Decision Analysis

Urban Water Systems

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Decision Analysis

- Developing decisions is a difficult task to achieve due to the errors and uncertainty in information.
- This results in projects failure to achieve their goals and objectives (Ewusi-Mensah, 2003)
- There is an increased awareness of the importance of dealing with both risk and uncertainty (Schutze et al., 2004)

Decision Analysis

- Translates the stakeholders' objectives into their relative worth to the decision maker or other interested parties (Pitt, 2007)

Uncertainty & Risk

- Uncertainty: *A state of having limited knowledge about an action or state of future outcome*
- Risk: *A state of uncertainty where desired outcomes may have an undesired effect and impact*

(Douglas Hubbard, 2007)

Utility Theory

- It is a successful method in assisting decision makers to deal with uncertainty and risk in information during decision analysis.
- Using the utility theory leads to high levels of confidence when deciding on systems.
- Utility theory is used to quantify the values of decision makers for consequences.

Example

- Best way to understand decision analysis and utility theory is through examples
- Going back to the E.coli example

Example

- Identify attributes of concern
  - Public health
  - Economic
  - Environmental
  - Resources
  - Cultural…etc
- Identify alternatives for implementation
- Each one of these attributes has a range of values from best to worst for each attribute

Alternatives

- Incineration
- Composting
- Filter Strip

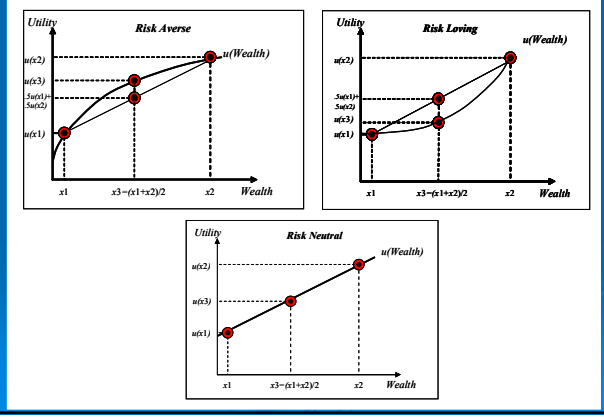
Attributes' Values for Alternatives

		Public Health	Environment & Ecology			Economic
Alternatives		Reducing E.coli	P	N	Sediment	Cost
Incineration	1	100%	100%	100%	100%	10.0
Composting	2	100%	90%	80%	60%	-24.0
Filter Strip	3	55%	85%	NA	60%	37.5

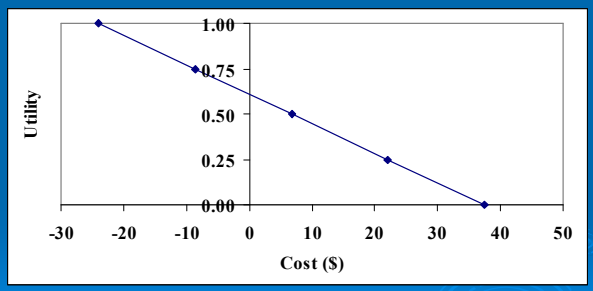
Attributes' Values

		Units	Best	Worst
Public Health		%	100	55
Environment & Ecology	P	%	100	85
	N	%	100	80
	Sed	%	100	60
Economic	Cost	$/ton	-24	37.5

Utility Curves



Utility Curves



Tradeoff Analysis

- Tradeoff: Exchange that occurs as a compromise

Example: Workout 3 times a week and reduce your health insurance by $5 a month or do not work out and increase your insurance by $5 a month

Attributes Ranking

- After utility curves are developed, the attributes are ranked.
- In our example:
  1. Public Health
  2. Cost
  3. Environment and Ecology

Tradeoff Analysis

- There are two possible situations for a pair of attributes “worst, best” compared to “?, worst”
- Assume that you are indifferent to both situations
- The common unit of comparison between the attributes is $

- The sets of comparisons are as follows

PH, Cost = (55%, -24)=~(75%, 37.5)

Cost, P = (37.5, 100%)=~(6.75, 90%)

…..and so on

Using Utility Function

U(x1, x2, x3, x4, x5)=Sigma KiVi(xi)

Where: x1: PH, x2:P, x3:N, x4:N, x5:$
k1:PH, k2:P, k3:N, k4:Sed, k5:$

Solving for k values
(k5/k1)=U1(75%) = 0.48
k2/k5=U5($6.75) = 0.5
k3/k5=U5($6.75) = 0.5….etc

- Solving for the ks

k1=0.44
k2=0.11
k3=0.11
k4=0.11
k5=0.22

Alternatives' Utility Values

Alternatives	Public Health	Cost	P	N	Sed
Incineration	1.00	0.48	1.00	1.00	1.00
Composting	1.00	1.00	0.75	0.49	0.00
Filter Strip	0.00	0.00	0.55		0.00

- Each attribute's utility score is multiplied by its relevant k value. For example:

The relevant utility value for public health for incineration is 1.0 and its k value is 0.44 then the value is (1*0.44 = 0.44)

All of these values for each alternative are added together and will have a score for that alternative

Alternatives	Score	Rank
Incineration	0.88	1
Composting	0.80	2
Filter Strip	0.06	3

For further information about decision making see Pitt and Voorhees, 2007 (Using Decision Analyses to Select an Urban Runoff Control Program)

Also Keeney and Raiffa, 1976 (Decisions with Multiple Objectives)