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RELEVANT WATER DEVELOPMENT TECHNOLOGY IN RELATION TO OPERATION AND MAINTENANCE ASPECTS UNDER UNCERTAINTY

INTRODUCTION

Uncertainty is a characteristic feature of our every day life. It is constant factor in all decisions we make, whether implicitly and explicitly expressed. In adequate information with respect to several outputs required in decision-making usually results in uncertainty and the attendant premises of risk. Thus, in evaluating any investment project there is sure to be some uncertainty about the future streams of costs and benefits. Changes in the different decision input variables such as tastes, discoveries of new sources of supplies, and technological innovations, all act overtime to raise or lower the prices of goods produced by and inputs used by, the project, in question, in ways we may sometimes guess at but cannot foresee.

The issue of uncertainty as it relates to water resources projects cannot be overemphasised. This is the sole consideration in the usual provision called "factor of safety" in systems engineering design. This provision usually escalates the system capacities in design and this normally results in escalation of costs during construction. Even with this provision the net effect of many of the waterworks may end up to be negative rather than positive as had been anticipated by the designers. Natural hydrological uncertainty is the most predominant and common type of uncertainty in all waterworks projects all over the world. The optimal size of a reservoir or dam will depend on the "uncertain future" of expected flood magnitudes which vary rapidly in time and space. Even where one has historical hydrological records going back forty-fifty years or more years, the uncertainty of future events is still high and the optimal size of hydraulic structure will have to be determined on the basis of prior probability of flood damage in the future.

In the developing nations, with practically no long history of water control, no reliable hydrological records, and no data bank, the issue of uncertainty is more severe. Again since a major characterisation of all developing nations is the non availability of adequate local technologies there is the added dimension of "technological uncertainty" resulting from lack of adequate manpower required for proper management, operation and maintenance of "imported technologies" from the developed nations. This also results in uncertainty in prices of imported construction inputs and uncertainty with respect to the future availability and supply of the necessary spare parts, even if scanty manpower were to be produced by more intensive educational programmes. Another characteristic parameter in describing a country as developing is the country's low Gorss National (product (GNP) which inherently implies lack of adequate financial resources for the execution of her developmental projects. Thus, there is the uncertainty associated with non-availability of funds. Also uncertainty associated with changes in political power and the associated premises of changes in policy contributes to complicate the problem further. The problem is really multi-dimensional.

One, therefore, is forced to ask : "How can we cope with natural hydroligical uncertainty as well as the 'incidental' technological uncertainty, or rather how do we prosper in the face of these uncertainties in our determined effort to develop our abundant water resources?" "Should we accept that the trick and challenge is to learn to prosper with these uncertainties, or are there better answers to the characteristic problem ?"

CONSIDERATION AND ANALYSIS OF THE MULTI DIMENSIONAL PROBLEM OF THE DEVELOPING COUNTRIES

The complexity of the situation of uncertainty in the developing nations is such that no adequate planning decisions can be effectively made without "sufficient"consideration for this. A lot of complications have arisen during operation and maintenance of waterworks projects because the approach employed in the preceeding phases of planning and construction was not relevant to the particular environment. Many things are usually taken for granted with over-optimistic assumptions that adequate problem solving techniques or project implementation technique employed "somewhere sometime in the past" would suffice. This has been shown to be an over sightedness and has manufested during the operation and maintenance.

The author is of the opinion that technology is

is a way of life. It has a cultural base and bias. It must be developed in tune with the existing value systems, traditions, educational standard, available resources, and manpower, that characterise the environment. The interest and co-operation of the people must be ascertained. In the event that a technology has to be imported from one culture to another, the "lender" of this "expensive good" must be available to educate the "borrower" on the features and must be prepared to work hard to make the beneficiary to accept this "good" wholeheartedly and be contempted with it.

In the Western countries the historical perspective on the invention, and growth of modern waterworks technology indicates that the technology has evolved over time, and against a background of characteristic high labour costs, and a desire of the population to obtain water with the least trouble to themselves, and without upsetting the socio-cultural equilibrium of their environment. The method of financing was such that the revenue was collected by means of "water rate" based on the "value" of the property. Because supervisory labour is expensive, the tendency has been in recent years to instal instrumentation and automation for collecting flow and treatment information and to control the processing and distribution of the water. This level of supervision in operating and maintaining these complicated and sophisticated technologies is beyond the technical absorbtive capacity of developing countries to supply. In developing countries population growth rates, migration of rural hierarchy to urban hierarchy, industrial and commercial development are often difficult to forecast not only because there is often a paucity of reliable data existing, but also because of "fluid" political conditions which result in grandiose planning proposals but no effective decision-making and no effective implementation.

In the developing countries, anxious to provide for themselves an infrastructure to enable their inhabitants to improve their way of life and the level of health, the demands on available finance are many and thus the availability of funds is limited and uncertain. This is bound to delay timely execution of planned water project designs until the designs become overtaken by the fast increasing population. Thus a "vicious circle" is created.

In any scheme of water supply there are the on-shore components (items which can be paid for by local currency e.g. local labour) and off-shore components (items which can only be paid for by foreign currency e.g. imported pumping equipments, machinery or materials). Foreign currency availability is a restricting factor. On many instances different Water Corporations have placed orders and opened letters of credit for pumping plants from Overseas Manufacturing Firms only to discover in time that the assumed financial commitment that was made sometime in the past is no longer being honoured. This introduces complications and uncertainty as regards the future completion of the project. In such cases much public money must have been expended for little or no output (return) since the project has not been utilized by the supposed beneficiaries.

To plan or design adequate water supply systems under such conditions of uncertainty as are prevalant in the developing countries requires more ingenuity than is normally possessed by an engineer alone. Team effort involving different experts and local community support is necessary. Established conventional techniques being used in the developed western countries to cope with "simple uncertainty" will not suffice for the "multiattribute compound and complicated uncertainty" of the developing countries. Since there is lack of reliable data with respect to all the componenets of uncertainty one has to compe with, be it process (natural) uncertainty, statistical (information) uncertainty, uncertainty induced by external circumstances (resulting mainly from changing policies, future technological innovations, social changes and future economic conditions), or uncertainty in factors reflecting human elements (such as urbanization rate) an analyst cannot even make an estimate of prior probabilities and the corresponding probability distributions that are vital for analysis. Thus there is the urgent need to recognize the role of uncertainty in planning decisions and realise that we are going to have to learn to live much more intelligently and realistically with subjective probability and uncertainty in the developing countries. If this aspect of planning is not weighted enough, inadequate management, operation, and maintenance of waterworks in the developing countries will always be the most likely cause of failure.

TOWARD A MORE EFFECTIVE APPROACH IN THE DEVELOPMENT OF RELEVANT TECHNOLOGY FOR APPLICATION IN DEVELOPING COUNTRIES

RELEVANT TECHNOLOGY PHILOSOPHY

The author prefers the terminology "Relevant Technology" to the more conventional terms of "Appropriate Technology" "Intermediate Technology" "Low-Cost Technology" and "Alternative Technology" because the objective here is to accept that what is required in the developing countries should be a departure from the conventional approaches of the developing countries. If the basic philosophy is that technology should have a cultural orientation, then it follows from simple deduction that what is needed is "that which is relevant to the culture of the region" and which can easily be integrated within the society without much inconvenience. Thus, Relevant Technology can be defined as that technology which evolves in consonance with the cultura and tradition of the people and which intends to provide the most socially and economically acceptable level of service to humanity with least inconvenience. Relevant Technology should, therefore, be characterised by the following :

1. Involvement of the local community residents in the decision-making process early enough in project planning. Proper consultation and communication channels must be established to stimulate community participation. Participation of the community should start right from the pre-feasibility and full-feasibility studies and data collection, through the design and construction stages, to the permanent management, operation and maintenance of the water-works installation. The objectives of community participation can best be achieved by :

a. Identifying and recognising the formal and informal community leadership and communication channels.

b. Determining the existing socio-cultural practices in water.

c., Determining the community's "willingness to pay" for improved water supply facilities and the mode of payment preferred either by cash and/or the "substitution of labour and materials.

2. Designs should be based on simple approaches with the involvement of local experts and based on the principle of "planned-staged development" of short intervals, e.g. 5 year, 10 year instead of 30 year design capacities. This will reduce to a minimum the amount of capital invested but un-utilized, and will also reduce the financial burden to the barest minimum.

3. Possibilities of using local construction materials which can be manufactured locally. This would reduce the off-shore cost component preserve foreign currency and simplify operation and maintenance. This would also facilitate easy, speed erection and would also minimise the extent of abandonment of "revious" plans resulting usually from changes in policies.

4. More emphasis should be placed on the simplicity of operation and preventive maintenance. Beneficiaries should participate in the management, operation and maintenance of facilities and collection of revenues. This would reduce water waste and encourage proper conservation practice in water use.

5. An educational programme to enlighten the operators and the beneficiaries is of utmost importance. Special on-the-job training programmes should be organised for local residents who are interested, dedicated, and committed to the efficient management, operation, and maintenance of the facilities.

6. Planners, designers, and policy makers have to make a deliberate effort to recognise the implicit effect of uncertainty in the developing countries. In the absence of reliable process and statistical information, determinisyic approaches are inadequate. Therefore approaches have to be devised for subjectively assessing the situation. Thus subjective estimate of probabilities must be introduced. This calls for the establishment of acceptable techniques that could be employed in decision-making under uncertainty, in the developing countries. If this were to be achieved then the objectives of "Relevant Technology" will be attained.

FIELD OBSERVATIONS WITH RESPECT TO OPERATION AND MAINTENANCE, MAINTENANCE PROGRAMMES IN ANAMBRA STATE OF NIGERIA

The Anambra State Water Corporation has eight administrative zones and twenty three local Government areas. In these zones there are many schemes which have been commissioned and are operational. However, field observations indicate that the output from these schemes could be improved by improving the operation and maintenance schedules. The constraints originate mainly from lack of funds for purchase of fuel required for plant operation, for purchase of water treatment chemicals, for adequate transport, for effective communication equipment, for metering output of stations, for purchase and speedy supply of spare parts, pipes and ancillary equipment, for provision of workshop facilities, as well as lack of skilled motivated engineering field staff and artisans. Table 1 is an estimated typical required annual operations budget and Table 2 is an estimated financial requirement for general maintenance for the eight zones. However, in the past the estimates provided for operations and maintenance have fallen much lower than the figures shown.

Field observations also reveal that the level of education of the operators is not adequate for proper and astute operation of the system. Usually operating schedules are not available at the pumping stations and the pumps are operated uneconomically. There are no installed water meters and pressure meters. Cases of submersible pumps sinking inside boreholes are common. Failures of pipe mains in the distribution system are common as is usually shown by broken pipemains.

Also the general observation of manpower in the operations and maintenance field is that the present establishment is sufficient in numbers to operate and maintain the systems. However there is a shortage of skilled senior artisans, particularly in the mechanical and electrical departments. It is the author's belief that on-the-job training could beideal in the lesser skilled manpower, such as pumping station operators and plumbers. Extra technical staff is required.

Generally supervision of the labour force is inadequate. The situation could be improved by making more funds available for the provision of better transport and communication facilities.

The collection of water rates if the most difficult administrative problem for the Anambra State Water Corporation. This emanates from the cultural beliefe that water is "traditionally free" and consequently "evasion" is high. This issue needs immediate attention if the revenues from water rates are to improve for more efficient operation.

TABLE I TYPICAL ANNUAL OPERATIONS BUDGET

Budget Item	Schedule No.	ZONE ALLOCATION Abakaliki	Aguata	Awka	Enugu	Nnewi	Nsukka	Onitsha	Udi
Fuel (diesel oil)	15	3 000	118 000	35 000	21 000	107 000	99 000	115 000	46 000
Power NEPA	16	89 000	--	--	299 000	--	56 000	346 000	--
Repair and replacement of plant	9 10 11	100 000	60 000	60 000	250 000	60 000	225 000	170 000	60 000
Chemicals incl. Chlorination Stage 1)	17	38 000	10 500	8 500	225 000	-	-	34 000	2 500
Cen. Maint.	6	16 000	6000	18 000	66 000	10 000	12 000	90 000	10 000
Mains Replacement.		-	--	--	10 000	-	--	10 000	--
Chlorination Stage 2	18	-	-	-	2 000	4 000	8 500	7 000	4 000
Transport (Replacement & additional vehicles and running costs)	20	29 000	28 500	29 000	187 000	58 000	80 000	85 000	28 500
ZONE TOTALS		275 000	223 000	150 500	1060 000	239 500	480 500	857 000	151 000

Workshops (14) 75 750

Total : N3 512 250

Updated to 1st April 1980 (15%). N4 039 000

BAYESIAN DECISION THEORY APPROACH AND RELEVANT TECHNOLOGY FOR DEVELOPING COUNTRIES

Since the philosophy of Relevant Technology lays more emphasis on what is culturally acceptable and emphasises community participation as a basic necessity, the decision making is a collective responsibility of both the planners, designers, policy makers and the beneficiaries. Maximization of economic returns from the project is not the dominant objective function. Rather miximization of aggregate consumption (utility) is explicitly emphasized and the sole objective function is to maximise utility. Since uncertainty is predominant characteristic, a stochastic analysis is required. Thus, the objective function should aim at "maximization of expected utility values." Since interdependant and interelated uncertainty components come into play, the approach ought to be capable of assessing probabilities subjectively. Compound subjective probability estimates will be the highest input in the approach.

Under the constraints of the above stipulation Bayesian Decision Theory Approach is most relevant, and should be readily applicable to the situations of the developing countries. Decision Thoery is most adequate for solving the key problem of operation and maintenance. This decision analysis approach will serve as a final departure from the conventional benefit/cost technique which is obsolete in an environment of complicated compound uncertainty matrix. The problem of water supply ought to be viewed more as a social problem rather than a regional economic efficiency problem. Therefore, the decision matrix should consider, in addition to costs and benefits, other attributes such as socio-cultural acceptance, growth considerations etc. for total evaluation.

Decision analysis technique is relevant to problems of uncertainty because it provides an objective analysis of subjective considerations. In complicated, compound decision problems it allows the decision makers to break the problem into many smaller and easy-to-handle decision

problems which can be quantified by subjective utility assessment. Once this is achieved the parties involved in the decision are in a much better position to develop mutual understanding and better perception of the problem. Thus it provides an effective medium of communication for interested groups with overlapping and diverging articulated preferences and backgrounds.

The whole process of Decision Theory takes cognizance of the value of the information, making best use of limited data while indicating the areas of greatest uncertainty, areas in which the need for additional information is most pressing. Moving backward in time, the decision maker can evaluate the outcome of certain observations, and in doing so can update his information and modify his actions so that the choice which he actually makes is most likely to be in harmony with the realised event, or to be an improved decision. The decision reached is more in line with public interest and thus the approach is further justified by the "Principle of Pareto Improvement", a socio-economic undertaking that makes everyone in the social organisation better off.

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