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Trade-Off Analysis Overview and a Simplified Example

Description of Trade-Off Analysis

Trade-off analysis is a methodology that can be used to compare different types of benefits and costs that cannot all be precisely quantified or quantified in monetary terms. If all of the benefits and costs associated with a project can be quantified in monetary terms, a traditional economic analysis can be used to compare benefits and costs and it can be determined if a project is economically justified. However, in many cases non-monetized benefits and costs must be considered in evaluating projects. A trade-off analysis can include a broader range of impacts than an economic analysis alone because the effects do not need to be translated into monetary terms in order to compare the impacts of alternatives. These trade-offs include economic, financial, environmental, and social effects.

Purpose of Trade-Off Analysis for the San Diego Basin Study

In the San Diego Basin Study (SDBS), the goal of the trade-off analysis is to identify the benefits and costs of different water management strategies, referred to as Adaptation Concepts. Projects included in the SDBS are categorized into Adaptation Concepts, which helps characterize and compare economic, financial, environmental and social effects across management strategies.

- Economic effects include the benefits associated with different types of goods and services supported by adaptation concepts, the costs of the different concepts, the impacts of the different concepts on the regional economy through changes in the amount and type of spending, and the cost effectiveness of different concepts.
- Financial effects include the impacts on water utility revenues and expenditures, impacts on utility bills, fiscal impacts on state and local governments.
- Environmental effects reflect the type and quality of environmental and natural resources that would be potentially influenced by a concept. Examples of environmental effects include water quality, energy consumption, impacts on habitat, and ecosystem function.
- Social effects reflect the social characteristics of a community or region and include education, environmental justice, and quality of life. In most cases,

various concepts will generate benefits for some impact categories but not others, and the trade-off analysis will provide a methodology for comparing different types of benefits and costs.

The San Diego Basin Study trade-off analysis will

- Estimate the impacts that Adaptation Concepts under consideration would have on various resources and activities,
- Provide a relative comparison of alternatives for each impact,
- Evaluate the strengths and weaknesses of each alternative, and
- Identify Adaptation Concepts that are effective in providing specific types of benefits.

The trade-off analysis results can be combined with information on the importance of different benefit categories to determine which alternative best satisfies the needs of the San Diego Region.

Trade-Off Analysis Steps

Step 1: Obtain Measures of Outputs

Obtain measures of outputs associated with each Adaptation Concept to allow comparison with other Adaptation Concepts included in the study. Ideally, these outputs will be quantified in units that represent relative values for different categories of benefits. This step is highly dependent on the measurement of resource and activity impacts attributable to a Concept.

Step 2: Place Values on Outputs and Costs

Place values on the various outputs and costs associated with the different Adaptation Concepts. Some outputs may be quantified and monetized, some may be quantified but not monetized, and some may only qualitatively measured.

Step 3: Determine the Relative Importance of Effects

Determine the relative importance of the effects, as measured by outputs and costs, associated with different concepts. In order to make objective choices between Adaptation Concepts that have varying effects, information is needed in order to be able to evaluate the relative importance of the effects associated with different Concepts. Without some measure of relative importance, we are stuck with subjective judgements for a wide range of effects when evaluating the effects of different concepts.

In trade-off analysis, the relative importance of different effects is typically accomplished by either asking a representative sample of the affected population for comparisons of value for different objectives/effects, reviewing completed studies that

have estimated values for different objectives/effects, or by reviewing laws and regulations that apply to different objectives/effects. A survey will be implemented as part of the SDBS to gather opinions and values of the population affected by water management in the San Diego region to determine the relative importance of the different effects.

Step 4: Evaluate and Combine Effects for Each Concept

The final step of the trade-off analysis is to combine the quantitative and qualitative impacts associated with each concept with the relative importance of effects to estimate a total score accounting for all effects. The results including all effects should be used as a baseline evaluation. The objectives included in the trade-off analysis can be changed to evaluate the sensitivity of alternative preferences to the types of objectives considered. It should be noted that a trade-off analysis can be used to identify categories/types of approaches that would best support the preferences of the affected population.

Example of a Simple Trade-Off Analysis

An example is shown below based on the use of adaptation concepts and assuming a survey of evaluation objectives is completed. Table 1 below summarizes hypothetical example concepts and evaluation objective effects. These effects represent outputs from models and/or estimates of benefits based on model outputs that can be a proxy for effects, the anticipated effects of concept characteristics on evaluation criteria, or best judgement of relative effects on evaluation objectives.

Table 1 - Evaluation Objective Effects

Concept	Evaluation Criteria Effects			
	Supplies/ Reliability (acre-feet)	Project Cost (dollars)	Quality of life/ Recreation (Number of visits)	Environmental Justice (scale of 1 to 10)
Infrastructure	1,000	$100,000	1,000	5
Ecosystem restoration	200	$50,000	2,000	8
Imported water	750	$75,000	0	3
Recycled water	300	$100,000	0	6
Stormwater capture	100	$20,000	500	7
Water use efficiency	100	$35,000	0	7

The effects presented above need to be normalized to show relative strength of effects. The process of normalization means that the “best” result becomes the basis for comparison. For example, the Infrastructure concept in Table 1 provides the greatest quantity of water supplies so it is the best result and all other concepts are a portion of that result. These normalized values are shown in Table 2 below.

Table 2 - Normalized effects

Concept	Evaluation Objective Effects				Total	Order unweighted
	Supplies/ reliability (1=best)	Project Cost (1=best)	Quality of life/ Recreation (1=best)	Environmental Justice (1=best)		
Infrastructure	1.00	0.20	0.50	0.625	2.325	2
Ecosystem restoration	0.20	0.40	1.00	1.000	2.600	1
Imported water	0.75	0.27	0.00	0.375	1.395	5
Recycled water	0.30	0.20	0.00	0.750	1.250	6
Stormwater capture	0.10	1.00	0.25	0.875	2.225	3
Water use efficiency	0.10	0.57	0	0.875	1.545	4

Assuming a survey is completed asking for estimates of the importance of each evaluation objective, the relative importance of different criteria can be estimated. Hypothetical weights considering all criteria are shown in Table 3 below and the weighted effects are shown in Table 4.

Table 3 – Weights based on hypothetical survey results

Evaluation Objective	Importance	Normalized Weight
Supplies/reliability	10	1.0
Project cost	8	0.8
Quality of life/recreation	7	0.7
Environmental Justice	6	0.6

Table 4 - Normalized and weighted effects (all objectives)

Concept	Weighted Evaluation Objective Effects				Sum of Normalized effects	Order
	Supplies/ reliability	Project cost	Quality of life/ recreation	Environmental justice		
Infrastructure	1.00	0.160	0.350	0.375	1.885	1
Ecosystem restoration	0.20	0.320	0.700	0.600	1.820	2
Imported water	0.75	0.216	0	0.225	1.191	4
Recycled water	0.30	0.160	0	0.450	0.910	6
Stormwater capture	0.10	0.800	0.175	0.525	1.600	3
Water use efficiency	0.10	0.456	0	0.525	1.081	5

Weights can also be estimated using a subset of evaluation objectives, such as more traditional measures of supplies/reliability and project cost. These results including supplies/reliability and project cost are shown in Table 5.

Table 5 - Normalized and weighted effects (Including only supplies/reliability and cost criteria)

Concept	Weighted Evaluation Objective Effects		Sum of Normalized effects	Order
	Supplies/reliability	Project cost		
Infrastructure	1.00	0.160	1.160	1
Ecosystem restoration	0.20	0.320	0.520	5
Imported water	0.75	0.216	0.966	2
Recycled water	0.30	0.160	0.460	6
Stormwater capture	0.10	0.800	0.900	3
Water use efficiency	0.10	0.456	0.556	4

Trade-Off Analysis Considerations

- Economic and trade-off analyses both require inputs from other disciplines to understand and measure the resource and activity impacts attributable to a project or action and to value these impacts. For example, if there is the potential for water supply benefits due to a supply shortage, then a project will generate water supply benefits only if the project provides increased water supplies relative to conditions if no project is in place. Engineering, hydrologic, and water quality data and analyses are needed to estimate the quantity, quality, and timing of water supplies provided.
- The order of concepts changes considerably depending on the combinations or subsets of evaluation objectives used.
- Combinations of Adaptation Concepts are included within different portfolios. Therefore, the results can be used to potentially improve a portfolio by addressing a portfolio shortcoming. For instance, a portfolio that appears lacking in the provision of quality of life benefits may be improved overall by including an ecosystem restoration component as part of the portfolio.
- Some combinations of Adaptation Concepts may be mutually exclusive, where an attempt to address a potential shortcoming may create an adverse effect that reduces the desirability of a portfolio.
- The trade-off analysis can be used to evaluate what Adaptation Concepts can be added to or subtracted from a portfolio to address potential shortcomings of a portfolio.