testing these perceptions with available evidence); (2) providing structure to the analysis; (3) extending the decision-makers' information processing ability; (4) facilitating concept formation; (5) providing cues and insights to the decision-makers; (6) stimulating the collection, organization, and utilization of data (which are often neglected); (7) freeing the decision-maker and analyst from a rigid mental posture; and (8) becoming an effective tool for negotiation, bargaining, and as a basis for persuasion.

4. Conclusion

The Nile River is a unique resource, and Egypt has done much to enhance its potential. Although other countries have contributed aid and expertise, the management of the Upper Nile is the responsibility of the Egyptian government. It is, therefore, essential that any suggestions concerning water resource planning be consistent with the goals and policies of Egypt.

The United States experience with water distribution systems cannot be completely transferred to Egypt. Workable systems must be developed in response to geographical, economic, and social conditions. The reasons behind the differences among the U. S. systems are as important to understand as the similarities. Any proposal for a new distribution scheme must be compatible with the social, physical, and political environment in Egypt.

The synthesis of the multiobjective policy approaches described above would consider many of the issues necessary to form a comprehensive plan for water use and development. There are obvious trade-offs between the benefits of a tractible model of unrealistic simplicity and one which is a complex reflection of the world in theory but unmanageable in practice.

Egyptian water policy is at a crossroad. Policymakers have no time to consider plans developed as an academic exercise. It is urged that a careful analysis of present conditions be undertaken and that the nation's goals be clearly defined. In this way, a water resource plan can be developed to fit Egypt's unique needs.

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