METHODS FOR EVALUATING NON-MARKET IMPACTS IN POLICY DECISIONS WITH SPECIAL REFERENCE TO WATER RESOURCES DEVELOPMENT PROJECTS

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METHODS FOR EVALUATING NON-MARKET IMPACTS IN POLICY DECISIONS WITH SPECIAL REFERENCE TO WATER RESOURCES DEVELOPMENT PROJECTS

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This working paper explores the as yet intractable problem of accounting for non-market impacts in policy decisions especially in the context of water resource development projects. In the first section, 19 methods will be presented and critiqued in general terms. In the second section, the social impacts of water resource projects will be reviewed and related to the 19 valuation methods. In the final section a number of critical issues involved in valuing non-market impacts will be discussed.

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PREFACE

Several issues typically surface as a Corps Planner begins a social impact assessment. For example, what is an impact? What type of data should be used? Is the analysis to be quantitative or qualitative? How can the monetary and non-monetary be compared? Too often such questions about data and techniques cloud another important issue; How will the social impact assessment fit meaningfully into the Corps planning process?

As outlined in Corps Engineering Regulations Series 1105-2-200-250, planning is done in three phases. However, four separate tasks are performed in each phase; Problem identification, formulation of alternatives, impact assessment and evaluation. Each task is repeated in each phase with different emphasis.

This report reviews those comparative techniques most applicable to the evaluation task. Since the emphasis on evaluation varies in each planning phase, resources devoted to the evaluation task within each planning phase are also likely to vary. Consequently, different evaluation techniques might be appropriate in different planning phases.

Whether one or several evaluation techniques are employed, they must fit with the assessment of identified problems and alternatives. This fitting can be difficult especially when comparing environment to social well-being or economic development. Social Science techniques which supplement and go beyond traditional cost/benefit analysis can be meaningful here in the evaluation task of the Corps planning process. Dr. Finsterbusch's review is a good place to start examining the available comparative techniques.

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INTRODUCTION

This working paper explores the as yet intractable problem of accounting for non-market impacts in policy decisions especially in the context of water resource development projects. In the first section, 19 methods will be presented and critiqued in general terms. In the second section, the social impacts of water resource projects will be reviewed and related to the 19 valuation methods. In the final section a number of critical issues involved in valuing non-market impacts will be discussed.

Work on evaluation frameworks is in a relatively primitive stage of development. All methods discussed in this paper have deficiencies and should be used cautiously. The limited achievement of the methods is to be expected because they must somehow accomplish the extremely difficult task of making interpersonal comparisons of utilities. Philosophers, economists, political theorists, and public decision-makers have been thinking about the problem for centuries and no solution is yet available. But some methods are better than other methods for various decision situations and the following review not only identifies a large number of methods but also assesses their strengths and weaknesses.

I. METHODS FOR VALUING NON-MARKET IMPACTS

I. Methods for Valuing Non-Market Impacts

Market impacts are all impacts directly measured in market prices; sharing the common metric of money, they can be evaluated relative to each other. Non-market impacts do not share a common metric, and, hence, cannot be evaluated relative to each other without a special methodology that compares unlike values. In this section a wide range of valuing methods are considered.

Table I presents the nineteen valuation techniques developed by social scientists to assess non-market impacts. Two generic sets of techniques can be identified. The first of these sets are the techniques to derive a cumulative number for each option under consideration; these numbers provide a concise basis for selecting the "best" option. These common-metric or weighting-scheme techniques are sufficient in themselves for making a decision (unless, of course, the absolute numbers derived are identical). The second set of techniques do not present cumulative numbers. Rather, they provide information - in itself insufficient to make a decision - to be utilized within a decision process. The former techniques completely determine the decision; the latter are indeterminant in themselves, leaving the final decision to a process sometimes prescribed by, but not controlled by, the research team.

A. Common Metrices

1. Objective Metrics

The ideal valuation technique is one which can account for all of the consequences of each alternative on a common objective metric. This is an unrealizeable ideal thus sole reliance on the objective metric technique cannot be recommended. The shortcomings of this technique can be illustrated by efforts to use money as the metric for all impacts (time, energy and lives are other possible objective metrics). Money measures market impacts of projects or policies and with ingenuity many non-market impacts can be converted to dollar values. Unfortunately, not all consequences of projects or policies can be accounted in terms of money; some impacts will be ignored, and others will be valued inaccurately. Since no valuation technique can be perfect, however, one might justify utilizing dollar valuations for all impacts as the best solution in an imperfect world. In our judgment the measurement problems are almost always too great to make this valuing technique the optimal approach.

A prime example of the difficulties inherent to dollar valuing a non-market impact is the price to be placed on lives which are estimated to be saved or lost because of a new highway. This issue is explored by Margaret Hornblower in the Washington Post, November 29, 1976. She reports that the Occupational Safety and Health

Table 1

Alternative Evaluation Frameworks for Comparing Non-Market Values

A. Common Metrics
   1. Objective Metrics
   2. Subjective Metrics

B. Weighting Schemes
   1. Consensual Weights
   2. Formula Weights
   3. Justified Subjective Weights
   4. Subjective Weights
   5. Inferred Subjective Weights
   6. Ranking
   7. Equal Weight
   8. Multiple Methods

C. Discrete Dimensions Evaluation
   1. Balance Sheet
   2. Lexicographic Pruning
   3. Minimum Criteria Analysis

D. Methods Which Utilize Public or Political Evaluations
   1. Public Choice
   2. Advisory Committee Choice
   3. Political Process Outcome

E. Methods Which Obviate Evaluation
   1. Standardize Costs or Benefits
   2. Minimize Negative Effects
   3. Compensation and Mitigation

Administration is requiring steel companies to install devices and adopt work practices for controlling coke fumes at a cost of $241 million a year in order to save an estimated 240 lives a year, i.e., $1 million per life saved. Another estimate is $158 million per life saved. The Council on Wage and Price Stability calculates the costs at $4.5 million per life saved and opposed the regulations as inflationary. Safety regulations in most other areas have much lower costs per life saved. So what is the "official" value of a life? The courts, for compensating the families of automobile crash victims, calculate the value of a life to be equal to a person'e expected future lifetime earnings. Another method for calculating a value for life is to estimate how much real income people would accept for an increased risk of death. Hornblower cites two studies which used this method and calculated that people value their lives at $15 million and $200,000 respectively. This extraordinary range badly discredits this method. Public opinion is also not very helpful. In a survey of 435 adults $28,000 was the average response to the question "How much in dollars is the human life worth?" As Hornblower concludes. "What is the value of a human life? Pick a figure: $153 million, $4.5 million, $200,000, $28,000."

The above discussion is a helpful tonic for a feverish enthusiasm for quantification, but it would be unfortunate if it squelched efforts to translate non-market impacts into monetary terms. Useful transformations abound. Two procedures with relatively general applicability are costing outputs and costing the negation of outputs. Schmid (1975) has the decision maker assign subject values to specified amounts of various project outputs. The outputs of each project alternative are measured and multiplied by the subjective values to obtain a total benefit score for each project alternative. He divides the benefit score by the alternative's cost to obtain the benefit-cost ratio. He even computes implied prices for each output from the subjective values and the costs. A less subjective method of computing prices for project outputs in proposed by Melinyshyn, et. al., (1973). The price of project impacts is equated to "the cost of preventing the impact, the replacement cost, or a value judgment." (p.4). Subjective judgments are used when no objective method is available.

It should be noted that benefit-cost analysis is committed to accounting impacts in monetary values. If benefit-cost analysis is only one of several analyses used in the evaluation of project alternatives, its limitation to dollar values is also its strength. Alternatives which have dollar costs greater than dollar benefits can be eliminated unless non-market net benefits are large. But generally non-market impacts of projects are on balance negative so benefit-cost ratios less than 1.0 can be an exclusionary criteria. Beyond this the benefit-cost ratio for market impacts is a valuable index for comparing alternatives. These assets of benefit-cost ratios are squandered when benefit-cost analysis ambitiously attempts to also

account non-market impacts. Then it combines values with very large error margins with values with very small error margins and dilutes its precision and losses its credibility.

2. Subjective Metrics

Subjective metrics should be distinguished from subjective weights which will be discussed later. Subjective weights may be obtained by asking subjects to place various items on a scale from -1000 to +1000 with zero as the neutral point. The scaling depends upon the particular set of items to be scaled since the worst or best item is assigned one of the extreme values and the remaining items are scaled in relation to it and the zero point. The subjective metric extends the weighting technique by constructing a metric for a specified dimension; hundreds of responses are averaged to determine a weighting value to be applied universally in the subsequent metrics. For example, Holmes and Rahe (1967) have established a Social Readjustment Scale for scaling all stressful life events. Many stressful events have been placed on the scale through national sample surveys - for example the death of one's spouse is 100 and moving to a new home, 20 - and others could be added without disturbing these placements. Subjective metrics, therefore, are more than subjective ad hoc weightings of a set of specific impacts, but are established sets of weights yielding generic metrics applicable to many decision processes. When carefully derived they are eminently useful. If such a scale could be created for the most general dimension of all, general personal utility, it would bring the millenium for valuation research. Unfortunately no such metric exists and probably never will. Meanwhile, all extant metrics, being less general cannot scale all impacts of complex policies. A subjective metric, therefore, cannot provide a complete evaluation framework.

B. Weighting Schemes

Because of the current weaknesses of common metrics techniques, they must be dismissed as unfeasible for public project planning decisions. In contrast, weighting schemes are both feasible and widely practiced. Weighting schemes do not seek the common ground between differing items as do common metrics. Rather, they recognize the uncommonness of differing items and measure them on different metrics. The weighting scheme then provides procedures for aggregating scores on separate dimensions into a total score for each policy alternative. Eight types of weighting schemes will be reviewed. (These schemes are not mutually exclusive.)

1. Consensual Weights

Consensual weights represent a consensus among experts or an

official decision of an authoritative group. Consensual weights do not presently exist in the field of impact assessment. Consensually derived thresholds, however are common. For example, 70 decibels is generally considered the threshold which should not be exceeded by highway noise levels and regulations now require that highways be designed to keep noise levels beneath this point. Thresholds for minimum acceptable performance levels are different enough to consensually establish but they are much easier to create than consensual weights. The weights should be constructed from empirically established trade-off curves for affected parties which are difficult to obtain with precision. Then aggregating the trade-off curves for each effected party into an overall trade-off curve requires subjective judgments of the relative importance of each groups' trade-off curves. When this process is repeated on various occasions with similar results and many experts agree that the average results can be generalized, consensual weights are created. This process is too cumbersome to be practical for deciding among alternatives for specific projects, but it is hoped that consensual weights will evolve in the future that can then be applied to specific cases.

2. Formula Weights

Formula weights are calculated by applying mathematical operations to quantified measures. For example, the weight for the ith impact might be expressed in the formula

$$w = \sum_{i=1}^{n} P_{ij} \; I_{ij} \; p_{ij}$$

where P_{ij} is the number of people of catagory j to be impacted by the ith impact times an average intensity I_{ij} of the ith impact for the jth group times an average probability p_{ij} of the ith impact for the jth group. In other words, for each impact the size of every impacted group is multiplied by the intensity and probability of impact on that group and these scores are summed for all groups and for all impacts. These are extremely difficult scores to determine so these formula weights are unfeasible for most projects. The most difficult task seems to be the estimation of the average magnitude of impact for each affected group. The widely accepted scale of stressful life events mentioned above (Holmes and Rahe, 1967) may provide the base for an impact magnitude scale but considerable research would be required to locate most project impacts on this or any other scale.

Two formula weighting systems are reviewed to indicate the magnitude of the effort required by this approach. Melinyshyn, et. al, (1973) have developed a formula weighting system for evaluating transportation improvements for the Ontario Ministry of Transportation. They describe their method as follows:

> Each social and environmental impact was. . .considered within the following framework
>
> Benefit or disbenefit (value equivalent) = quantity x sensitivity x cost.
>
> Where quantity is a measure of the amount of change that takes place because of the introduction of an improvement (e.g., 25 acres of recreational land taken, 2,000 people in community relocated, unemployment rate reduced by 1.5 percent); sensitivity indicates the relative sensitivity of the community to the quantity of improvement impact, is designed to take on values ranging from 0 to 1, and can be direct input from public participation programs; and costs is taken as the cost of preventing the impact, the replacement cost, or a value judgment that would be subject to sensitivity analysis and revision by decision-makers. (p.4)

This formula weighting system is a component of a complex priority planning methodology. The formula results are used

> to develop time streams of present worth of benefits as functions of the year of implementation. The functional benefit and cost time streams are combined with future budget estimates and subjected to linear programming analysis. The linear program selects and stages a mix of transportation improvements that maximizes the total present worth of benefits capable of being realized, given the assumed budgets. The methodology has important potential uses as both a management decision-making tool and a readily accessible transportation planning data source. (p.1)

Formula weights have been used for water resource developments by a group at Battelle-Columbus (Baker, et. al., 1974). Their environmental Evaluation System (EES) consists of four components: ecological, physical-chemical, esthetic, and human interest factors. Each component is subdivided into subcategories and sub-subcatagories. For example, the human interest factor "refers to those aspects of human life that are above and beyond the absolute necessities for human existance and the quality of which are highly dependent on the condition of the natural environment." (p.12) It has five subcategories: 1) education and science, 2) history, 3) culture, 4) mood/atmosphere, and 5) life patterns. Each of these subcategories is further divided into sub-subcategories. For example, life patterns is subdivided into: 1) employment opportunities, 2) housing, and 3) social interactions.

The items at this third level of subcategorization are scored according to a set of assessment instructions. The authors' description of their instructions for scoring the educational/scientific subcategory is summarized as follows:

1. Identify all occurences within the project area that apply to this parameter.

2. Think of all occurrences totally as a package.

3. Determine whether or not this total "package" is of any significance.

4. a. If it is determined that the package does have significance, refer to the value function to make a "without/with" evaluation of the package.
   b. If it is determined that the package does not have significance, it will not be included in the valuation. (p.17)

The above packages are identified as either internal or external. Internal packages are ones that directly affect persons in the project area but are not of significant concern to persons outside the project area. External packages are for projects that do have significance for persons outside the project area ("area" may or may not have a particular geographical connotation or boundary).

The valuation function with scores for internal and external packages is:

		Internal Package	External Package
a.	High	.5	1.0
b.	High - Medium	.3	.8
c.	Low - Medium	.2	.7
d.	Low	.1	.6
e.	None	0	0

The bases for determining the value of the package are

1. The number of people visiting or using the components of the package.

2. The intensity of interest shown by those people making use of it.

3. The intensity of objections expressed by people if change to the package or a part of the package is indicated.

4. The value placed on the package by an expert in the field (e.g., archeologist, ecologist, or a geologist). (p.18)

The authors do not provide the formula for determining the value of the package but their instructions imply some formula such as the following:

$$\text{value} = PIV$$

Where P = the number of people visiting or using the components of the package, I = the intensity of interest of users plus the intensity of objections to changes, and V = the value placed on the package by an expert. The authors also do not indicate how all of the value scores are combined into an overall EES score but we assume that they are simply summed.

Formula weights must be computed from quantified measures. Most formulas also require that the measures be ratio scaled. Measureable quantities, like the number of people impacted, cost of compensating adverse impacts, cost of nullifying adverse impacts, or vehicle miles carried per day, can be used for formula weights. Both of the above examples, however, included variables which are difficult to quantify and impossible to measure with ratio scales. They are therefore not true examples of formula weights. No examples of strictly formula weighting procedures have been observed which suggests that they may be too demanding or too impractical for assessments given current levels of funding. Though complete reliance on this approach can not be recommended until its feasibility has been successfully demonstrated, its use along with other approaches deserves consideration.

3. Justified Subjective Weights

Subjective weights are commonly used in formal decision making frameworks but justification for the selected weights is rarely provided. Greater use of justified subjective weights is recommended because reviewers need to know on what basis the weights were devised. Only when the criteria for assigning weights are explicitly identified can criticisms of subjective weights be properly targeted and induce revisions which will have greater persuasiveness. Consensus evolves out of critical dialog which is stimulated by justifications of subjective judgments. Sometimes consensus does not emerge but this in itself is an important fact.

Justified subjective weights may be explicit weights which the research team selects on the basis of all of the information available to it. In this manner the author has proposed weights for census area variables which were used in a highway location formula (Finsterbusch, 1977). Explanations are provided for assigning large or small weights to variables. New information or good counter arguments would lead to revisions of the formula.

When outside experts are used to provide weights in a full delphi process the individual experts must justify their weights and criticize the weights of those with whom they disagree. Thus, delphi involves discursive feedback that results in revisions in individual judgments, generally in the direction of greater consensus. The delphi technique, therefore, produces a group decision and arguments which can be synthesized into a rationalization of the group decision.

Dean and Shih (1973) use a delphi process to obtain weightings for water quality, water quantity, social acceptability and costs in computing utility values for different water resources alternatives for San Angelo, Texas. They do not think, however, that the group weights warrant any confidence. "Due to the small sample of ten persons that took part in this particular survey, the results are highly questionable." (p.947) This author takes exception to that statement. Ten experts, if they are in general agreement, can command considerable confidence especially if their reasons are presented to the reader. Only when we do not know on what basis they made their judgments are we unable to evaluate the credibility of their judgments.

4. Subjective Weights

An extremely prevalent evaluation technique is subjective weighting which deserves extensive treatment in this review. There are many variations of this technique which differ in terms of the elements which are weighted and the choice of weighting procedures. Subjective weights may be assigned to objectives, dimensions, impacts or alternatives. Subjective weights may be assigned by decision makers, expert judges, representatives of interested parties, or samples of the relevant general public. Subjective weights may be assigned by a simple score assignment process, a trade-off matrix, paired comparison trade-offs, indifference curves, or delphi procedures. These four elements for weighting, the four types of assessors, and the five weighting procedures make 80 combinations. Our comments will be limited to the elements for weighting and the weighting procedures.

Weights may be assigned to objectives, dimensions, impacts or alternatives. These are distinct but related and overlapping concepts. Objectives are goals which the project is to serve. For example, an objective of a highway would be to increase the accessibility between areas. Dimemsions are analytical categories for studying impacts. Many dimensions are directly related to objectives. For example, one dimension used by highway planners is travel time savings which is a good indicator for the accessibility objective. Another dimension is the number of residents displaced. Minimizing residential displacement may or may not be an objective of the highway plans. A dimension which is not likely to be related to an objective of the highway is the increased or decreased value of properties adjacent to the highway. In sum, most dimensions are measurable indicators for objectives but not all.

Dimensions are also related to impacts. Dimensions measure many but not all of the impacts. For example, an alignment which displaces 640 residents is so scored on the residential displacement dimension. Some impacts, however, will not be covered by a dimension and will be ignored in the assessment. For example, highway construction fills the air with dust which settles on neighboring

properties. Seldom is this impact made part of the impact analysis.

Below we review a number of examples of formal decision making frameworks which are based on subjective weights. The items weighted may be objectives, dimensions, impacts or alternatives. For illustration purposes suppose that a citizens panel is asked to provide subjective weights for evaluating four highway alignments. The panel may be asked to assign scores directly to each alignment after reviewing their specifications and impacts. The panel may be asked to assign plus or minus scores to all of the impacts of each alignment and the analysts would add these scores to obtain a total score for each alignment. The panel may be asked to rank or score served highway related dimensions like user savings, noise impacts, residential displacement, etc. Then the analysts would multiply each alignment's score on a dimension by the panel's weight for that dimension and sum across dimensions to obtain total scores for each alignment. Finally, the panel may be asked to weight the various objectives. Then the various alternatives would be scored on the degree to which they fulfil various objectives. The relative scores on objectives would then be multiplied by the respective weights for objectives to obtain total scores for each alternative.

An approach to assessment which focusses on objectives was developed by Charnes and Cooper (1961) and Charnes, et. al, (1969) and is called goal programming. Objectives are identified and targets and acceptable minimal levels are set on each objective. Some alternatives may be disqualified for failing to attain the minimum acceptable standards. The remaining alternatives are assessed in terms of deviations from the targets. The deviations are subjectively weighted and the alternative is selected which minimizes the weighted deviations from the targets.

The goal programming technique is very similar to the "goals achievement matrix" evaluation technique developed by Hill (1967 and 1973), Jessiman, et. al., (1967), Falk (1968), and Schimpeler and Grecco (1968) for assessing transportation improvements. Objectives or goals are identified and subjectively weighted for an improvement, a measure (or dimension) is specified for each objective, achievement on each objective is measured or estimated for each alternative. From these operations a weighted goals achievement index can be computed for each alternative to determine the best choice. Sometimes rather simple goal structures are used but sometimes they are very complex as in the transportation goal hierarchy of Hill (1967) presented in Figure 1.

The subjective weighting of dimensions is central to a developing field called multiobjective planning. For two overviews of this field see MacCrimmon (1973) and Cohon and Marks (1975). The dimensions are variously named as attributes, decision criteria, objectives, evaluation parameters, etc. Sometimes they are broadly defined and overlap with objectives. For example, as cited above,

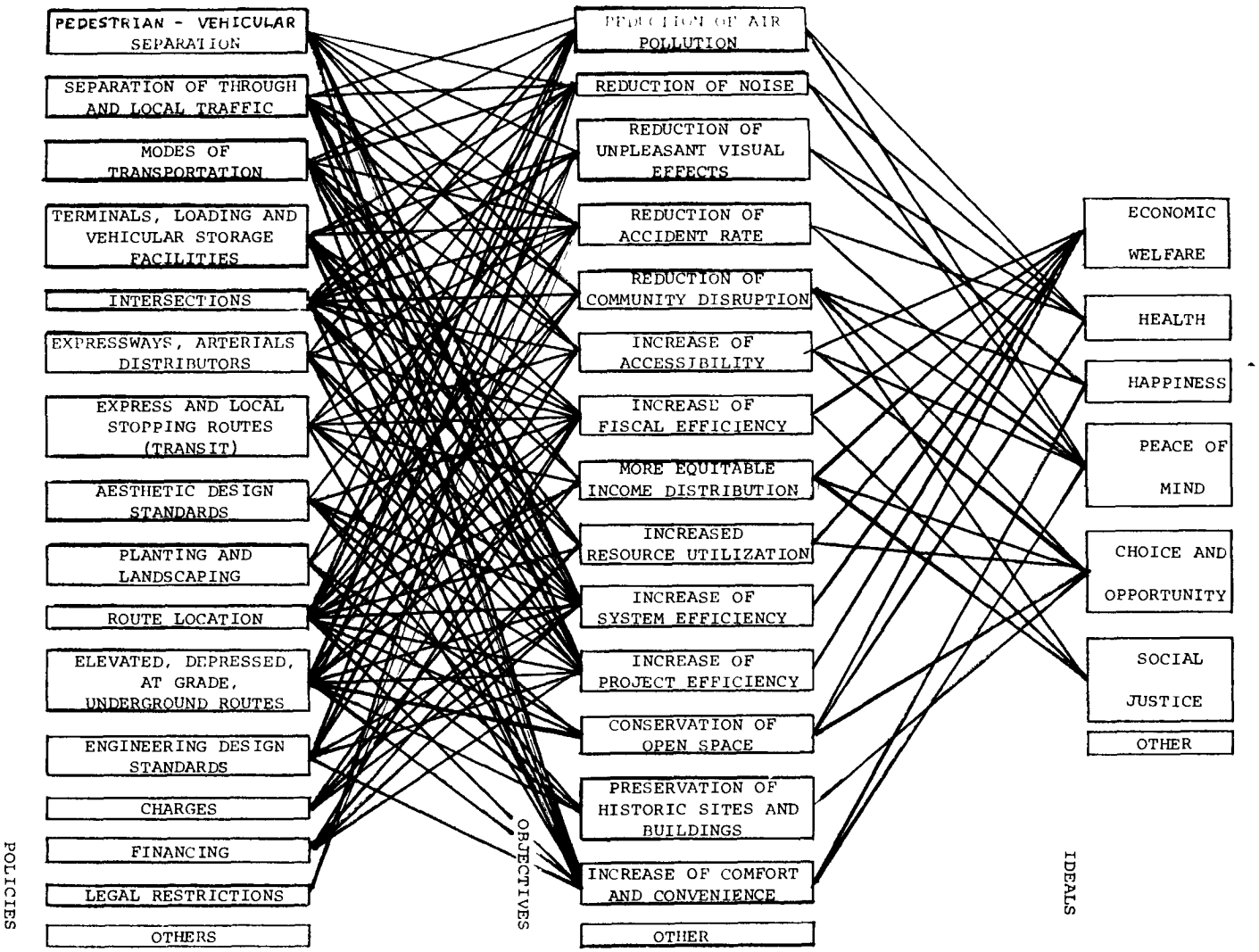


Figure 1. Transportation goal flow chart.

REQUISITES: FEASIBILITY IMMEDIACY INTERACTION

Dean and Shih (1973) employed and weighted the dimensions of water quality, water quantity, social acceptability, and costs. Other studies use more narrowly defined dimensions which can be considered impact categories. For example the 34 dimensions used by Georgia's Department of Transportation in their priority analysis of highway improvement projects include dimensions such as pavement adequacy, noise pollution, and impacts on the tax base (Breen and Covault, 1976).

Another possible evaluation framework is to subjectively scale all measured impacts, e. g., on a scale ranging from -1000 to +1000. The scores could be summed and compared for each alternative. We have not come across an example of this approach in highway or water resources evaluations. Nevertheless, we recommend this approach over the weighting of objectives or dimensions which we suggest are too abstract for people to rate with any precision. One cannot rate safety relative to travel time saved in the abstract. One needs to know whether two highway accidents per year are involved or 200 accidents. In other words it is at the level of specific impacts that meaningful weights can be applied.

Another procedure would be to present to the evaluators all of the available information on the alternatives and ask them to directly weight or rank the alternatives. This is a holistic approach. Some decision-makers like to break a decision down into all of its individual elements, evaluate each element and add up the individual evaluations into an overall score. Others prefer to group elements to evaluate the whole picture at once. They would holistically rank the alternatives on a tentative basis and then examine the individual elements to check on their grasp of the overall picture. We recommend the use of this procedure in conjunction with one of the above procedures when the assessment is not too complex. Using two methods of evaluation (one holistic and one piece meal) increases the reliability of the results.

Subjective weighting procedures can be categorized into five general types: 1) point allocation, 2) trade-off matrix, 3) paired comparison trade-off, 4) indifference curves, and 5) delphi weights. The first type of weighting procedure - the point allocation procedure - is the simplest. Judges are asked to score a number of items by one of many possible pointing systems. Three examples of point allocation scales are:

1. A scale of a fixed number of points - the items are to be scaled on a 0 to x scale, e.g., 0 to 1.0, 0 to 10, 0 to 100, 0 to 1000, or on a minus to plus scale, e.g., ±1.0, ±10, ±100, ±1000.

2. Scale around a middle value - take a middle score item and score it at 100 and score all other items relative to this item as ratios.

3. Distribute a set number of points - the judge is given a budget or a prescribed number of points to allocate among the items (for example see Pendse and Wyskoff, 1976; Stewart and Gelberd, 1976).

The second weighting procedure is the trade-off matrix. The judge is given a table with categories or points on one variable in the rows and the categories or points of another variable in the columns. The judge ranks the cells of the tables (see Table 2 for an example). This procedure is especially useful when the trade-offs between variables are not linear but a simple procedure is required. It grows out of the work on conjoint measurement in mathematical psychology (Luce and Tukey, 1964) and it has been developed in market research (Green and Rao, 1971; R. Johnson, 1974).

The third subjective weighting procedure is the paired comparison trade-off. All items are first ranked. Then adjacent pairs are traded off. The judge indicates the fraction of the first item which is equal to the second item and repeats the process down the ranking. Gardiner and Edward (1975) prefer to start with the least important item (attribute) and assign ratio scores sequentially up the ranks with ratio checking for non-adjacent pairs. Another variant of the paired comparison method is to first pair every factor with every other factor and then have judges select the preferred factor in each pairing. Relative importance of a factor is then determined by the frequency that it is preferred over other factors (Falk, 1968). Bishop (1972) uses a graphical description called factor profile for non-menetary impacts to facilitate paired comparisons of alternatives. On every dimension the largest score is set at 100 percent and the other scores are made percents of the largest. Unlike Falk, Bishop does not have judges compare all pairs. Instead, the winner in one comparison is compared with alternatives until it loses. Conjointly, the economic factor is also compared. If the winner on the social criteria costs more than the other alternatives, then the judge must decide if it is worth the extra cost.

An elaborate paired comparison technique is the outranking method called ELECTRE used by David and Duckstein (1976). They compute both a concord index and a discord index for the five "non-dominated" (i.e., non-inferior) alternatives in their study. The concord index (from the perspective of alternative j relative to alternative i) uses subjectively assigned weights for evaluative criteria, adds all of the weights for the criteria on which j scores higher than i, and divides by the total sum of weights. The concord index for $i < j$ is compared to the concord index for $i > j$ to determine which dominates the other, the discord index for j relative to i examines only the criteria where $i > j$. For each of these criteria the difference between i and j is divided by the total range of the scale. Weights for the evaluative criteria are then applied and the largest resulting criteria difference

Table 2: Six Pairwise Trade-Off Matrices for an Actual Respondant for Four Attributes of Automobiles. Rank Orders of Preference

Price	Top Speed 130	100	70	Seating Capacity 2	4	6	Months of Warranty 60	12	3
$2,500	1	2	5	2	1	3	1	3	4
$4,000	3	4	6	5	4	6	2	5	6
$6,000	7	8	9	8	7	9	7	8	9
Top Speed									
130 MPH				2	1	3	1	2	5
100 MPH				5	4	6	3	4	6
70 MPH				8	7	9	7	8	9
Seating Capacity									
2							2	5	8
4							1	4	7
6							3	6	9

Source: Richard M. Johnson, "Trade-Off Analysis of Consumer Values," Journal of Marketing Research, 11, (May, 1974), p 122.

score is used for the discord index of j relative to i. This index is also used to indicate the patterns of domination among the alternatives.

The fourth subjective weighting procedure is the creation of indifference curves or trade-off functions. The Priority Evaluator Technique (PET) developed by Social and Community Planning Research in London has been applied by Pendse and Wyskoff (1976) to water resource projects. It starts with perceptions of the existing situation and has respondents select improvements (with prices indicated) within a fixed budget. Improvements are traded-off at several budget levels. This evaluation system provides points for graphing the curve. [See also Haines and Hall (1974) for another trade-off function method called the surrogate worth trade-off method.]

The fifth subjective weighting procedure is the use of delphi techniques to evolve a set of weights for a group of judges. One of the previous four techniques may be used to obtain an original set of weights but the judges would also provide the rationale for the weights they choose. Then the judges anonomously criticize each others' weights and revisions are made on the basis of this feedback. The revised weights are averaged to make group weights.

5. Inferred Subjective Weights

When a certain type of judgment is made repeatedly the judges' subjective weights may be inferred from past choices using linear regression. The independent variables in the linear regression are the assessment dimensions (judges' criteria). The dependent variables being predicted are the judges' previous choices. The coefficients for the assessment dimensions are the implicit weights which the judges use in their judgments. Dawes (1971) uses this approach to determine an admissions committee's basis for the admission of students into a Ph.D. program. It turned out that his equations predicted success in graduate school than the committee's ad hoc judgments which sometimes suspended the normal criteria and made exceptions in specific cases.

Subjective weights can be inferred from data other than previous choices. S. Johnson (1977) applies linear regression analysis to judges' ratings of scenarios to discover the implicit weights for evaluation dimensions which the judges use. Johnson gave judges cards to rank and scale which had different scenarios on them. Each scenario had a unique set of performance levels on five dimensions. Through computer analysis of the scale scores for the various scenarios the implicit weights which the judges were using became clear. Crews and Johnson (1973) advocate a similar scenario judging procedure but alter the mathematical model for determining the implicit weights by substituting exponential equations for the linear equations. A further modification is proposed by Stewart and Gelbard (1976) who found the parabola formula more congruent with their data.

6. Ranking

One of the easiest weighting systems is to rank objectives, dimensions, impacts or alternatives. It is easy to judge whether one item is preferable to another and to establish a ranking on a particular dimension. When several dimensions are involved, however, rankings on individual dimensions are less likely to sum to the best choice than are ratio scaled subjective weights.

7. Equal Weightings

The ubiquitous equal weights are the simplest to use but also the least accurate. Equal weights often are used to avoid the recriminations to which subjective weights or rankings are open. It is cowardly, however, to treat dimensions of very unequal importance as though they were equal in order to avoid accusations of bias in assigning them weights.

8. Multiple Methods

Frequently, projects combine several of the above techniques in the evaluation of alternatives. One type of weighting may be used to combine input variables into general dimensions and another type of weighting to compute a total score out of the dimension scores (see for example, Pikarsky, 1967). Sometimes, however, more than one method is used for the same evaluations and the results are compared and combined into a compromise set of scores. Breen and Covault (1976) have judges weight the importance of evaluative dimensions and also weight a sample of specific projects. These projects are then scored on the dimensions and the results are multiplied by the dimension weights and summed to total project scores. The two sets of project scores are compared and the dimension weights are then modified by reducing the squared differences between the results obtained by the two methods.

C. Discrete Dimensions Evaluations

It is common practice in environmental impact statements and other evaluation studies to assess alternatives on each of the evaluative dimensions but not to combine the assessments into an overall score using a set of weights for the dimensions. This practice we designate as discrete dimension evaluation. It is a minimal decision making framework and does not lead to a decision among alternatives. In only lays the groundwork for the decision. Three techniques for discrete dimension evaluation are described in this section.

1. Balance Sheet

The first technique for discrete dimension evaluation is the balance sheet approach. In this approach all important costs and bene-

fits are presented on a "balance sheet" summary as in the two figures on the following two pages which indicate the level of impacts for Route 1A, Harrington, Maine (Maine Department of Transportation, 1972 and reported in Manheim, et. al., 1975) and I-664, Hampton Roads, Virginia (U.S. Department of Transportation, 1973 and reported in Lane, et. al., 1975). No attempt is made to combine the various impacts into an overall score but the alternatives are compared on each impact relative to each other. The text accompanying such tables then discusses the pros and cons of each alternative in terms of their relative scores. The balance sheet approach is common in environmental impact statements for new highways.

2. Lexicographic Pruning

The second technique for discrete dimension evaluation is lexicographic pruning. It is presented for the first time in this article. It is most appropriate when one or two dimensions have overriding importance. Lexocographic pruning immediately eliminates from consideration all alternatives which are low on the key dimension. Only the top few alternatives on the key dimension are reviewed on the second most important dimension and the best alternative on these two dimensions is selected. The remaining dimensions are checked to see if the selected alternative has serious disadvantages which call into question its superiority. If so then a full multidimensional evaluation would be conducted. Otherwise, the decision is quickly made largely on the basis of one or two criteria. For example if one wants to build a cabin on a 100-acre parcel of mountain property one chooses the spot with the best view and then judges whether the accessibility of that spot from the mountain road is adequate. If so then the search is terminated and the selected spot is checked out on many additional factors to see if it has any special problems which indicate that the comparison of locations should continue.

3. Minimum Criteria Analysis

A third technique for discrete dimension evaluation, minimum criteria analysis, is also available. All methods for computing an overall evaluation score for alternatives can be criticized for making it possible to conceal fatal flaws. An alternative may attain the best overall score but be completely unacceptable because of its performance on one dimension. We are recommending, therefore, that minimum standards be identified for all dimensions and that all alternatives be eliminated which violate any of these standards. (For unimportant criteria the minimum standard would be zero.) Certainly a highway project should have benefit/cost ratios greater than 1.0, reduce travel time, spare major historical landmarks, have some community support, compensate the most adversely affected, etc. The minimum criteria analysis should be combined with some other evaluation procedure to make the final selection of the best alternative but it should not be left out of any evaluation. (In some evaluation frameworks minimum criteria are included as constraints.)

FIGURE 2: EXAMPLE OF BALANCE SHEET APPROACH TO EVALUATION

ESTIMATED IMPACTS OF VARIOUS ALTERNATIVES. HARRINGTON, ME.

INTEREST/IMPACT TYPE	ALTERNATIVE 0	1	2	3	4
1. THROUGH TRAFFIC					
- SPEED (AVG)	25 MPH	55 MPH	30 MPH	30 MPH	55 MPH
- DISTANCE	3 7 MILES	3 2 MILES	3 8 MILES	3 8 MILES	3 7 MILES
- ACCIDENT RATE FACTOR[1]	4	1.2	3 5	2 5	0.6
2 STATE DEPT OF TRANS ($1000)					
- ROW COST	0	22	205	129	122
- CONSTRUCTION COST	0	1447	1377	1050	1416
- TOTAL COST	0	1499	1582	1179	1538
3 TOWN CENTER BUSINESSES					
- DISPLACED	NONE	NONE	GAS STATION, AUTO PARTS STORE	SAME AS 2	NONE
- LOSS OF BUSINESS FROM THROUGH TRAFFIC	NONE	YES - TO GROCERY STORE LUNCH COUNTER GAS STATION (ABOUT 10% OF TOTAL RETAIL SALES)	NONE	NONE	YES - TO RESTAURANT, GROCERY STORE LUNCH COUNTER 3 GAS STATIONS (ABOUT 20% OF TOTAL RETAIL SALES)
4 TOWN CENTER RESIDENCES					
- DISPLACED	NONE	NONE	7 SINGLE-FAMILY	3 SINGLE FAMILY	NONE
- RELOCATION PROBLEMS	NONE	NONE	YES	YES	NONE
5 TOWN CENTER ENVIRONMENT					
- THROUGH TRAFFIC VOLUME (ADT) - 1970	2620	1400	2620	2520	1250
- 1990	4350	2325	4350	4180	2075
- SAFETY	POOR	GOOD	POOR	FAIR	GOOD
- AIR QUALITY (ug/m^3 CO-1990)[2]	825	306	825	536	386
- NOISE (dBA L_{10} - 1990)					
- AT 50 FT DISTANCE	73	70	73	73	70
- METHODIST CHURCH	70	70	70	74	70
- BAPTIST CHURCH	73	70	73	73	70
- ELEMENTARY SCHOOL	58	54	58	58	65
- VISUAL	NONE	(SEE TEXT)	(SEE TEXT)	SMALL	NONE
- SCHOOL SAFETY IMPACT	NONE	NONE	NONE	NONE	150' FROM SCHOOL
6. TOWN GOVERNMENT-TAX BASE LOSS	NONE	SLIGHT	HIGH	MODERATE	SLIGHT
7 OTHER AREAS					
- RESIDENTIAL DISPLACEMENTS	NONE	NONE	NONE	NONE	3 UNITS
- AIR QUALITY	NONE	NONE	NONE	NONE	NONE
- NOISE	NONE	SOME	SLIGHT	SOME	EXTENSIVE
- VISUAL					
- VIEW OF HARRINGTON RIVER	NONE	YES	NONE	NONE	NONE
8 NATURAL ECOLOGY					
- SALT MARSH DISPLACEMENT	NONE	1 5 ACRES	NONE	NONE	NONE
- UPSTREAM SALT MARSH	NONE	IMPROVED	IMPROVED	SOME	SOME
- DOWNSTREAM SALT MARSH	NONE	SOME	SOME	CONSIDERABLE	CONSIDERABLE
- INCREASED RUNOFF	NONE	SOME	SOME	MUCH	MUCH
- TREE ACREAGE	NONE	SLIGHT	SLIGHT	25 ACRES	28 ACRES
- WHITE-TAIL DEER MIGRATION	NONE	NONE	NONE	SOME DISRUPTION	SOME DISRUPTION
- LOWERING OF WATER TABLE	NONE	SLIGHT	SLIGHT	SOME	SOME
- EROSION FROM NEW SLOPES	NONE	SLIGHT	SLIGHT	SOME	SOME

[1] RELATIVE TO STATEWIDE AVERAGE FOR THIS TYPE OF FACILITY.

[2] WORST CONDITION OF SEVERAL TOWN CENTER LOCATIONS.

SOURCE: MARVIN MANHEIM ET. AL., TRANSPORTATION DECISION-MAKING: A GUIDE TO SOCIAL & ENVIRONMENTAL CONSIDERATIONS, NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM REPORT, 156, TRANSPORTATION RESEARCH BOARD, WASHINGTON, DC (1975).

FIGURE 3: EXAMPLE OF BALANCE SHEET APPROACH TO EVALUATION

I-664 VIRGINIA: SUMMARY OF ENVIRONMENTAL IMPACTS OF ALTERNATE ROUTES

		Alternate Route Alignments								
Quantitative Impacts	No Action Alternate	1A Segments $A_1B_1CD_1E_1FGH_1$	1B Segments $A_1B_2CD_1E_1FGH_1$	2A Segments $A_1B_1CD_1E_1JR$	2B Segments $A_1B_2CD_1E_1JR$	3A Segments $A_1B_1CD_1E_1KQR$	3B Segments $A_1B_2CD_1E_1KQR$	4 Segments A_1LMNGH_1	5 Segments A_1LMQR	6 Segments A_1LMPQR
A ROUTE LENGTH (in feet)										
1 Highway	---	49 115	49 615	38 115	38 615	38 115	38 615	37 535	26 535	26 535
2 Bridge Tunnel	---	24 650	24 650	26 900	26 900	28 370	28 370	32 030	34 000	33 820
3 Total	---	73 765	74 265	65 015	65 515	66 485	66 985	69 565	60 535	60 355
B TRAFFIC VOLUMES (1995 ADV)										
1 High Segment Volume	--	77 200	77 200	91 700	91 700	91 700	91 700	68 800	70 800	70 800
2 Low Segment Volume	-	47 000	47 000	57 300	57 300	57 300	57 300	38 600	56 900	56 900
3 Hampton Roads Crossing Volume	--	47 900	47 900	61 200	61 200	61 200	61 200	44 400	63 300	63 300
C DISPLACEMENT										
1 Residential Units	not measurable	137	106	134	103	134	103	32	29	29
2 Business Units	not measurable	78	65	77	67	77	67	20	19	19
3 Estimated Jobs	not measurable	819	795	809	785	809	785	170	160	160
4 Institutional Units	not measurable	3	1	3	1	3	1	1	1	1
5 Park Land (Acres)	not measurable	11 1	15 2	16 1	20 2	16 1	20 2	26 8	31 8	31 8
6 Cemetery Land (Acres)	not measurable	1 1	1 1	8	0	0	0	4 9	3 8	3 8
7 Annual Tax Yield Displaced	not measurable	$ 283 100	$ 282 100	$ 280 700	$ 279 700	$ 280 700	$ 279 700	$ 109 100	$ 106 700	$ 106 700
D RIGHT OF WAY ENGINEERING AND CONSTRUCTION COSTS	---	$269 945 000*	$280 505 000*	$264 125 000*	$274 685 000*	$268 635 000*	$279 195 000*	$219 180 000*	$214 490 000*	$214 890 000*
E ANNUAL OPERATING AND MAINTENANCE COSTS	-	$ 1 125 000	$ 1 128 000	$ 1 061 000	$ 1 064 000	$ 1 071 000	$ 1 074 000	$ 1 075 000	$ 1 011 000	$ 1 011 300
F ECONOMIC DEVELOPMENT (PROJECTED TO 1995)										
1 Employment	673 000	+11 700	+11 700	+6 265	+6 265	+6 265	+6 265	-8 775	+6 265	+6 265
2 Population	1 602 900	+27 800	+27 800	+14 800	+14 800	+14 800	+14 800	-20 800	+14 800	+14 800
3 Earnings	15 433	---	---	---	- -	--	-		- -	-
4 Households	476 598	+8 421	+8 421	+3 974	+3 974	+3 974	+3 974	+6 380	+3 974	+3 974
5 Housing units	204 720	+9 020	+9 020	+4 000	+4 000	+4 000	+4 000	+6 618	+4 000	+4 000
6 Retail Sales	$2 909 058 726	+$ 50 366 741	+$ 50 366 741	+$ 26 882 350	+$ 26 882 350	+$ 26 882 350	+$ 26 882 350	+$ 37 536 982	+$ 26 882 350	+$ 26 882 350
7 Retail Space (sq ft)	30 369 397	+524 016	+524 016	+272 931	+272 931	+272 931	+272 931	+384 133	+272 931	+272 931
8 Office Space (sq ft)	21 038 000	+400 000	+400 000	+220 800	+220 800	+220 800	+220 800	+297 400	+220 880	+220 800
9 Land Needs (Acres)										
a. residential	32 260 0	+1 495 0	+1 495 8	+660 0	+668 0	+668 8	+660 0	+1 115 0	+660 8	+660 0
b. industrial	4 250 8	+280 0	+280 0	+181 0	+181 0	+181 8	+181 0	+243 8	+181 0	+181 0
c. office	966 8	+18 3	+18 3	+10 1	+10 1	+10 1	+10 1	+13 6	+10 1	+10 1
d. retail	3 031 2	+52 3	+52 3	+27 2	+27 2	+22 2	+27 2	+38 4	+27 2	+27 2
10. Fiscal Impact	$ 28 063 000	+$ 1 105 000	+$ 1 105 000	not measurable	not measurable	not measurable	not measurable	not measurable	not measurable	not measurable
Qualitative Impacts (Code 0 = no impact; 1 = minimum impact; 2 = moderate impact; 3 = major impact)										
A Impact on water use patterns	8	2	2	2	2	1	1	2	2	1
B Impact on historic landmarks	0	1	1	1	1	1	1	1	1	1
C Impact on religious institutions and practices	not measurable	2	1	2	1	2	1	1	1	1
D Impact on educational institutions	not measurable	2	3	2	3	2	3	2	2	2
E Impact on recreational patterns	not measurable	1	1	1	1	1	1	1	1	1
F Impact on Section 4(f) park and recreational areas	not measurable	1	2	2	2	2	2	3	3	3
G Impact on ecological balance	not measurable	2	2	2	2	2	2	3	3	3
H Impact on acceptable noise levels	2	2	3	2	3	2	3	2	2	2
I Impact on air pollution levels	2	1	1	1	1	1	1	1	1	1
J Impact on water pollution levels	not measurable	2	2	2	2	2	2	2	2	2
K Impact on neighborhood and social disruption	not measurable	2	2	2	2	2	2	2**	2**	2**
L Impact on esthetics	not measurable	1	2	2	2	2	2	2	2	2

* Above costs based on tunnel crossing of channel with 45' depth and 800' width. Adjustment to above costs for crossing of channel with 55' depth and 1 000' width: Construction cost +$12 000 000. Operating and maintenance +$100 000. Adjustment to above costs for crossing of channel with 65' depth and 1 200' width: Construction +$27 000 000. Operating and maintenance +$210 000.

** Rating based primarily on potential neighborhood disruption due to anticipated auto traffic patterns through established neighborhoods due to detours to reach the Newport News shipbuilding employment area.

Source: Jonathan S. Lane, et. al., The No Build Alternative, National Cooperative Highway Research Program, (1975).

D. Methods Which Utilize Public or Political Evaluations

The above techniques assume that evaluation is part of the research task. Some would argue, however, that the public or its representatives should do the evaluating. In this section, therefore, we review decision-making frameworks which minimize the evaluative role of the researchers and confers the evaluation function to the public or its representatives.

It should be noted that all evaluation techniques include the public in some way or another. Public support is included in some studies as one of many evaluative dimensions. In all studies public comments and criticisms are invited and considered to some degree in the decision making process. In a few studies surveys are used to determine public attitudes toward project impacts or goals and this information is used in the creation of weights (Wachs, 1968; Oglesby, et. al., 1970; Falk, 1968; and Schimpeler and Grecco, 1968). But it is rare for a study to provide citizens with the impact balance sheet and have them choose the alternative. An unusual example of the public having the major role in the evaluation of plans and alternatives is the Boston Transportation Planning Review (Gakenheimer, 1974; and Sloan, 1974). Citizen participation was extensive and influential. As a result, an ambitious system of additional interstate highway construction in the Boston area was drastically cut back, mainly because the new highways would have had negative impacts on the corridor communities and because many questioned that additional highways in the area would have significant accessibility benefits.

Several studies have reviewed the utility of various citizen participation techniques for water resources planning (Bishop, 1970; Warner, 1971; Willeke, 1971; Wolff, 1971; Wagner and Ortolano, 1975). Another useful summary of citizen participation is by Manheim, et. al., (1975) and is focused on transportation projects. Types of citizen participation have been described by Arnstein (1969).

A variant on the citizen evaluation approach is the publicity approach. The study team publicizes the information on estimated impacts so that interested parties can react and use the political process to influence the decision in ways compatible with their interests. According to this approach evaluation and choice of alternatives is not the researcher's role and should be left to the public acting through the political process.

We identify three variants of the external evaluation approach: public choice, advisory committee choice, and political process outcome. These are neither exhaustive nor mutually exclusive. The idea behind these evaluative approaches is that the government agency should aid the public or the relevant interested parties in choosing the alternatives. This reverses the normal practice of obtaining public participation as an aid to the agency in making its decision.

1. Public Choice

The idealogy of democracy is that the government is the servant of the people rather than vice versa. When a project is largely to serve a local area then why not let the people of that area determine the choice of the alternative? The agency must protect whatever interests outsiders may have, especially the interests of taxpayers, but local citizens could decide many of the design characteristics of a project within budget constraints. Ideally a referendum would determine the issue because it provides for the widest participation and the greatest legitimacy of the outcome. A random sample survey of two hundred or more citizens should have the same outcome but it would provide neither the same sense of participation in the decision nor as much legitimacy. A survey would have to be used, however, if the agency wants to be guided but not commanded by the public. To act counter to a referendum vote would cause more public resentment than acting counter to a public opinion survey. Thus, surveys allow the agency some discretionary power even after the public will is determined. It would seem preferable, however, to exercise agency discretion first and then solicit public participation. In other words, first exclude from consideration all alternatives which the agency judges unacceptable in terms of costs on technical problems and then let a referendum determine the choice among the remaining alternatives.

2. Advisory Committee Choice

When the project issues are complex and the decision must be guided by technical information, it is difficult to sufficiently inform the public to enable the citizens to vote their true interests. In such cases citizen advisory committees can be appointed to represent the public to the agency. Advisory committees may be limited to an advisory role or they might have real power as in the Boston Transportation Planning Study. They can be an effective mode of public participation because they can meet frequently, digest the summaries of the analytical studies, develop working relationships with the research team and the agency and thoroughly communicate their views to the agency. However, they are often unrepresentative of the community. Sometimes they are stacked with people who have the agency point of view. More often they are comprised of prominent persons and/or citizens known to the community leadership who may represent a wide range of interests but almost invariably have an elitist perspective.

3. Political Process Outcome

A small minority of planners argue that evaluation research should be designed to serve interested parties in their efforts to influence policy decisions (see Peterson and Gemmell, 1977). Normally, evaluation research serves decision-makers rather than interested parties by providing the information needed for making policy decisions. Some researchers want to limit their responsibilities to research.

Others want also to play a political role. These researchers want to influence the political process so that "desirable" policy decisions are made. They might stimulate the political process by distributing the research reports to the public or they might interactively articulate the research with the political process. Much innovation is currently occurring in the structuring of the relationship between project research and project politics. Understandably, the new ideas are tentative and require elaboration and development.

Cohon and Marks (1973) represent the view that the analyst can identify the trade-offs and eliminate the inferior alternatives but the choice among the noninferior set of alternatives must come from the political process.

> In light of the empirical difficulties in quantifying the preferences of society for objectives, it is recommended that the analyst not attempt to select the optional solution. The approach suggested here is to generate the TC (transformation curve) and supply it to the political process from which the optional solution will come. • (p 828)

Burke, et. al., (1973) notes that the social and political context for water resources planning decisions has recently changed dramatically. The far reaching consequences of water resources decisions are increasingly recognized by an increasingly environmentally conscious and politicized public. Hence, the decision-making process should change accordingly. It is tempting to seek the solution in a centralized authority such as Goldman's (1972) suggestion of a federal level planning agency which is to be completely separate from the construction and regulatory agencies. Burke, et. al., however, sees the greater need to be the articulation of planning and interested groups at the local level. They propose the creation of a "bargaining arena" through which "the local political process is incorporated in the flow of technical planning activities" (p 439).

The bargaining arena links a public participation program with technical planning, altering both in the process. The public participation program emphasizes negotiations and bargaining interactions utilizing delphi techniques and computer assisted problem solving methods. The technical planning not only uses the inputs from the public participation program but it also simulates the socio-political system to test out the socio-political acceptibility of alternatives as they evolve and to modify them in politically desirable directions. Thus the influence of the local socio-political system is intermittent in public participation terms and continuous in terms of an evaluating system which simulates the socio-political system. This simulation model is constructed from the following information:

1. An identification of interest groups with active participation in water issues;
2. A measure of group preferences for project attributes;
3. For each interest group, acceptable levels for these components;
4. Measures of various attitudes, opinions, perceptions; and
5. Measures of relative power for each group. (p 443)

The above proposel of Burke, et. al., accepts the socio-political system without raising the question of its fairness. But Rawls (1971) theory of justice persuasively argues that social institutions are just only if they are based on a fully developed concept of equality. Burke, et. al.'s, simulation incorporates and probably exaggerates the injustice of socio-political systems. They chose to include only "groups with power in the real world situation (voiceless groups were not represented)" (p 444). We suspect, however, that real politicians take voiceless groups into account though giving them a very low weight. But even a low weight is infinitely higher than Burke, et. al.'s, zero weight for nonpowerful groups. More importantly, government agencies have at least <u>some</u> responsibility to voiceless groups and some concern with justice as fairness.

Murphy, et. al., (1971) explicitly rejects the political placation model which is competing with the traditional least-cost procedures in the location of controversial facilities. They note that concessions are generally made to the more powerful interest groups in order to forestall opposition. They do not object to the idea of side payments or concessions often in the form of additional facilities or services but object to the basis for making them. They argue that need or the extent of disamenity impacts rather than political power should determine the side payments and with this principle Rawls would agree. Thus the authors would have the planning process opened up to the demands of the political process but also extend the concessions to negatively impacted groups which are not effective in politically championing their interests.

Manheim (1973) proposes planning procedures which utilize the socio-political system as did Burke, et. al., and incorporates equity considerations and concessions into the project plan as did Murphy, et. al. His planning procedure entails four stages:

1. Initial Survey - The technical team is "to acquire basic data and to develop an understanding of the interests, needs and desires of all potentially affected interest groups" (p 11).

2. Issue Analysis - The technical team develops "a range of alternatives which represent different assumptions about the objectives to be achieved, and which, when presented to various interest groups, helps them to clarify their own objectives" (p 11).

3. Design and Negotiation - On the technical/design side, variations on several basic alternatives are developed to provide the basis for compromise solutions. Ways are also sought "to reduce or eliminate inequities - through redesign, through development of associated non-physical program elements, or through direct compensation" (p 12). On the community interaction side, constructive negotiation is stimulated. In this process the team has a larger role than simple mediation.

> As the representative of the responsible decision-maker in a public works project, the team implicitly also represents the interests of voiceless groups or interests which are not active participants in the interaction process. In some situations, these may include the long-term interests of a particular community; national interests, and others for which no representation may be available (p 12).

The objective of this stage "is to produce substantial agreement on a single alternative" (p 12).

4. Ratification - If stage 3 has produced a relatively consensual alternative it is ratified. If not, the team lays out for the legally designated authority all the issues, advantages/disadvantages of alternatives, the trade-offs and the last analysis of community preferences.

It should be noted that a somewhat radical ideal underlies the above proposal. "The role of the technical team is to clarify the issues of choice, to assist the community in determining what is best for itself" (p 13). In other words the technical team is to assist the community in arriving at a community decision regarding the project.

Hudson, et. al., proposes a procedure called dialectical scanning, which is somewhat similar to Manheim's but focuses more on the nature of the conflicts. The context is the confrontation of a regional plan with local interests. In the first stage:

> Major characteristics of a plan are listed, and a discussion is held to determine whether each characteristic is acceptable to all participants, or whether it is a controversial element of the plan. . .
>
> The second stage of the process has the objective of resolving the differences which were determined

> during the first stage. It begins by looking at the nature of the contradictions which have been identified and selecting a form of analysis appropriate to dealing with each type of issue (p 262).

One type of contradictions are factual misunderstandings which can be dispelled by more accurate information. Another type of contradictions are different assumptions about impacts and these can not be resolved without further research which is designed to settle the issue. A third type of contradictions are value differences. These are irresolvable but at least they can be properly identified as value conflicts.

E. Methods Which Obviate Evaluation

There are several ways to take nonmarket impacts into account without evaluating them. These methods reduce the evaluative task but do not eliminate it.

1. Standardize Costs or Benefits

If either the costs or the benefits of a project are made the same for all alternatives the evaluation process is greatly simplified. If several alternatives have the same benefits, e.g., a highway that runs from town A to town B through desert terrain, but have different costs, one selects the least costly. Or else when costs are constant the alternative with the most benefits is chosen. Usually this involves choosing between various combinations of benefits. Sometimes, however, adjustments can be made to make all benefits equal except one. Then the benefits do not have to be traded-off and a best choice can be determined. Even when costs are not constant the best choice can be determined if all costs utilize dollar values (see Schmid, 1975).

2. Minimize Negative Effects

The second procedure for making the evaluation of nonmarket impacts unnecessary is to minimize them from the start. Highway location formulas serve this purpose (see Finsterbusch, 1977). The more sophisticated formulas minimize relocation, negative proximity effects, and neighborhood disruption. By using such formulas and other highway location techniques (see Finsterbusch, 1977; Lane, et. al., 1975; and Skidmore, Owings, and Merrill, 1976) alternatives are selected in the first place which have minimum negative impacts. Then appropriate design features can reduce negative impacts further. The more that negative impacts are eliminated the less they have to be evaluated.

3. Compensation and Mitigation

The third procedure for obviating evaluation is compensation -

though establishing the compensation price is an evaluation of a type. The point here is that those impacts which are compensated do not have to be evaluated relative to other impacts. Unfortunately, compensation is often not sufficient because it covers economic but not psychological and social costs (see Fried, 1963; and Finsterbusch, 1976 for a discussion of the psychological and social costs of relocation). And as Downs (1970) points out even many of the economic costs of residential displacement are generally not compensated.

F. Case Studies

The above review of 19 evaluation techniques presents the field of options for the reader. It does not give a sense for how these options are combined in actual practice. In this section we review a number of case studies that serve as working models. Valuable lessons can be learned by observing how researchers evaluate alternatives under political, budgetary and substantive constraints. The cases have been selected from assessments of water resources projects, highway alignment selections and transportation projects rankings.

1. River Walk Expansion in San Antonio

Because the current San Antonio River Walk, a mile-long horseshoe bend in downtown San Antonio, is a successful tourist attraction and a stimulus to development, plans were made to expand it. Eight expansion alternatives were considered. Dean and Shih (1975) report on the evaluation methodology. Five attributes were selected as evaluative criteria: urban enhancement, economic growth, cost, recreation and social acceptance. A sixth attribute, flood control, would have been included but was not because its value would be the same for all eight alternatives. The scores of each alternative on each attribute are measured and the probabilities of chance events which would affect the scores are taken into account. Each attribute is then scaled from 0 for the worst alternative to 1.0 for the best alternative. Decision makers subjectively weight the attributes relative to each other and provide utility ranges for alternatives for each attribute. A sensitivity analysis was performed on the utility data by generating random numbers within the specified ranges. The resulting utility distributions identified four leading contenders and a clear ranking amongst them. It turned out that the leading contenders were generally the most costly.

2. Chicago Crosstown Expressway

Pikarsky reports on an evaluative framework developed over a 20 year period and used by Chicago's Department of Public Works, of which he was the Commissioner. The framework features several successive levels of assessment. First, the choice between an expressway and alternatives was considered and the expressway was judged to be the best choice. Second, at a general level of evaluation "all possible

alignments" (eight alignments for the north-south section and four for the east-west section) were assessed using readily available measures and three north-south alignments and two east-west alignments were eliminated and others were modified. Third, at an intermediate level the remaining alignments were examined more closely and all but two north-south alignments and one east-west alignment were eliminated. Finally, at the detailed level the two finalist north-south alignments were carefully evaluated and modifications to eliminate defects were considered.

At the three levels of analyses for alignments three "viewpoints" were assessed independently by three separate investigating groups representing appropriate professional disciplines: engineering aspects, impact on community, and land use improvements. No effort was made to weight or trade off the three viewpoints but the specific evaluative criteria within each of the three viewpoints were subjectively ranked by the appropriate group. Then alternatives were scored on the specific criteria on a scale from 1 to 10 on the basis of quantitative measurement or subjective judgment. A total rating was computed for each alternative for each viewpoint and low ratings on any two viewpoints meant rejection.

3. Tisza River Basin

David and Duckstein (1976) describe a "cost-effectiveness approach" which they applied to a water resource system of the Tisza River Basin in Hungary. Their methodology is based on the following ten steps (discussed in detail in Popovich, et. al., 1973):

1) Define the desired goals, objectives, or purposes that the systems are to fulfill or approach.
2) Identify the set of engineering specifications essential for the attainment of the desired goals.
3) Establish system evaluation criteria that relate system capabilities to specifications and hence to goals.
4) Select fixed-cost or fixed-effectiveness approach.
5) Develop alternative systems for attaining the goals.
6) Determine capabilities or performance of the alternative systems in terms of evaluation criteria.
7) Generate system versus criteria array.
8) Analyze merits of alternative systems.
9) Perform sensitivity analyses on all previous steps which introduce feedback into the procedure.
10) Document the rationale, assumptions, and analysis underlying the previous nine steps. (p 732)

Six goals are specified and evaluated in terms of measures of effectiveness for alternatives: water requirements (inclucing recreation), flood protection, drainage and used water disposal, utilization of resources, environmental impact, and flexibility. The measures of effectiveness are quantitative when possible but qualitative or

mixed when appropriate. The fixed effectiveness approach is chosen over the fixed cost approach. Five distinct alternative water resource systems are capable of meeting the goals and are evaluated relative to each other. The multi-criterion algorithm ELECTRE (elimination and (et) choice translating reality) is used for the evaluation (Benayoun, et. al., 1972). It is based on outranking relationships. Comparisons are made on twelve evaluative criteria which are weighted either 2 or 1 and the concord indices and discord indices are computed as described in Section I-B-4.

4. Highway Improvement Projects in Georgia

Breen and Covault (1976), (see also Mak and Jones, 1976), present a "priority analysis model" for evaluating highway improvement projects relative to each other. It contains five steps:

1. Highway improvement projects are categorized according to their functional classification and improvement types so that they may be compared under compatible sets of parameters.
2. The evaluating parameters pertinent to each category under consideration are identified.
3. The relative importance of the evaluating parameters is determined and expressed through a set of weighting factors.
4. The rating of each parameter is derived through objective and analytical methods where possible, otherwise through subjective judgments, for each project in each category.
5. The overall rating of each project is then derived by multiplying each parameter rating by its weighting factors. Priorities for each category are determined by summing the products for all parameters. (pp 618-620)

The priority analysis model produces one set of scores for projects. Another set of scores is generated using the delphi technique with experts evaluating randomly selected projects within project categories. The two sets of scores are compared and "adjustments were then made by normalization and by varying parameter weights to calibrate the model" (p 620). Adjustments were made in the direction of minimizing squared differences in the two sets of scores.

5. A General Evaluation Methodology for Public Sector Plans

Hill (1973 and 1967) develops a general evaluation methodology for public sector plans and applies it to urban transportation plans. According to Hill rational planning entails the following steps:

1. The identification of goals.
2. The ranking of goals in term of their relative importance.
3. The identification of alternative courses of action.
4. The comparative evaluation of alternative courses of action.
5. The selection of the best course of action.
6. The effectuation of the selected course of action.
(pp 5,6)

The distinctive features of Hill's method is his extensive analysis of the hierarchy of goals on which the evaluation is to be based. The goal system includes ideals, objectives, policies and requisites (conditions which must be satisfied). The goals are defined operationally. The degree of achievement of goals is measured or estimated for alternatives and then the goal achievement scores are evaluated for groups and for the community as a whole in terms of subjectively generated weights for the objectives. Hill leaves undetermined who should do the weighting of objectives. Candidates, whom he mentions, are decision makers, elected officials, members of the power structure, interest groups, or various "publics." Several weighting procedures are discussed but preference is expressed for trade-off function of the type proposed by Ackoff (1962). In an application of his methodology, however, he first uses equal weights and then considers what kind of weights would be required to choose a different alternative and whether such weights are unreasonable.

6. A General Transportation Decision-Making Process

Manheim, et. al., (1975) opposes most of the above evaluation methodologies which use weights to arrive at an overall score for each alternative. The selection of the judges who supply the weights is a difficult ethical question which Manheim, et. al., relates to other problems.

> "Any benefit/cost analysis or linear scoring function uses 'weights' for particular impacts, where values are assigned that represent the importance of those impacts. But <u>whose</u> 'weights' should be used? Different groups have different weights, which largely are not determinable in the abstract. Only a very naive group would agree to a compromise on a set of weights beforehand and then find that the resulting 'highest score' alternative has disastrous results for them. Each group's values are important in the choice, and their importance should not be diluted by aggregating together the values of many groups. The convenience of having one 'total score' does not outweigh the loss of information about the trade-offs necessarily involved in the choices among alternatives. These techniques tend to hide the issues--who gains? who loses?--instead of bringing them out."

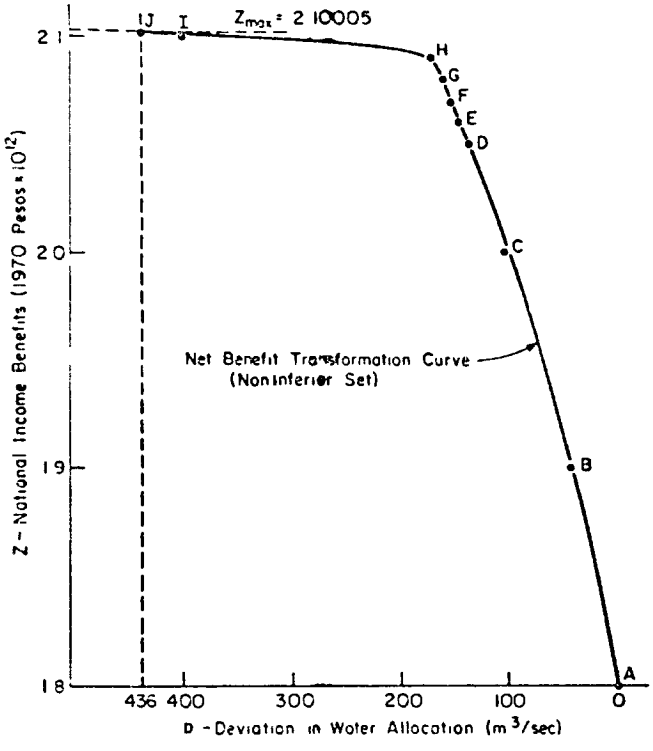
> "Our approach does not assume that persons can consistently formulate their goals and values in an operational way without going through a process of looking at choices as they evolve over time." (p 40)

They propose instead laying out the consequences (specified for specific groups) of the alternatives for everyone to see. The decision then must be worked out among the interested parties, planners and decision makers through an interactive process over time. Their evaluation methodology involves both the assessment of impacts by the research team and the evolution of a community decision through the interaction of officials and affected groups.

7. River Basin Planning

An important characteristic of river basin planning in contrast to highway location decisions is that it deals with an infinite set of continuous options rather than a small number of discrete alternatives. The first step, therefore, is to reduce the population of alternatives from the set of feasible alternatives to the set of efficient (noninferior) alternatives which includes all of the points on the net benefit transformation curve. The tangency point of the transformation curve and the highest social indifference curve (representing the preferences of society) is the optimal solution. The latter curve must be generated by the political process. When there is only one objective, normal linear programming can solve for the maximum solution. With multiple objectives, however, linear programming can supply the set of noninferior solutions but it can not determine the optimal solution unless weights are supplied. Cohon and Marks (1973) discuss river basin planning in these terms and work out an exceptional hypothetical example in which the transformation curve bends sharply at a point which is the obvious solution point (point H in Figure 4). Except in their contrived example their evaluative methodology can not make a decision, but it can provide decision makers with the best set of alternatives from which to choose (and inexpensively, as they show).

FIGURE 4: THE GENERATED NET BENEFIT TRANSFORMATION CURVE



Source: Jared L. Cohon and David H. Marks, "Multiobjective Screening Models and Water Resource Investment," Water Resources Research, 9, 4, (August, 1973), p 834.

II. SOCIAL IMPACTS OF WATER RESOURCE PROJECTS

II. Social Impacts of Water Resources Projects

Hitchcock (1977) has recently completed a review of the research on the social impacts of water resources development projects which will provide the main data base for this section. His list is not exhaustive but it is sufficient for our purposes. He groups impacts into 4 types and 21 categories as follows:

A. Distribution

1. Population density
2. Population mobility
3. Housing/relocation
4. Income/distribution
5. Costs/benefits

B. Opportunity

6. Educational
7. Cultural
8. Recreational
9. Aesthetic
10. Economic

C. Local Service Delivery

11. Safety
12. Health
13. Local government revenues
14. Local expenditures
15. Law enforcement
16. Local government structure

D. Community Cohesion

17. Conflict
18. Opposition/support for project
19. Awareness of project
20. Unwanted changes
21. Anxiety/stability

Some general comments on this list can guide the application of evaluation frameworks to water resources development projects. Many of the above impact categories are prevalent in the evaluation of other types of projects so evaluative frameworks from other policy areas can probably be used for water resources development projects. The range of the impacts and the nature of many of them suggest that common metrics are unfeasible for general evaluative frameworks dealing with water resources projects. Specific projects sometimes involve relatively few impact dimensions and may accommodate a common metric as in cost-benefit analyses. We have not found a full economic analysis

of impacts that seriously takes social impacts into account.

The distribution impacts and the local service delivery impacts are impacts which are common to many types of projects and have been researched in many contexts. Standard assessment methods have dealt with them and in understanding of their relative importance in various situations is evolving in the literature. It should be noted, however, that water resources research which is reviewed does not concentrate on these impacts. Hitchcock's review of 38 empirical studies located only 13 analyses of distribution impacts out of a total of 104 impacts analyzed in the studies. Local service delivery impacts were analyzed more frequently (22) but still only in 14 of the 38 studies.

The opportunity impacts contain some items which are relatively unique to water resources development projects, i.e., cultural, aesthetic and recreational impacts. These impacts are extremely difficult to evaluate relative to economic, safety, relocation and other impacts because they are not primary in people's hierarchy of needs. Nevertheless, they can be extremely important to people. It is also very difficult to evaluate the community cohesion factors relative to other factors but this problem is common to many other types of projects. The community cohesion factors do not affect the quality of the lives of citizens directly and tangibly as much as they affect institutions and processes which indirectly affect the quality of people's lives. If members of the "public" are asked to evaluate community cohesion impacts they may assign unduly small weights to them, because people do not "feel" impacts on the functioning of social systems. These comments apply also to other impact categories like population density and mobility, government revenues, and local government structure.

In order to provide a richer understanding of the types of impacts caused by water resources development projects we will very briefly describe a selection of the 38 research projects that Hitchcock reviews (the numbering is Hitchcock's).

#1. Chemical plant location in a coastal area - opposition of environmentalists and residents leads to its cancellation. Major issue is pollution versus jobs.

#3. Series of reservoirs - many objectives: beautification, flood control, irregation and economic benefits. Residential gardening is a popular by-product. Results in increasing juvenile delinquency because of more affluence and automobile ownership.

#7. Bear Lake - farm land becomes taxed and farmers must sell out.

#10. Seven reservoirs in various stages - relocatees and their attitudes are studied.

#21. Two dams on Seintiam River - increased formalism and less personalized style in government, especially law enforcement. New people favor new style. Substantial increase in local purchase of recreational equipment. Influx of

urban-suburbanites cause cultural shift from logging informality to more urbane style. Construction increases population and expands services. After construction, population decreases and taxes must increase to pay for the additional services, e.g., sewer system.

#24. North Springfield Dam - hardships caused by delayed compensation payments. Increased law enforcement problems. Insufficient compensation to community for loss of tax revenue from unindated farm land.

#31. Black River Reservoir - local businesses expect benefits from reservoir. Anxiety over relocation is widespread and an elderly couple loses the will to live.

Another review of the literature on social impacts (Portland District, Corps of Engineers, 1976) uses the following impact categories for water resources development projects:

Land-use
Land-value
Institutional impacts (mainly local government budgets but also increased formalization)
Community cohesion
Attitudes
Population movement
Individual or family level impacts.

Social impacts of water resources projects have been reviewed above and some general points on valuing these types of impacts have been presented. Below specific valuing methods will be recommended for specific impacts.

Some identified impacts would not normally be included in the valuation process though higher order consequences of these impacts may be included. Population density, population mobility, local expenditures, local government structure and awareness of the project may warrant examination as indicators of what is going on but since they are not directly costs or benefits they do not become evaluative criteria. Some other impact areas require greater specification before they can be properly valuated. Unwanted changes and anxiety probably refer to the other identified impacts or else should be more exactly specified if they are to be examined. The remaining impact categories can be divided into impacts on individuals' utilities or impacts on community functioning. The latter often lead to impacts on individuals' utilities in the long run. Individuals' utilities are involved in the housing/relocation, income/distribution, and the opportunity impacts (educational, cultural, recreational, aesthetic and economic). Impacts on community functioning are involved in conflict and local service delivery. The remaining two impact categories, costs/benefits and opposition/support for the project, are largely factors affecting the

sponsoring agency.

The problems inherent in the aggrgation of individuals' utilities into a social utility score are well known and insurmountable in strictly objective terms. The most promising approach involves the Kalder (1939)-Hicks (1939) compensation principle and Pareto optimality. According to this approach the alternative is selected which maximized benefits when the costs of compensating everyone who is disadvantaged by the alternative are calculated. Actual compensation was not required to make the decision in the Kalder-Hicks procedure but I emphasize the need for actual compensation. The objective of a policy decision should not be some abstract rational best choice but the most beneficial choice based on justice. The group gain should not be at the uncompensated or unfair expense of an individual. The first principle which I recommend for a valuation methodology for impacts on individuals' utilities is, therefore, compensation. The second principle is that potentially affected individuals (or random samples of such individuals) should make the valuation, i.e., determine the subjective weights, for impacts on individuals' utilities.

The impacts on community functioning is best approached through a policy of mitigation. If the project has a high benefit/cost ratio the resources should be available to mitigate potential negative impacts on communities. An intense effort should be made to utilize or crease the necessary institutional arrangements for complete mitigation of these negative impacts. The second principle which I recommend for a methodology for valuing impacts on community functioning is that community representatives should make the valuation judgments.

III. ISSUES IN EVALUATION OF WATER RESOURCES

III. Issues in the Evaluation of Public Projects

A. The Priority of Social Criteria over Engineering-Economic Criteria

A basic issue in evaluation methodologies is the relative priority of social impacts and engineering-economic considerations in the thinking of the decision makers. Since decision makers generally are officials of government agencies it is natural for them to place the highest priority on the engineering-economic considerations. The agency's purpose is to build projects with high pay-offs using as few tax dollars as possible. Social impacts are to be taken into account but are not to lessen the attention devoted to the main goal of building projects which serve society.

The above priorities seem to be short sighted. If we ask ourselves what factors tend to be responsible for stopping projects which have been planned and what factors lead to costly delays of constuction projects we note that the answer is the opposition of communities or neighborhoods or of groups who claim to represent the people or the environment. This pattern suggests that planners and decision makers are giving insufficient weight to social criteria. If social/community interests are given greater weight relative to engineering-economic considerations then the unacceptable alternatives could be ruled out early in the planning process and overall project costs would be lower. It may well be that undue attention has been paid to the engineering-economic criteria because on paper these criteria largely determine the "best" or the "rational" project. However, the project is not built on paper but in a community, and increasingly, in a community that cares. Projects would not be opposed (or opposed as vehemently) and they would be finished sooner and, therefore, at less cost if social criteria were more emphasized and the public had a more important role in the decision making process.

B. The Principle of Justice

Justice must be the grounds for government actions if they are to rightfully claim legitimacy. Rawls' (1971) theory of justice is the most compelling available and Rawls defines justice as fairness, which means equality except when inequalities serve the interests of the least advantaged. Put negatively, "Injustice, then is simply inequalities that are not to the benefit of all" (p 62). In contrast the principle of adding up individual utilities (weighting people equally) into a total score and choosing the alternative with the highest score (a referendum should produce the same result) has the virtue of majority rule but also allows the majority to inflict suffering on minorities for the greater good for the largest number. Cost-benefit analysis is essentially based on this utilitarian principle of maximizing the good dispite the bad which is inflicted on some. Some may define such choices as rational but they must not be defined as just (at least not according to Rawls).

In the context of government projects, Rawls' theory of justice would emphasize two prinicples of operation: 1) compensation and mitigation and 2) advancing or protecting the interests of the least advantaged. Compensation and mitigation are to be as complete, extensive, and generous as possible. The ideal is to insure that no one loses from the government action. The second principle applies most emphatically where the first principle fails. If some people must lose because of a project which substantially benefits the larger community or society, then the losers should not be the disadvantaged. As long as the agency gives highest priority to the interests of the disadvantaged in society they are likely to make the right choices according to Rawls' theory of justice.

C. Selection Versus Elimination

Decision making proceeds along somehwat different lines if it is viewed as a selection process or as an elimination process. The former wants to retain a maximum number of options from which to make the final selection and the latter reduces the options as quickly as possible. We recommend a sequence of three evaluations using the principle of elimination for the first two evaluations and the principle of selection for the third. The procedure described by Pikarsky in Section I used a sequence of three evaluations and serves as a rough model of the evaluation methodology which we are recommending. The three evaluations in Pikarsky's procedure were based on increasingly detailed information. It is inefficient to research in detail alternatives which can be quickly identified as inferior. The first two evaluations screen out all alternatives which do not deserve very careful consideration. All alternatives which pass the first evaluation should be in the noninferior set but even some alternatives in the noninferior set are screened out through the use of subjective weights. Like Pikarsky, we are recommending a sequence of three evaluations to be applied to the noninferior set.

An important aspect of the elimination process in the first round evaluation we are proposing is the specification of exclusionary criteria and of minimum acceptable levels on each evaluation criteria. A danger of evaluation methods which aggregate scores on a number of evaluative criteria into a total score is the possibility of overcoming an intolèrable score on one criteria by good scores on other criteria. In other words, the alternative with the best total may have a fatal flaw which continuous linear weighting procedures fail to signal. So the first round evaluation should eliminate all "inferior" and fatally flawed alternatives. Then the second round should narrow the field of alternatives down to the three to five finalists.

The first two rounds narrow the field of alternatives to the very few that deserve careful consideration. The focus in these rounds is not on choosing the best but on eliminative all but the very good alternatives. As recommended above all alternatives which are unac-

ceptable to the public should be deleted in these rounds (probably in the second round). The final round tries to select the best from amongst the good. A detailed analysis is made of each alternative on the complete range of evaluative criteria. Then the final selection can be made on the basis of the optimization of weighted criteria or on the basis of the compromise solution which mazimized support and minimizes opposition. The former procedure involves the summation of criteria scores times subjective weights. The weights are supplied in an earlier phase in the research process by the researchers, the decision makers or "publics" and often have the weakness of being based on evaluations of dimensions in the abstract. The latter procedure involves the dissemination of research findings and the operation of a political process. The methods for structuring the political process are in early stages of development and have been seldom tested.

D. The Human Limits to Evaluation

We have reported favorable evaluation methods which involve the public in the decision making process. However, there are limitations on the ability of people to consider large amounts of information in a decision situation which make citizen participation an uncertain guide to their real interests. Considerable research indicates that people devise simplifying strategies when faced with complex multidimensional choices (see Shepard 1964). Unable to handle the complexity they sacrafice much of the information as they follow some easy road to the decision. Most of these adaptations involve the compression of the evaluative criteria into a general good/bad dimension with a high probability that a suboptimal choice will be made in relatively difficult choice situations. The fallibility of human judgment applies to decision makers as well as participating citizens and will affect all evaluations.

E. Building Cummulation into Evaluations through Rationalized Weights

Evaluation methodology should develop rapidly in the next decade because many evaluations will be made and they will be made in an increasingly systematic manner. The development will be more rapid if cummulation occurs in the weighting process of evaluations and weighting by rationalized subjective weights will facilitate cummulation. Using rationalized weights forces the researchers to consider all significant factors, the experience of previous studies of similar projects, inputs from the public, and the subsequent critical review of interested parties and fellow professionals. Care, caution, explicitness, and just criteria are likely to result. Knowing that one's work will be critically scrutinized is a stimulus to excellence on the one hand and a stimulus to use defensible procedures on the other hand. Defensible procedures tend to be those having precedents and the respect of the professionals in the field. It is unfortunate that the need to use defensible procedures will tend to suppress creativity but at least

it will make cummulation more rapid.

F. Recommended Package of Evaluation Procedures

As the case studies indicate the 19 evaluation frameworks are generally used in various combinations. In like manner we recommend using multiple procedures. In particular we recommend combining five methods in a standard evaluation: 1) minimum criteria analysis, 2) minimize negative effects, 3) justified subjective weights, 4) subjective weights supplied by the relevant public, and 5) compensation and mitigation. First all fatally flawed alternatives are eliminated. Second, analytical procedures are utilized which minimize negative effects in the alternatives to be considered. Third, the research team calculates overall desirability scores for alternatives on the basis of justified subjective weights. Fourth, these results are to be compared to the overall desirability scores derived from subjective weights supplied by relevant publics (or an advisory committee if continuous interaction with the research team is necessary). If there are discrepencies which cannot be compromised between procedure 3 and procedure 4 the decision maker(s) must select the alternative on the basis of the two sets of scores. Fifth, generous compensation and mitigation procedures are employed to insure that the benefits of the public project for some people are not at the expense of other people. In conclusion, we recommend the following evaluation system:

1. Minimum criteria analysis (C3)
2. Minimize negative effects (E2)
3. Justified subjective weights (B3)
4. Subjective weights (B4)
5. Compensation and mitigation (E3)

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