Zeitschrift: IABSE journal = Journal AIPC = IVBH Journal

Band: 5 (1981)

Heft: J-13: Planning and design in the public sector and formal evaluation methods

Artikel: Planning and design in the public sector and formal evaluation methods

Autor: Hutchinson, Bruce / Pozzi, Angelo

DOI: https://doi.org/10.5169/seals-25642

Planning and Design in the Public Sector and Formal Evaluation Methods

Méthodes d'évaluation de projets de travaux publics

Methoden zur Beurteilung öffentlicher Investitionsvorhaben

Bruce HUTCHINSON
Professor Dr.
University of Waterloo
Waterloo, Ontario, Canada

Angelo POZZI
Professor Dr. sc. techn.
Swiss Federal Institute of Technology
Zurich, Switzerland

SUMMARY
A six stage classification of evaluation problems frequently encountered in public sector planning and design activities is presented. The characteristics of avaible evaluation techniques that might assist in the evaluation of alternative solutions to problems of each of the six types are reviewed.

RÉSUMÉ
Les méthodes utilisées pour l'évaluation de projets dans le secteur public font toujours apparaître les mêmes types de problèmes. Ces derniers peuvent être classés en six catégories. L'article présente les caractéristiques des différentes méthodes d'évaluation.

ZUSAMMENFASSUNG
Bei der Beurteilung öffentlicher Investitionsvorhaben stellen sich immer wieder ähnliche Probleme, die Problemstellungen werden in 6 Klassen eingeteilt und die für die Lösung passenden Beurteilungsmethoden charakterisiert.

1. INTRODUCTION

The use and impact of formal evaluation techniques as an aid to project selection in the public sector have varied widely between problem areas and countries. In North America their principal applications have been in the water resources and transport sectors, while in Europe formal evaluation techniques have had very limited application. In most of the earlier applications to the water resources and transport sectors the techniques were used in a rather absolute sense to justify the economic feasibility of projects to public decision makers.

During the 1960s and 1970s the range of project impacts that analysts had to consider in the evaluation of projects expanded sharply, as the public and decision makers became more concerned with the long-run environmental impacts of projects. Difficulties in quantifying many of these impacts in economic terms led to the formulation and use of a variety of evaluation techniques based on a variety of principles in an attempt to overcome some of these problems of quantification.

The purpose of this paper is to review the range of evaluation techniques available and to identify the types of planning and design problems to which the various classes of techniques might be applicable. The perspective taken in this paper is that the principal role of evaluation methods is to identify the optimal investment region on which more detailed planning and design activities might be focussed. The emphasis is on the use of these techniques to promote efficiency in planning and design activities to produce solutions that are technically, economically and politically feasible.

2. TYPES OF DECISION

In reviewing the relevance of formal evaluation techniques it is important to recognize the hierarchical nature of planning and design decisions. Table 1 provides one classification of the spectrum of evaluation problems in the public sector along with some of their general characteristics. Six broad classes are identified ranging from the relatively well defined problems of identifying least cost solutions through to large scale one-off projects where social and political impacts dominate.

Clearly certain types of projects may be classified into different levels of Table 1 at different stages of project planning and design. For example, the decision to build or not to build a new airport may belong initially to the sixth classification of Table 1, but once the decision has been taken the evaluation problems shift to other levels of the evaluation classification. For example, the determination of optimal runway capacity may involve a consideration of benefits and costs while runway pavement design may involve long-run cost minimization for pre-specified performance standards.

	PROBLEM TYPE	PROBLEM CHARACTERISTICS
1	COST MINIMIZATION FOR PRE-SPECIFIED OUTPUT STANDARDS	MINIMUM CAPITAL AND CONTINUING COSTS OVER LIVE OF PROJECT
2	COST MINIMIZATION FOR PRE-SPECIFIED STANDARDS AND MULTIPLE INPUTS	IDENTIFICATION OF OPTIMAL SCALE FOR EACH COMPONENT PROJECT FOR MINIMUM COST CONFIGURATION
3	NET BENEFIT MAXIMIZATION	BENEFIT ESTIMATION, LEAST COST CONFIGURATION AND NET BENEFIT MAXIMIZATION
4	NET BENEFIT MAXIMIZATION WITH MULTIPLE OBJECTIVES	CONSISTENT BENEFIT MEASURES REQUIRED FOR ALL OBJECTIVES
5	LEAST CONTROVERSIAL PROJECTS	FACTORS OTHER THAN ECONOMIC DOMINATE WITH INTER-GROUP COMPARISONS CENTRAL
6	LARGE SCALE ONE-OFF PROJECTS	IMPACTS ARE WIDESPREAD GEOGRAPHICALLY WITH MANY INTEREST GROUPS

Table 1: A Classification of Evaluation Problems

Each problem class identified in Table 1 is discussed in more detail later in this paper along with representative problem types. The evaluation methods that might be useful for each problem type are described.

3. BASIC ECONOMIC IDEAS

The principal concern of this paper is with evaluation methods that have a basis in economic theory or which are compatible with basic economic concepts. While economic theory is difficult to apply in many cases, it offers the only comprehensive theory of choice that might be applied systematically to public sector decisions at this time. This section of the paper provides a very brief review of some relevant economic concepts. With most public projects involving capital investments in physical infrastructure the benefits and costs occur at different points in time and it is necessary to reduce these to a common point in time for comparison. An interest or discount rate is typically used to reduce benefits and costs to equivalent annual values or present worths.

There are many who argue that interest rates have no role in public sector expenditure decisions since financial resources are obtained each year through various types of taxation and these resources have to be spent anyway. This view is as untenable in the public sector as it is in the private sector. Financial resources used by the public sector are diverted from consumption and investment in the private sector where money has a significant time value. The market interest rate reflects the weight placed by an economy on current consumption versus current investment which will yield a larger amount of future consumption. The same principle exists in the public sector where many governments borrow money to undertake investments which cannot be financed solely from current revenues, implying that consumptions at different points in time are weighted differently.

Interest rates also serve as a capital rationing device in the public sector just as they do in the private sector. If a zero discount rate is used, then alternatives with large initial capital expenditures will be favoured over those that involve more modest, staged investments over time.

The economic ideas of marginal productivities and of marginal costs for different technically feasible input factors are central to the identification of least cost configurations for projects involving multiple inputs. The classical water resources example is a multiple reservoir storage system with each reservoir having different cost characteristics and different effectivenesses in reducing floods. The issue is to identify the least cost combination of reservoirs that reduce flood flows by a particular amount. The least cost solution is obtained by using each reservoir at the scale for which the marginal productivity of the reservoir in reducing flood flows divided by the marginal cost of providing the storage capacity is equal for all reservoirs used on the river system.

In the very general sense desirable public projects consume scarce resources in order to produce social benefits that are in some sense larger than the resources consumed. The theoretical inspiration for identifying desirable projects is a so-called Pareto improvement in social welfare (after a 19th century Italian economist) which is defined as an economic change in which some members of an economy are made better off without anyone being made worse off. Clearly, this condition is difficult to satisfy since in the public sector those who pay for a particular project through general taxation are not necessarliy the chief beneficaries of the project. These difficulties have been avoided traditionally by using the idea of potential net changes in social welfare. A Pareto change is re-interpreted as one in which it is conceptually possible for those who gain from a project to compensate financially those who lose from a project and still be better off than before the action.

The critical problem in applying these ideas is to develop consistent methods of estimating benefits. The idea of social benefits does not flow directly from the market-based notion of revenues. Goods and services may be thought of as having two types of value and these are value in use and value in exchange. The value in use reflects the ability of the good to satisfy the needs and desires of consumers, while the value in exchange reflects the market value of a good. The value in use is larger than the value in exchange and the difference, or excess above market value, represents what is known as the consumer's surplus. The change in consumer's surplus is the conventional measure of change in welfare.

Problems of the third type identified in Table 1 require that benefits and costs be considered explicitly in identifying the optimal project scale. By analogy with the profit maximizing notions of the private sector, the optimum project alternative is that with the maximum difference between the benefits and costs, with the costs reflecting the ideas of least cost project configurations mentioned previously. Optimal project scale may be identified by the equivalent condition of equality of marginal benefits and marginal costs. Many large scale public projects have multiple objectives which are in some sense competitive, with the classical water resources example being reservoir storage which could be used for hydro-electric power generation and flood control. In general, the optimum project scale with respect to the two objectives will be different from the optimum project scales for the two projects taken separately. The problem is to develop consistent benefit functions for each objective so that the trade-offs between different levels of achievement of the two objectives may be examined. The optimum multiple objective project is that for which the marginal benefits are equal to the marginal costs for each objective. More detailed descriptions of the economic principles highlighted in this section may be found in Hutchison (1980). The following sections of this paper illustrate how the economic principles outlined in this section may be applied to some of the problems classified in Table 1.

4. COST MINIMIZATION FOR SPECIFIED STANDARDS

Many engineering design activities involve problems of this type where the issue is one of identifying the least total cost solution that achieves specified performance standards. A typical example is provided by the thousands of bridges that have been in service for many years and have reached the point where major repairs to the deck and structure are required, or the bridge may have to be re-built. A steel girder bridge with concrete deck is used in this section of the paper to demonstrate how simple economic analyses may be used to focus technical discussions. The actual bridge on which this example is based is 50 years old and the basic issue is whether to re-build the deck only, or to replace the bridge completely.

Table 2 summarizes the capital cost and the expected service life characteristics of the two alternatives. The maintenance costs of the two alternatives have been assumed to be the same and there is some uncertainty about the service life of the bridge under-structure.

ITEM	A DECK REPLACEMENT	B NEW BRIDGE
CAPITAL COST IN SFR	11'900'000	30'000'000
EXPECTED LIFE IN YEARS	30	100
EQUIVALENT ANNUAL COST IN SFR/YEAR	531'000	696'000

Table 2: Characteristics of the Bridge Re-Construction Alternatives

Since the two alternatives have different service lives the capital costs must be converted to equivalent annual costs, and this has been done in Table 2 using a discount or interest rate of 2 % per annum. This represents the difference between the current borrowing rate for governments in Switzerland and the average annual rate of inflation in construction costs over the past 50 years. The annual costs may be interpreted as the amount that would have to be paid each year over the life of the project to retire the capital debt plus the accrued interest. An inflation-corrected discount rate has been used since the deck repair alternative has an expected life of only 30 years and it would have to be replaced at a higher cost at the end of this period.

The table indicates that the equivalent annual cost of the deck repair alternative is about 25 percent lower than for the new bridge. If the bridge under-structure were to become unserviceable in, say 40 years, and a completely new bridge had to be constructed, then alternative A as analyzed in Table 2 is not directly comparable with the new bridge alternative. If SFr 30'000'000 had to be spent in 40 years then this is equivalent to an additional annual cost of SFr 497'000 which would make alternative B more economical. In fact the break-even life for the bridge under-structure may be calculated which would yield equivalent annual costs for the two alternatives and this is about 75 years. That is, unless the existing bridge under-structure lasts for more than 75 years, then the most economical solution is to re-construct the new bridge, and this break-even life calculation serves to focus the technical discussion.

It must be emphasized that analyses of this type are sensitive to the particular interest rate used. If the borrowing rate of 5 % is used then the break-even under-structure life would decrease to about 22 years. That is, the under-structure would only have to last a further 22 years to make alternative A the more economical solution. This simple sensitivity analysis serves to emphasize the point made earlier about the role of the interest rate as a capital rationing device. Low, or zero interest rates tend to encourage the adoption of capital intensive alternatives, where higher interest rates encourage the adoption of time-staged incremental type alternatives.

5. COST MINIMIZATION WITH MULTIPLE INPUTS

Consider a river which passes through an intensively formed and urbanized region where water pollution control plants exist at a number of locations along the river. A major source of water pollution is dissolved organic carbon and the problem is to identify the best set of additional investments in water treatment plants to reduce the expected dissolved organic carbon concentrations to the pollution control standards.

Existing treatment plants use a mechanical/biological treatment process to reduce the dissolved organic carbon content of waste water. The removal efficiency of this process is governed by the volume of the aeration tank. The upper limit of removal efficiency for this treatment technology is about 80 percent and further increases in the aeration tank volume have little impact on the removal efficiency. Higher removal efficiencies may be achieved by the addition of an activated carbon unit but this treatment technology is much more expensive.

Figure 1 summarizes the annual treatment cost information for two major treatment plants along a Swiss river experiencing pollution problems where these costs represent annual operating costs plus amortized capital costs. The annual costs are shown as a function of the additional concentration of dissolved organic carbon discharged into the river. The treatment costs at the two plants are a function of the volume of waste water to be treated, the pollutant concentrations and the river flow volume at each treatment plant site. The three points of mechanical-biological costs shown are for different sized aeration tanks and the four points of activated carbon costs are for increasing scales of treatment.

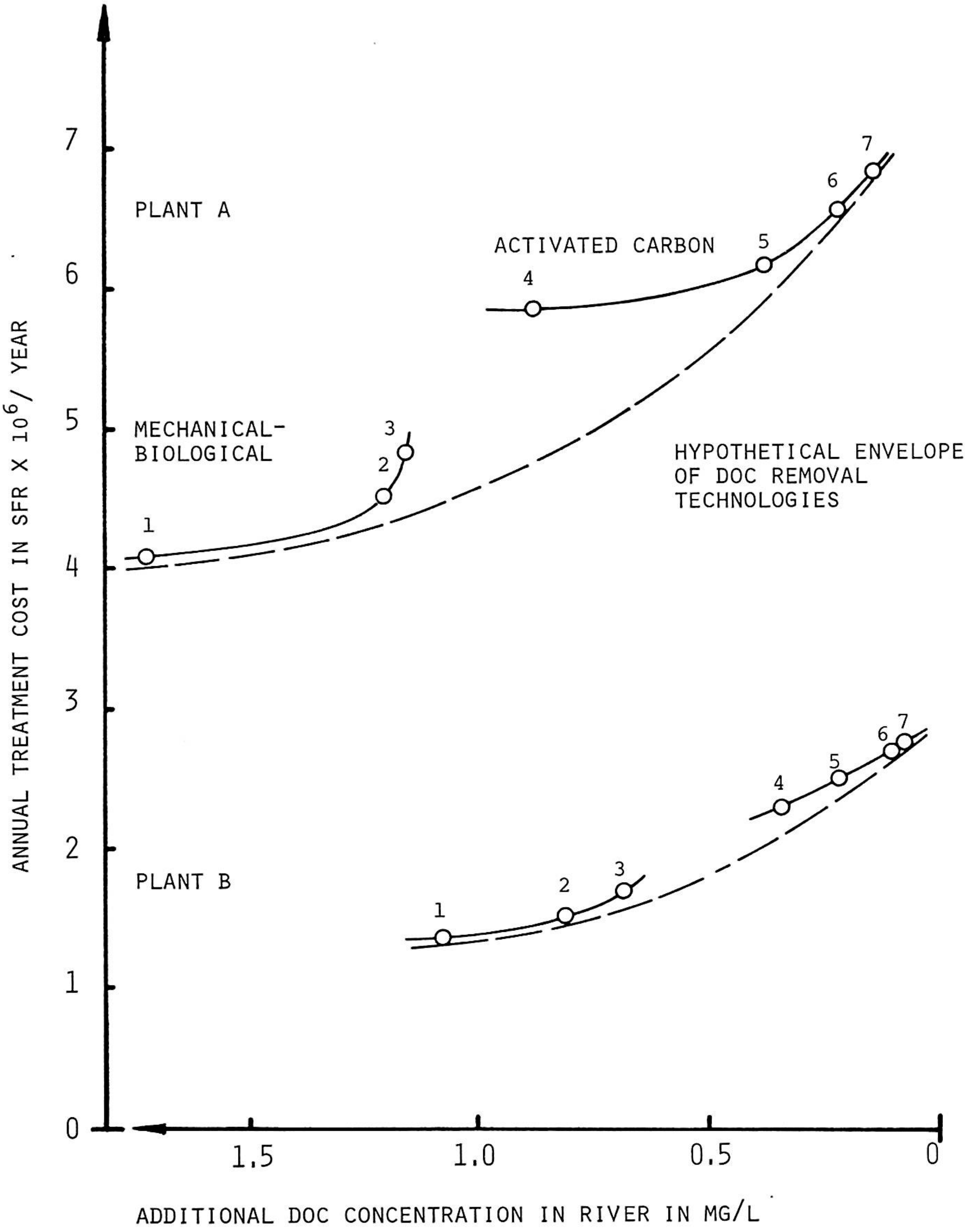

Figure 1: Annual Treatment Cost versus Additional Dissolved Organic Carbon Discharge

A hypothetical envelope for dissolved organic carbon treatment technologies for the two plants is illustrated on the diagram for each plant. Inspection of the mechanical-biological treatment cost function for plant A illustrates that a large increase in aeration tank capacity (alternative 3) has little impact on additional dissolved organic carbon removal. The cost characteristics of this technology diverge sharply from the hypothetical supply curve illustrating that it is being used beyond its optimal efficiency level. A similar tendency may be detected for plant B, but the divergence is not as large since plant B is a much smaller operation.

The cost characteristics of the activated carbon process also exhibit typical economic properties. The process is not very efficient at lower treatment levels (alternative 4 and 5) but the efficiency of the process approaches the hypothetical supply curve as the treatment intensity increases. A comparison of the cost characteristics of the two treatment processes and the hypothetical envelope would suggest that a treatment technology intermediate between the two might exist.

The least cost treatment investment combination between the two plants is achieved when the marginal costs per unit of pollutant removed are equal for both plants. The annual treatment cost characteristics of Figure 1 are expressed in marginal cost terms in Table 3, where the marginal costs simply reflect the rate of change of the annual cost curves of Figure 1. The marginal costs presented in Table 3 allow the best sequence of treatment plant investments to be readily identified until an adequate level of dissolved

TREATMENT ALTERNATIVE		INCREASE IN ANNUAL TREATMENT COST IN SFR	DECREASE IN DOC CONCENTRATION IN MG/L	MARGINAL COST SFR/MG/L
PLANT A	2 → 1	458'000	0.53	864'000
	3 → 2	300'000	0.04	7'500'000
	5 → 2	1'920'000	0.83	2'313'000
	6 → 2	2'361'000	1.05	2'249'000
PLANT B	2 → 1	95'000	0.26	365'000
	3 → 2	207'000	0.12	1'725'000
	5 → 2	1'219'000	0.46	2'650'000
	6 → 2	1'422'000	0.72	1'975'000
	6 → 3	1'215'000	0.60	2'025'000

Table 3: Marginal Costs of Dissolved Organic Carbon Removal

organic carbon removal is achieved to maintain pollution standards along the river. The sequence should be plant B - alternative 2, plant A - alternative 2, plant B - alternative 3, plant B - alternative 6 and plant A - alternative 6. The table illustrates very clearly the sharp increase in treatment costs that occur with very high levels of disolved organic carbon removal.

6. NET BENEFIT MAXIMIZATION FOR A SINGLE OBJECTIVE

In the example presented in the previous sections it was assumed that standards existed for the performance of the systems, and the benefits obtained from the systems did not have to be considered explicitly. For example, in the pollution control example it was assumed that an upper limit existed on the allowable concentration of dissolved organic carbon and that this limit had to be satisfied by any system being recommended. In other cases, specific standards do not exist and the benefits expected from alternative solutions must be considered explicitly.

A representative example of this problem class is provided by a flood control example where flood damage may be decreased by various levels of investment in flood retarding reservoirs on the river system. Figure 2 illustrates the benefit and cost characteristics of a typical flood control system.

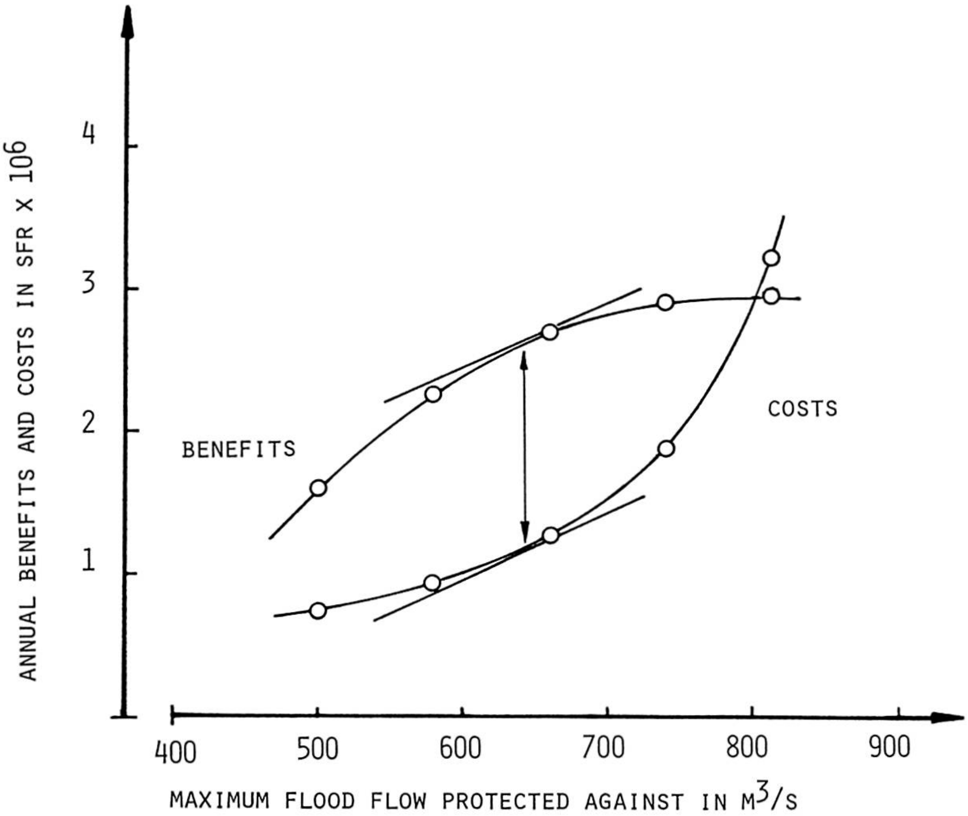

Figure 2: Annual Benefits and Costs of Flood Control

The annual costs reflect amortized capital costs plus annual operating and maintenance costs. The benefits are the expected annual savings in flood damage costs derived from providing protection against various flood flow magnitudes. The costs continue to accelerate as higher levels of flood protection are provided, while benefits begin to level off reflecting the fact that flood damage savings are being derived from protection against low frequency of occurence floods.

Inspection of Figure 2 shows that the maximum difference between benefits and costs is obtained by providing protection against a flood flow of about 640 m3/s. That is, net benefits are maximized at this project scale, or alternatively marginal benefits are equal to the marginal costs. The analyses summarized in Figure 2 are based on five project scales and the costs for each project scale are a minimum in the sense that they represent the least cost combinations of possible reservoirs. The estimation of flood damage benefits is straight-forward in the sense that they are derived from savings in flood damage costs. The estimation of benefits for other public sectors, such as transport, is more complex in that the expected changes in transport demand resulting from a particular project must be first estimated and then used to estimate changes in consumer surplus, Hutchinson (1980).

7. NET BENEFIT MAXIMIZATION FOR MULTIPLE OBJECTIVES

It has been pointed out previously that a classical multiple objective problem is a reservoir whose storage capacity may be used either for flood control or for hydro-electric power generation. This situation is illustrated in Figure 3 using the concept of a production possibility frontier, or transformation function. The storage capacity provided by a particular level of investment may be used completely for flood protection (point A), completely for energy production (point B), or some combination (point C) along the production possibility frontier.

The frontier ACB is for a particular project scale and a lower level of investment might yield the production possibilities illustrated by the broken line. The production possibility frontiers represent the most efficient allocations of resources to production in the sense discussed in Section 5.

The best combination of outputs to produce depends on the relative values of the outputs. For the two outputs used in this example the benefits may be expressed directly in monetary terms and the point on the transformation function that maximizes the benefits derived from the two outputs identified, say point D. Thus the optimal dual purpose project may have a different character from the two optimal single purpose projects; the optimal single purpose flood control project would of course be represented by point A.

Multi-objective evaluation procedures have been widely used in the water resources planning area particularly in the U.S.A. With systems involving several objectives and a variety of constituent projects it is not possible to apply the ideas illustrated in Figure 3 directly. Cohan and Marks (1975) provide a comprehensive review of much of the American work.

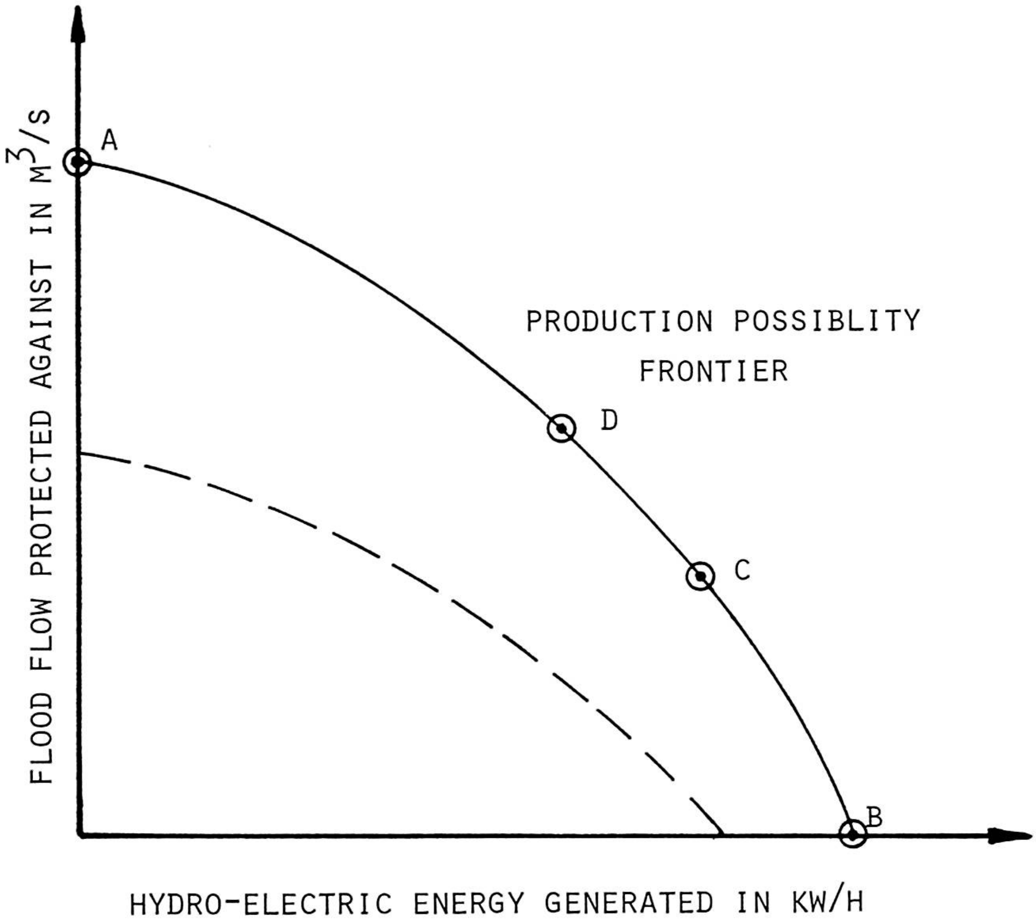

Figure 3: Flood Control and Electricity Generation
Production Possibility Combinations

9. LEAST CONTROVERSIAL PROJECT

In certain types of public projects there may be a number of projects that are roughly equivalent in the economic sense described in the previous paragraphs, but where the evaluation issue is to identify the least controversal project. It is often argued that it is impossible to convert all of the important impacts of projects into equivalent monetary terms because of the many interest groups with their different value systems. The inter-personal comparisons of utilities represents one of the intractable problems of economic based methods. It can be argued that under these circumstances the principal issues in evaluation are: (i) the isolation of unacceptable alternatives, (ii) the identification of inferior alternatives, and (iii) the trade-offs between the impacts of the remaining alternatives.

Figure 4 illustrates the essence of the evaluation problem when there are significant differences in the perceived impacts of alternatives between different socio-economic groups, or positions. A cell entry in any of the alternatives - impact matrices represents the perceived utility by a particular position where this entry is constrained to a range between 0 (least desirable) and 1 (most desirable). The mean scale value may be assigned a magnitude of 0.5 with values of less than 0.5 being considered as unacceptable and values of greater than 0.5 being acceptable.

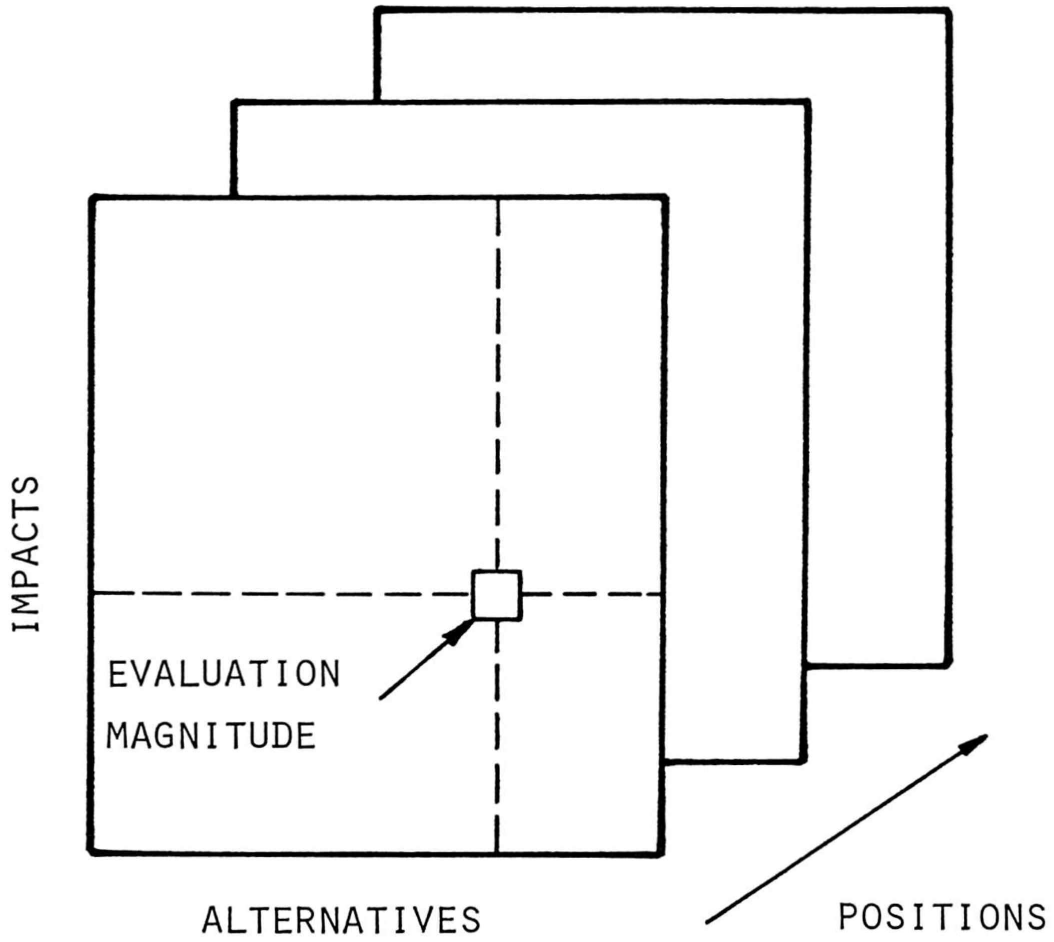

Figure 4: Evaluation Matrices for Different Alternatives, Impacts and Positions

Consider an example of a hypothetical water resources project with seven alternatives and seven classes of impacts described by Znotimas and Hipel (1979). The impact-alternative matrices for three interest groups are summarized in Figure 5, where the (-) for the cost line of position 3 indicates that the downstream group affected by the project have no direct involvement with the cost factor. The basic program in this type of evaluation method is how to aggregate the evaluation matrices so that the most desirable alternative may be identified.

Using some principles of fuzzy set analyses Znotinas and Hipel (1979) identify a number of operations for aggregating the matrices, where the operation discussed in this paper is known as the pessimistic operation. The pessimistic aggregation attempts to minimize the risk of project rejection by considering the worst impact viewpoint for each of the three positions. The pessimistic aggregation of the three positions of Figure 5 is presented in Figure 6. This pessimistic aggregation has been obtained by selecting the lowest cell entry for each of the three positions.

NET BENEFIT EVALUATION MATRIX FOR POSITION 1

FACTORS	ALTERNATIVES						
	A_1	A_2	A_3	A_4	A_5	A_6	A_7
AGRICULTURE	.7	.6	.4	.8	.7	.7	.1
FISH	.7	.6	.5	.7	.8	.8	.3
RECREATION	.7	.7	.7	.7	.7	.7	.4
SOCIAL	.7	.6	.6	.7	.7	.7	.1
WATER SUPPLY	.7	.4	.3	.7	.7	.7	.2
WILDLIFE	.4	.6	.7	.5	.6	.6	.6
COST	.3	.6	.8	.5	.3	.3	.5

NET BENEFIT EVALUATION MATRIX FOR POSITION 2

FACTORS	ALTERNATIVES						
	A_1	A_2	A_3	A_4	A_5	A_6	A_7
AGRICULTURE	.5	.6	.7	.5	.5	.5	.9
FISH	.5	.5	.5	.5	.6	.6	.6
RECREATION	.6	.6	.6	.6	.6	.6	.6
SOCIAL	.4	.5	.6	.4	.4	.4	.8
WATER SUPPLY	.6	.4	.3	.6	.6	.6	.4
WILDLIFE	.4	.5	.6	.4	.5	.5	.8
COST	.3	.6	.8	.5	.3	.3	.5

NET BENEFIT EVALUATION MATRIX FOR POSITION 3

FACTORS	ALTERNATIVES						
	A_1	A_2	A_3	A_4	A_5	A_6	A_7
AGRICULTURE	.5	.5	.6	.4	.3	.4	.8
FISH	.4	.4	.5	.3	.5	.5	.8
RECREATION	.4	.4	.5	.4	.5	.5	.6
SOCIAL	.4	.4	.5	.4	.4	.3	.7
WATER SUPPLY	.4	.4	.5	.4	.3	.4	.8
WILDLIFE	.4	.4	.5	.3	.3	.3	.8
COST							

Figure 5: Evaluation Matrices for Three Interest Groups

It is now possible to review the pessimistic matrix and to perform the following operations:

(i) remove impact factors from further consideration if it has identical magnitudes across alternatives; or, if an impact has a magnitude greater than the acceptability magnitude (0.5 or above) then the impact is not critical and may be removed from the evaluation.

PESSIMISTIC AGGREGATE							
FACTORS	ALTERNATIVES						
	A_1	A_2	A_3	A_4	A_5	A_6	A_7
AGRICULTURE	.5	.5	.4	.4	.3	.4	.1
FISH	.4	.4	.5	.3	.5	.5	.3
RECREATION	.4	.4	.5	.4	.5	.5	.4
SOCIAL	.4	.4	.5	.4	.4	.3	.1
WATER SUPPLY	.4	.4	.3	.4	.3	.4	.2
WILDLIFE	.4	.4	.5	.3	.3	.3	.6
COST	.3	.6	.8	.5	.3	.3	.5

Figure 6: Pessimistic Aggregation of Positions

(ii) remove alternatives from further consideration whose evaluation proviles are dominated by other alternatives.

Neither of the conditions identified in (i) exist for the pessimistic aggregation presented in Figure 6 but with condition (ii) it may be seen that alternative 2 dominates alternatives 1 and 4 and the dominated alternatives may be removed to produce the reduced aggregate table shown in Figure 7.

Inspection of Figure 7 shows that alternative 3 dominates the other three alternatives except for the impacts identified by the squares. At this stage, further aggregation of the matrix to produce a single index of value for each alternative may only proceed if further assumptions are made about the relative importance of the different impacts. Ultimately with this method judgments about the trade-offs between different objectives cannot be avoided. However, the advantage of the approach is the reduction of the dimensionality of the problem to the minimum number and discussion may then be focussed on the critical trade-offs.

REDUCED PESSIMISTIC AGGREGATE				
FACTORS	ALTERNATIVES			
	A_2	A_3	A_6	A_7
AGRICULTURE	.5	.4	.4	.1
FISH	.4	.5	.5	.3
RECREATION	.4	.5	.5	.4
SOCIAL	.4	.5	.3	.1
WATER SUPPLY	.4	.3	.4	.2
WILDLIFE	.4	.5	.3	.6
COST	.6	.8	.3	.5

Figure 7: Reduced Pessimistic Aggregation

9. LARGE SCALE ONE-OFF PROJECTS

Some projects, such as large new airports, may have such widespread impacts of different types on different interest groups that formal evaluation techniques may have little to contribute to the choice process. For example, a new airport may reduce expected aircraft congestion significantly but may impose high noise levels on areas containing significant amounts of developments. While economic-based methods of evaluation may help to highlight some of the consequences, the essential problem is one of reconciling the differences between the various interest groups.

One proposal that may make a contribution to problems of this type is the use of game-theoretic approaches. Hipel (1974), Ragade (1976) and Hipel and Fraser (1980) have suggested the use of metogame analyses as an aid to the identification of politically feasible water resources projects. The preferences of the various interest groups with respect to alternative courses of action are developed and metogame analyses may be used to predict potential politically feasible solutions.

10. CONCLUDING REMARKS

The use and impact of formal evaluation techniques on public sector planning and design has been quite variable. One of the difficulties has been that professionals have attempted to use the available evaluation techniques in some absolute sense, rather than as an aid for focussing planning and design activities.

An hierarchy of typical evaluation problem classes has been identified where these problems range from relatively straight forward cost minimization problems to problems which are dominated by political and social issues. A variety of evaluation techniques exist which may assist in the evaluation of alternative solutions to problems of each type. These techniques range from the simple techniques of engineering economic analysis through the welfare theory based methods of benefit-cost analysis to game-theoretic methods. To be effective the techniques must be carefully applied and should be thought of as methods for assisting the technical analyst to identify solutions which are technically, economically and politically feasible.

REFERENCES

Cohon, J.L. and Marks, D.H. (1975) "A Review and Evaluation of Multiobjective Programming Techniques", Water Resources Research, Vol. 11, No. 2.

Hipel, K.W., Ragade, R.K. and Unny, T.E. (1974) "Metagame Analysis of Water Resources Conflicts", Journal of the Hydraulics Division, ASCE, Vol. 100, No. HY 10, pp. 1437-1455.

Hipel, K.W. and Fraser N.M., (1980) "Metagame Analysis of the Garrison Conflict", forthcoming in Water Resources Research.

Hutchinson, B.G. (1980) "Investment Evaluation and Programming for Public Systems", Institut für Bauplanung und Baubetrieb, ETH Zürich.

Ragade, R.K., Hipel, K.W. and Unny, T.E. (1976) "Metarationality in Benefit Cost-Analysis, Water Resources Research, Vol. 12, No. 5, pp. 1069-1976.

Znotinas, N. and Hipel, K.W. (1979) "A Comparison of Alternative Engineering Design", Water Resources Bulletin, Vol. 15, No. 1.