Identifying Decision Criteria for the Proposed Resource Recovery Wastewater Facility on UBC.

Prepared by Pedram Alvari

University of British Columbia, Department of Geography

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EXECUTIVE SUMMARY

Problem

In the interest of sustainability, researchers at the University of British Columbia have proposed the construction of an integrated liquid and solid waste resource recovery facility on campus that functions as a full-scale research laboratory while processing waste streams. The decisions involved in the planning processes are complex and are likely to result in stakeholders holding different preferences and views.

Objective

This research aims to clarify the complexities within the decision-making process by uncovering how stakeholders can best assess the appropriateness of decision criteria.

Recommendation

I recommend the use of Multi-Criteria Decision Analysis (MCDA) as an integrated assessment approach to refine decision criteria and subsequently explore how appropriate criteria can be identified when dealing with complex decision-making.

Process

The study is based on interviews with two key stakeholder groups, the researchers who have proposed the construction of the facility and members of UBC operations who would be implementing the facility. The interview data was analyzed using a data matrix of preferred criteria and then refined using the MCDA methodology.

Results

The initial analysis of interview data showed both stakeholder groups sharing similar criteria preferences. These findings did not coincide with the presented problem, as the presence of decision complexities would mean the presence of differentiating preferences and views. The second stage of analysis involved refinement of data using MCDA methodologies. Findings suggest that certain criteria, even those mutually favoured, can be problematic in the decision-making process.

Although stakeholder groups agreed on the importance of similar criteria, their desired end goals were outside the criteria's parameters. Highly valued criteria such as resource recovery was valued for the educational benefits which it could bring to the university, and interests that are itself outside of the resource recovery criteria's initial goals. Therefore, resource recovery took on the characteristics of education criteria. Education criteria, in turn, was valued for its ability to generate revenue, which, in turn, placed it more in the interests of cost criteria. The results of the study further analyze the barriers differentiating preferences can bring to the decision making process.

1. INTRODUCTION

The proposal to build an integrated research oriented resource recovery facility on the Point Grey campus poses many challenges, as the various needs of stakeholders have resulted in differentiating views and subsequently to complexities in the decision-making process. To overcome decision complexities, it is beneficial to use Multi-Criteria Decision Analysis (MCDA). The methodology is an integrated assessment approach that incorporates available technical information and stakeholder values to refine decision criteria and provide decision makers with the necessary information needed to determine appropriate criteria. MCDA is very valuable in environmental decision making, as socio-ecological systems are often complex and multifaceted. Furthermore, MCDA can provide an ideal framework for potential trade-offs among various problems while ensuring accuracy by identifying inconsistencies of judgments (Gregory et al., 2012).

My research focuses on two key stakeholder groups, the engineering researchers who have proposed the new facility and members of UBC operations who will operate and maintain the facility if built. The study utilized MCDA methodology to refine criteria selection through the criteria proposed by engineering and UBC operation groups. The central differences between these groups can help locate where decision complexities exist, and possibly where common ground may occur.

2. THE COMPLEXITY OF DECISION MAKING

2.1 Trade-offs

The different preferences of stakeholder groups in achieving a sustainable system means that trade-offs must be made. The researchers who have proposed the new system believe that a research oriented resource recovery facility can enhance the sustainability of the universities water management system, as well provide opportunities for research and a continual revenue stream. Building such a facility, however, would require a large capital investment and the provision of land. Evidently, the UBC operations group perceives that the universities current wastewater system is efficient and effective and that a system on campus is not necessarily needed to achieve sustainable wastewater practices. Yet, in keeping with current practices, the university misses the potential benefits that can be gained from resource recovery. This study was conducted to shed light on the different preferences underlying the two positions to see if it is possible to find a solution that meets the efficiency criteria expressed by UBC operations group while reaping the opportunities of resource recovery, as argued by the research group.

The variability of objectives and the requirements from individual stakeholders varies. Therefore, it is important to develop criteria considering all factors in the decision making process (Berndtsson & Jinno, 2008; Benedetti et al., 2012; Guest & Skerlos, 2009; Sahely et al., 2005; Palme et al., 2005; Poustie et al., 2015; Wiek & Larson, 2012). For this reason, the utilization of multi-criteria decision analysis (Gregory et al., 2012) can aid stakeholders to reach an agreement on a way forward as it can be used to clarify differences in preferences related to key objectives, based on performance measures of the alternative solutions.

2.2 Multi-criteria Decision Analysis

Multi-criteria decision analysis is a body of techniques and research methodologies that considers multiple criteria in a decision-making environment to improve the transparency of decisions. This simple process greatly reduces decision complexity by identifying and ranking the performance of decision options against the multiple criteria (Hajkowicz & Collins, 2007).

MCDA establishes preferences between options by incorporating the key objectives of decision makers with the measurable criteria used in achieving those objectives. In simple circumstances, the process of identifying objectives and criteria alone may provide enough information for decision makers. However, in situations involving extensive technical and scientific data, MCDA can be used as an effective method to aggregate criteria data streams to provide indicators of the overall performance of options. For this reason, MCDA has been widely utilized for urban water system analysis, especially in water policy and supply planning and infrastructure selection (Sahely et al., 2005). The method is also advantageous where there is an absence of data, such as cases dealing with stakeholder or policy makers' values, or social criteria (Upadhyaya & Moore, 2012).

One limitation of MCDA is that it cannot fully show the extent that a decision will either improve or lessen the welfare of a situation. Therefore, the best option at times can be inconsistent with improving welfare; essentially where doing nothing may be the preferred choice of action.

2.2.1 The Steps of MCDA

The MCDA methodology can be summarized into the following main steps:

Step 1: Defining the problem, generating alternatives and establishing criteria

The first step in MCDA is to establish a shared understanding of the overarching context surrounding the problem. Here, we must first identify the stakeholders who are involved, their objectives, any distinguishable alternatives for action, the people who may be affected by the decision, and any points of conflict. These initial steps can greatly clarify the end goals of the decision (Gregory et al., 2012).

Step 2: Assigning criteria weights

Next weight must be assigned to criteria. These weights show the relative importance of criteria in the multi-criteria problem under consideration (Gregory et al., 2012).

Step 3: Construction of the evaluation matrix

In the third stage a model is constructed to simplify the complex nature of the problem, allowing it to be assessed adequately. One favoured model is the data matrix, which can be expressed, in the following order:

Criteria	C1	C2	C3
Weights	W1	W2	W3
Alternatives			
A1	X1-1	X1-2	X1-3
A2	X2-1	X2-2	X2-3
Am	X3-1	X3-2	X3-3

Where X is the evaluation given to the alternatives with respect to the criteria (C) and weight of the criteria (W) (United Kingdom, 2009).

Step 4: Selecting the appropriate method

An appropriate MCDA method must be selected to rank alternatives. The relevant data and the degree of uncertainty are important factors for the stakeholder when selecting an appropriate method (Gregory et al., 2012).

Step 5: Ranking the Alternatives

The final step involves ordering the ranking of alternatives and subsequently the best-proposed solutions to the problem (Gregory et al., 2012).

2.2.2 Application of MCDA

A practical example of MCDA beneficial approach to decision making can be of two associates trying to book a hotel (Figure 1): Alice and Jane are two collogues who need to book a hotel in order to attend a weekend conference on waste water management. After some discussion, they decide that the most important factors in a hotel are the distance of the hotel from the conference and the cost of their stay. They are both on a modest budget and therefore easily come to an agreement on cost; that they will divide their expenses and will not pay more than $300 a night. However, distance is something they do not agree on. Jane prefers to be far from the conference, as she would like to walk in the morning, while Alice on the other hand would rather be closer to the conference, as he doesn't want to worry about being late. The two are now faced with a problem: How do they pick the most appropriate hotel? More specifically how do they accommodate each other's preferences in the decision making process? Upon first glance it would seem that the problem is merely rooted in each person's preference of distance. Luckily, Catherine, a decision-making expert overhears their conversation and recommends the two utilize multi-criteria decision analysis. Alice and Jane are asked to dig deeper into their preferences underlying distance. It turns out that Jane prefers a walk a farther distance she values exercise in the morning. Alice on the other hand, wants to limit her distance because she likes to sleep in in the morning.

Now that the two understand why they have different views, they may begin the process of revisiting their criteria in order to identify a solution that suits the two of them. For example, choosing a nearby hotel with recreational facilities may help Jane get the exercise she needs and give Alice the extra sleep that she needs.

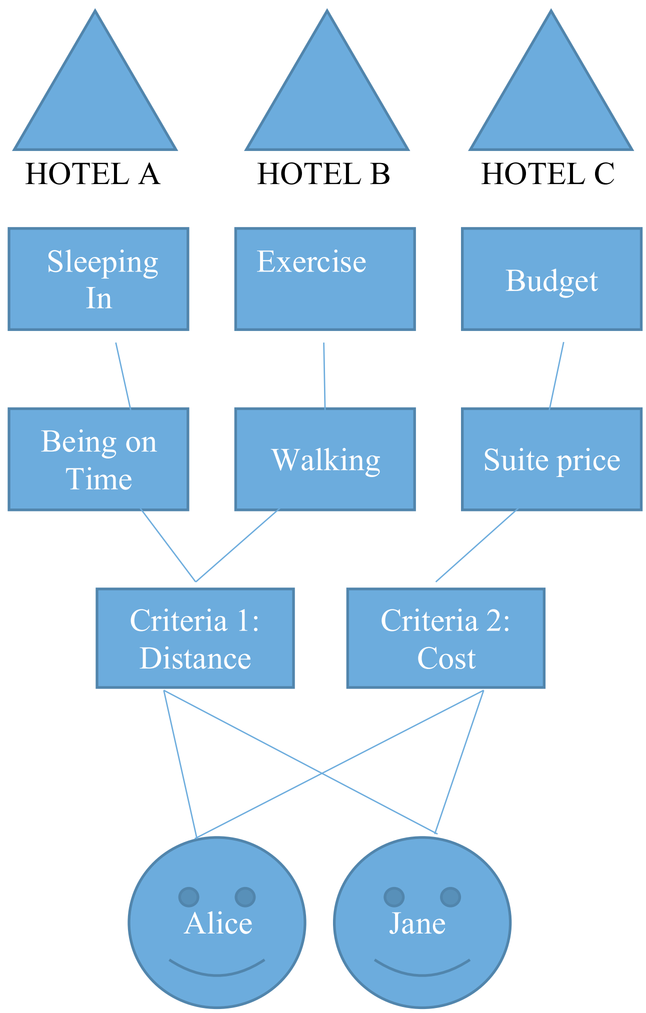

Figure 1: The selection of hotel criteria

As I previously discussed, the strengths of MCDA is its ability to ranks decision performance against criteria (Hajkowicz & Collins, 2007) and, as illustrated in the hotel selection example, its ability to refine criteria in order to explore how appropriate criteria can be identified when dealing with complex decision making.

3 RESEARCH & METHODOLOGY

In this study, I make the argument that multi-criteria decision analysis methodologies are useful in the identification of criteria in that they allow for decision criteria to be negotiated, specifically in case of the proposed resource recovery wastewater treatment plant on. In order to explore this argument, I have focused my research on the two key stakeholder groups involved; the researchers who have made the argument for the creation of the facility and members of UBC operations, who will be responsible for operating and maintaining the facility. In choosing these stakeholders, I have made the assumption that there are central differences between the two groups. In my research I aim to uncover the motivations behind stakeholders' individual preferences that are related to the wastewater system, and in doing so attempt to identify criteria that can help clarify where agreements and differences occur.

To achieve my aim, I interviewed eight experts involved in campus wastewater decision-making. I was introduced to each subject through my community partner Gunilla Öberg, professor at the Institute for Resources, Environment, and Sustainability. In respect to privacy, their stakeholder category and an assigned number have replaced the names of subjects. Each interview lasted approximately 30 minutes, and consisted of the same four questions:

Q 1: Are there any aspects of UBC's wastewater system that you think needs to be changed?
Q 2: What are the benefits of these changes?
Q 3: How can these changes lead to a sustainable system?
Q 4: What needs to happen for these changes to take effect?

The interviews were designed to understand which criterion stakeholders valued in the development of the new system, as well the potential trade-off that could be gained in the process. The first question aims to give subjects the chance to state their impressions on UBC's wastewater management systems as well position their stance on the proposed resource recovery wastewater system. In doing so stakeholders were able to freely express their views through their personal expertise. The next three questions were aimed to refine the subjects selected criteria, exploring benefits, trade-offs, the concept of sustainability, and the process of making decisions.

4 RESEARCH RESULTS

In the interviews, all stakeholders identified a variety of objectives as mandatory areas of consideration. These objectives were analyzed through the scope of environmental, economic, social, and technological criteria. By analysing stakeholder responses it was possible extract relevant criteria needed in the construction of a resource recovery facility. In total six key criteria were identified:

1. *Use of natural resources:*

   Otherwise known as integrated resource recovery, the approach aims to recover renewable resources from wastewater, from which materials, such as fertilizers, bioplastics, and energy, and water can be sourced. Rather than viewing waste as something to be disposed of, an integrated resource recovery approach views waste as a resource that is anticipated to continually provide economic, environmental and social benefits.

2. *Education opportunities:*

   UBC's strategic plan positioned the university as a "living laboratory in environmental and social sustainability by integrating research, learning, operations, and industrial and community partners" (UBC, 2012). Indeed, by leveraging academic resources with the natural resources available on UBC's land, the university has the potential to provide educational opportunities through the resource recovery facility. Education can take the form of student research projects and the openness to share research with the broader UBC community.

3. *Cost (Initial and future):*

   In principle, an economically sustainable system is one that will minimize the total costs of resources over the life of the treatment facility. Consequently, the systems initial costs (the capital cost) and its lifetime costs (for operation and maintenance) need to be considered to ensure that the system can be paid for. Resource costs include initial capital (land plus construction), operation, maintenance (labour, energy) and replacements (treatment technology).

4. *Service area/ population served:*

   Service area considers the total land area that will be eventually served by the proposed wastewater treatment facility. The area may be based on natural drainage, property boundaries, or both. Evidently, the service area can determine the volume of wastewater, which flows through the system. It is, therefore, important to factor the population demands of the wastewater system.

5. *Land requirement:*

   In order to select a suitable site for the wastewater facility, careful consideration must be given to UBC's regional land use and development patterns as well as any possible social, environmental, and engineering constraints. Furthermore, the wastewater system may pose long-lasting social, economic, and political effects on the serviced community. Therefore, the chosen site and amount of land provided for the system to build the system are crucial

6. *Operations and Maintenance:*

   It is important that the system provide a good working environment for both operators and researchers. For this to be achieved the design of the system must be simple and in a manner which provides for additional improvements and upgrades.

The criteria selection was next refined through the MCDA methodology and developed into a data matrix (table 1), which organized and grouped criteria by stakeholder preferences. Through this process it is evident that the majority of stakeholders agree on similar criterion.

	Stakeholder							
Criterion	Eng. 1	Eng. 2	Ops. 1	Ops. 2	Ops. 3	Ops. 4	Ops. 5	Ops. 6
Resource Recovery	X	X	X	X	X	X	X	X
Education & research	X	X	X	X	X	X	X	X
Capital costs (Initial + future)	X		X	X	X	X	X	X
Service area & population served	X	X		X	X	X		X
Land requirements	X	X	X	X	X	X	X	X
Operations and maintenance	X		X	X	X	X	X	X

Table 1: Suggested criteria for resource recovery plant

4.1 Analysis

The aim of this research was to suggest criteria by which it can be decided whether the proposed resource recovery facility ought to be built or not. If we were to take the data results at face value, we might make the assumption that highly favourable criteria lead to mutually agreeable decision making; that the emphasis on resource recovery or capital costs would ultimately lead to effective decision making. Therefore, it would seem that in terms of criteria, stakeholders have very little disagreement. However, this is not the case that the initial problem presented. By analysing why stakeholders chose their preferred criterion, it became evident that although groups often find common ground in criterion, their individual preferences greatly differ. Subsequently, my analysis identified resource recovery and education as potentially problematic criteria. To illustrate the findings, I have positioned stakeholder perception into segmented scenarios that take on characteristics of negotiation processes.

Resource recovery:

Scenario 1

Research groups believe that recourse recovery will provide opportunities for research and education. Researcher #1 expressed the values of resource recovery (minerals, heat, waster, energy) in the ability to advance technological research and the development of patents. On the other hand, Operations #5 believe that although research is important and intellectual property is a valuable end result, the two are experimental in nature and may become an added expense for the system.

Scenario 2

Researchers #2 believes the benefits gained from resource recovery "could work to offset initial costs" and make the system "revenue neutral". Operations groups agree, with Operations #2 stating that recovered resources such as heat can be diverted back into the UBC system to heat buildings. However, as Operations # 1 elaborates, it is not financially attractive to make large investments in energy recovery, based on the argument that the energy capacity of water is limited when compared to other renewable and fossil energy sources.

These two scenarios illustrate the potential problems embedded in the resource recovery criteria. Each group agrees to the need for the criteria, though has a separate end goal in mind. Research stakeholders wish to use resource recovery to further education and research efforts, thus making the criteria of resource recovery more about the criteria of education. Similarly, operation groups are interested in resource recovery, though in order to divert recovered resources into the universities infrastructure with the aim of reducing energy costs. In this sense, the preference for resource recovery criteria becomes more a preference for cost criteria.

Education and research:

Scenario 1

Researchers believe that it is important for the wastewater facility to provide education and research opportunities. The system can in effect facilitate the growth of students within multiple departments through the provision of advanced research opportunities and the potential for students to obtain PhD dissertations. In effect the research opportunities provided could incorporate students into the future operations of the facility. The operations group agree with the researchers, stating that the education criteria fit into UBC's living laboratory model. As Operations #4 states, education would ultimately improve the universities international image as "unlike any other university or institution". However, the operations group believe that the education component cannot take place in conjunction to facility operation, as it could be a tremendous detriment to the maintenance and operations of the system, and furthermore a potential health risk.

In this scenario both groups agree on education and research as important criteria. However, the disagreement is rooted in the end goal each group has with the educational component. It is evident that researchers would want to improve education, though the problematic aspect of this criterion may be the goal to incorporate operation and maintenance of the wastewater system into the research component. Education criteria in turn becomes more an operations and maintenance criteria. Similarly, although the operation group agree with researchers on education and research, they too make their claim for the criteria based on operations and maintenance needs.

5 CONCLUSION:

Environmental decision-making is, of course, a perfect realm for the development of strategic decision systems, as socio-ecological systems are highly complex and have the potential to provide value to many different groups of actors. For UBC to develop a resource recovery consideration must be made not only for the natural environment and its physical resources but also for the greater socio-ecological system as a whole. Attention must be given to economic, technological, and social means. Evidently, the geographical scale of a resource recovery facility would stretch through broad range environmental, social, and economic factors, and as a result, multiple stakeholders will be involved; each positioned as experts and gatekeepers of valuable knowledge. In reflection of human nature, it would seem as no surprise that stakeholders might share and have different preferences based on their personal values and claims to physical landscapes, social relations, technological advancements, and economic gain. This is why it is important to adopt systematic decision-making tools, such as multi-criteria decision analysis. As such, it would be beneficial to extend systematic regulations to protect the environment from our human nature. I simply propose that we start with our decision-making. As such, I recommend the university of British Columbia to conduct more research into how best to access its future development through decision-making strategies. For the stakeholders who are involved in the development of the wastewater facility, I recommend more discussions on how a resource recovery facility may benefit all stakeholders.

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