Decision Support for Selection of Food Waste Technologies at Military Installations

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Abstract

Evaluating and selecting appropriate sustainability technologies for U.S. Army installations is a major obstacle for a resource constrained and overburdened installation personnel. The main objective of this study is to demonstrate an excel-based dashboard tool incorporating Multi-Criteria Decision Analysis (MCDA) for waste management technology selection. The dashboard uses a series of weighted metrics to evaluate technologies over, and to query the preferences of an installation. With this information the dashboard can rank the technologies to find those that are simultaneously appropriate for specific sites' capabilities and available resources, and that also meet the high-level goals set by U.S. Army Installation Management Command (IMCOM). 14 different technology makes and models were evaluated in this study including dehydrators, pulpers, garbage disposals, containerized in-vessel composting, windrow composting, forced-air static composting, and containerized anaerobic digestion. The dashboard was calibrated and tested using three scenario installations each with unique resource constraints, and then additionally applied to Fort Hood, TX. For each application, the results of the dashboard rank each technology according to its level of appropriateness for the needs of a specific installation, and then by the technology's MCDA score. The results of the dashboard for each scenario installation had the expected technologies ranked accordingly to the constraints of the installation. For Fort Hood, windrow composting was ranked over dehydrators corroborating the results of a feasibility study performed at the installation outside of this study. MCDA provides for transparent comparison of technologies and the dashboard additionally visualizes the level of appropriateness of each for a specific site.

Keywords: Multi-Criteria Decision Analysis, Food waste, Net zero, U.S. Army, Technology selection

1. Introduction

For large, diverse organizations, the selection of a waste management technology can be a complex issue. For these entities, a selected technology must meet specific high-level goals; however, the same technology is not likely to be appropriate at every site across the entire organization. Sites can vary widely in their access to resources such as water, electricity, space, or personnel; as an example, some U.S. Army installations consist of a few buildings for a small National Guard unit while others support populations of over 100,000 (Hemmerlybrown, 2011; Harmon, Goran, & Harmon, 2014). Moreover, waste management technology selection is a critical issue for the U.S. Army due to progressive sustainability goals such as its Net Zero Initiative announced in 2011, and foreseen reductions in financial and labor resources (Foster, 2011; IMCOM, 2011).

U.S. Army Installation Management Command (IMCOM) handles the day-to-day operations of U.S. Army installations domestically and abroad. Installations are required to adequately feed their soldiers and thus must provide food in excess (Medina et al., 2014). Training activities can create weekly variations in population, further exacerbating the oversupplying of food and the resulting food waste (Holsinger, 2011).

Currently food waste management technology selection at Army installations is performed by installation personnel without much guidance or a clear set of evaluation parameters; developing a more effective and transparent method for technology selection is an important goal for IMCOM decision makers (Foster, 2011; IMCOM, 2011). To address this issue, the authors developed a dashboard tool where proposed technologies can be evaluated using Multi-Criteria Decision Analysis (MCDA) to compare the relative utility of different alternatives along multiple criteria by specifying the utility function and the trade-off between criteria (Belton and Stewart, 2002). Additionally, the dashboard tool provides a means to consider and visualize both the broader organizational priorities and the capabilities of an individual site in order to gauge a technology's suitability.

The value MCDA provides for transparent, integrated evaluation of different alternatives and quantitative trade-offs between different objectives (Howard, 1988; Keeney and Raiffa, 1976) has led to its wide application in many fields (Linkov and Moberg, 2011; Ferreira, Santos, & Rodrigues, 2010; Tony et al., 2011). MCDA is often used in technology selection, and for waste management processes. Collier et al. (2013) used MCDA to compare sustainable roofing alternatives for US military installations. Babalola (2015) conducted a study to evaluate different treatment options for large volumes of food and organic waste and their suitability for Japan using MCDA. Similarly Mir et al. (2016) used MCDA to compare and rank 11 Municipal Solid Waste treatment method scenarios environmentally and economically.

This paper presents the design, function, and initial implementation of the dashboard decision support tool designed by the authors to aid U.S. Army Installations in the selection of food waste management technologies that can reduce the volume of food waste sent to landfill or convert it into usable products. The goal of the dashboard was to display both the relative utility of each technology alternative as well as the proportion of criteria over which each technology was evaluated that fall within or outside the range a site can accommodate. To test the dashboard it was applied to three scenario installations representing installations with different constraints, as well as to Fort Hood, TX where results from a previous food waste management feasibility study separate to the project were available for comparison.

2. Methods

2.1 Approach to Technology Selection

This decision support tool was developed to bring transparency to technology selection, and enable the consideration of both the individual capabilities and limitations of a specific site as well as the priorities of the sites' overarching organization. In the context of the U.S. Army, a hierarchy of objectives, criteria, and metrics were identified to capture what IMCOM and installation Waste Managers hope to achieve through use of a food waste management technology (U.S. Department of the Army, 2011). This hierarchy consists of five objectives, 35 criteria, and 55 metrics, as shown in Figure 1, and forms the basis of the dashboard. The objectives form basis for the quantitative evaluation of different technologies. Criteria decompose each objective into its constituent parts, and are evaluated only within the context of their parent objective. The metrics under each criterion are measurable properties that characterize part of the system and are used to quantify and compare the performance of the technologies.

Each of the objectives, criteria, and metrics need to be weighted to reflect the high-level priorities of the organization for which the dashboard is being used. The weights are set using a modified "SMARTER" (Simple Multi-Attribute Rating Technique Exploiting Ranks) approach (Edwards and Barron, 1994). In this approach, an organization respondent assigns an importance score of 100 to the top ranked objective and determines the importance of the other objectives relative to that objective. This process is repeated for the criteria under each objective, and the metrics under each criterion. Equal weighting among objectives, criteria, and metrics is allowed, as are weights of zero. Normalized weights summing to 100% are calculated preserving the ratios of importance between objectives, criteria or metrics. For this study initial weights were selected for the objectives, criteria, and metrics without consulting IMCOM, but with keeping in mind the Army’s Net Zero goals.

A range of technology makes and models can be compared by the dashboard via their evaluation over each of the 55 metrics by subject matter experts. For the purpose of this study the client, IMCOM, selected 14 technologies for comparison of their ability to reduce food waste weight and volume and to repurposing waste. The technologies selected included: several models of dehydrators from two different manufacturers, two models of pulpers, an in-vessel composter, an anaerobic digestion system, and windrow and forced air composting systems. In addition to food waste reduction technologies, two business-as-usual food waste disposal scenarios were considered, an industrial garbage disposal and landfill disposal; neither of these options diverts any percentage of food waste from landfills. Field experience, manufacturer information, as well as knowledge of technology implementation and operation at U.S. military installations were used to select the technologies and score each for every metric.

On the dashboard, the hierarchy of objectives, criteria, and metrics are also connected to the capabilities and limitations of an installation to accommodate a technology. To ascertain installations capabilities and limitations an installation personnel is interviewed via a pre-interview document and follow-up in-person interview. The pre-interview document consists of 30 "yes" or "no" questions that align to each metric and are designed to identify areas of constraint for the installation. Pre-Interview questions which receive a "no" answer are followed-up in the in-person interview. The interview questions are comparative to the performance of each technology over each metric. Upon completion of the interview, a site's capabilities and limitations are reflected in the development of a green, yellow, and red range for each metric. The "green" range for a metric question reflects that the site would be comfortable in committing that level of resource or accommodating that consequence of implementing a new technology. The “yellow” range reflects that the site would be somewhat uncomfortable in committing that level of resource or accommodating that consequence of implementing a new technology, but would be able to if necessary. The “red” range reflects that the site would not be comfortable in committing that level of resource or accommodating that consequence of implementing a new technology.

Once the technologies that are to be considered are selected and their relative performance evaluated, the relative weights set, and the installations capabilities and limitations gauged, the data is entered into the dashboard and is utilized by the tool’s MCDA. For simplicity, the value of each metric is assumed to increase linearly with the performance score (i.e. value functions are linear-additive) for each objective, criterion, and metric. The tool’s MCDA calculates each technology’s utility as a product of that technology’s relative performance, and a weighted sum for that technology. The total utility, $y(i)$, for a technology, i, is calculated as Eq. 1 (Neumann & Morgenstern, 1944):

$$y(i) = \sum_{m=1}^{M} w_m \, z_i \qquad \textbf{(1)}$$

where M is the number of possible metrics on which technology i can be evaluated, w_m is the relative importance weight specified for each metric and m is an index of metrics such that $1 \leq m \leq M$, and z_i is the performance score of technology i on metric m. The performance of each metric was considered over a local scale based on the minimum and maximum performance of the technologies evaluated on each specific metric.

The dashboard allows for the visualization of the MCDA results with a series of tables evaluating the technologies performance over each objective, criterion, and metric. The main table is a summary table, an example of which is shown in Figure 2. Column one of the summary table lists the technologies evaluated. Columns two and three show two color displays, the first shows the color (red, yellow, or green) that corresponds to the color range where the highest proportion metrics fall (MAX). The second display uses color mixing to show the color associated with the average across the three color ranges (AVG). For example in Figure 2, Technology 8 has 50% percent of its score in the red range, 25 percent of its score in the yellow range, and 25% of its score in the green range, the MAX color for the technology is red and the AVG color is orange. Columns four, five, and six give the proportion of the metrics that fall into each color range (R = red, G = green, Y = yellow) for the installation. The seventh column gives the overall MCDA score for the technology generated over all the objectives, criteria, and metrics. By sorting this table first by lowest proportion of metrics in the red range, and then by overall MCDA score, a ranking of technologies that are most appropriate and implementable for a specific site is developed, which simultaneously considers how each technology meets the high-level priorities set by the organization (the overall MCDA score).

2.2 Installation Scenario Sensitivity Analysis

To calibrate the dashboard, three scenario installations were developed each designed to be constrained in the application of resources for waste management in a different way. The scenarios were labeled Fort No-Land, Fort No-Money, and Fort No-Water to reflect limited availability of space, financial resources and water, respectively, for implementation of food waste diversion. Some of the key differences in the installations capabilities under each of these scenarios are listed in Table 1. A sensitivity analysis was performed using the installation scenarios, where the weights for each were augmented until one set of weights returned acceptable results across all three scenarios. These weights are included in Table 2.

2.3 Fort Hood Case Study Application

A case study application was undertaken at Fort Hood, TX in order to assess the performance of the calibrated approach. Fort Hood was selected for the case study because

ERDC-CERL had previously performed a feasibility study at Fort Hood comparing the applicability of several different food waste diversion technology alternatives, namely dehydrators and windrow composting. While separate to the dashboards development and application, the earlier conducted feasibility study considered a subset of the metrics included in the dashboard, including: the annual volume of waste generated at Fort Hood; the capital, equipment installation, and operation and maintenance costs of the technology alternatives; the land available at Fort Hood; the existing infrastructure at the site; and the potential for the generation of a useful product from the food waste management technologies.

Fort Hood's Net Zero Waste and Sustainability Program Manager was interviewed regarding the capabilities of Fort Hood to accommodate food waste conversion/reduction technologies. All the information necessary to run the dashboard for Fort Hood was gained from the initial visit. After the sensitivity analysis was performed and the dashboard was calibrated, it was run using the capabilities and limitations solicited from the November interview with Fort Hood. The results from the dashboard were compared to those of the earlier feasibility study performed at Fort Hood.

3. Results and Discussion

The results of the dashboard ranked each technology according to its level of suitability for the needs of a specific installation while also considering IMCOM's high-level priorities and goals. Table 3 lists the top ranked technologies and their respective strengths and weaknesses revealed by the analysis for each scenario installation and Fort Hood. Figures 3, 4, 5, and 6 show the results of the dashboard run for Fort No-Land, Fort No-Money, Fort No-Water, and Fort Hood respectively.

For a land constrained installation such as Fort No-Land, the containerized composting system and forced-air static composting technologies ranked higher than one would expect because they require a significant commitment of land. However, the Land Resources metric is only one of 55 metrics and accounts for only 6.5% of the total score. While forced-air static composting did perform very highly, its land requirement exceeds the land availability of Fort No-Land and thus it is not a feasible technology for an installation such as Fort No-Land. Windrow composting performed much worse than forced-air static composting, because the latter can process almost six times as much food waste per acre of land available.

For a financially constrained installation like Fort No-Money, garbage disposals perform very well in terms of capital cost and electricity costs. If an installation is more concerned with finances than diverting food waste the selection of a garbage disposal may be appropriate. In comparison, windrow composting has a very high capital cost, but financial strengths such as zero or near zero annual electricity costs, a high value product that can be sold or used by the installation, and savings from eliminated landfill tipping fees and transportation costs incurred in sending food waste to a landfill. When a large volume of food waste requires processing windrow composting has an economy of scale advantage over technologies such as dehydrators or pulpers which have smaller per-unit capacities.

As an installation constrained by its water resources, the dashboards output for Fort No-Water makes sense as the technologies that require the least amount of water: forced-air static composting, windrow composting, and the containerized composting system, had the lowest number of metrics in the red range.

The weights calibrated using the three scenario installations were applied to evaluate the U.S. Army installation at Fort Hood which has substantial resources at its disposal for achieving Net Zero Waste and to focus on food waste diversion. Running the model with Fort Hood's capabilities returned windrow and forced-air static composting as the two top performing technologies, followed by dehydrators. These results corroborate the results of the earlier feasibility study performed for Fort Hood which recommended windrow composting over dehydrators as the technology to handle the installations food waste. Windrow and forced-air static composting are the top performing technologies according to the dashboard because they can process a high volume of waste each year, require little or no electricity, and convert 100 percent of the waste into high value compost. The dehydrators (except for one model) ranked third because of their low capital cost, the low risks they pose to air and effluent quality, the minimal space each unit takes up, and their reduction of food waste volume by approximately 90 percent resulting in a viable feedstock for composting or anaerobic digestion. The containerized composting system was not ranked in the top three technologies because it's higher capital and operations and maintenance (O&M) costs, as well as its limited throughput per unit. On the IMCOM dashboard, the main reason that windrow and force-air static composting have a lower percentage of metrics in the red range than dehydrators is due to the lower throughput and higher electricity costs of the dehydrators.

4. Conclusion

Given the U.S. Army's need for efficient selection of sustainability technologies and impending resource constraints in the comings decades, necessitates a tool such as the IMCOM dashboard. The dashboard approach builds upon previous MCDA applications but differs in that it classifies acceptability ranges for each evaluated metric for every use of the tool. An alternative approach would have been to change or limit the value scale for each case in which the tool was applied. However, this would limit the comparison of the tool's outputs across sites, because the MCDA model itself would be different. By preserving the model and adding the dashboard visualization, we allow the technology performance to be consistent across applications and identify the different capacities of individual application sites.

Although the model has not been fully verified by multiple real world applications, the potential of the model to capture the needs of an installation and aid in the selection of a suitable technology were deemed practical and feasible as a result of the scenario installation tests and the analogous performance of the dashboard to an earlier feasibility study at Fort Hood. While the dashboard was used in the context of waste management and the army, it can be applied to other contexts where technologies need to be compared across a large organization comprised of multiple units. This approach is valuable because it provides a visualization of how different technologies fulfill the priorities of an organization and the limitations of implementation at a specific site.

A complete table of differences between the scenarios installations can be found in the accompanying file of supplementary material.

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Table 1: Major differences in constraints for three scenario installations

Metric	Fort No-Land	Fort No-Water	Fort No-Money
Land Available	¼ acre	10 acres	10 acres
Volume of Water Acceptable to Process Waste	High	Low	High
Water Sources Permissible for Use	Potable or Non-Potable	Non-Potable	Potable or Non-Potable
Cost of Electricity Affordable Annually	\$3,000-\$7,000	\$3,000-\$7,000	\$2,000-\$5,000
Highest Capital Cost Affordable	\$1,000,000	\$1,000,000	\$150,000

Table 2: Weights for Objectives, Criteria, and Metrics as percent of total score

Objective	Objective Weight	Criteria	Criteria Weight	Metric	Metric Weight
Human Capital	8.48%	Personnel Requirement	0.57%	Full-Time Equivalent (FTE)	0.57%
				Personnel Quantity	0.00%*
		Technical Expertise	0.56%	Training Hours	0.28%
				Required Certification	0.28%
		Knowledge Management	0.56%	Annual Training	0.28%
				Update Training	0.28%
				Institutional Retainment	0.00%*
		Occupational Health & Safety	5.65%	Necessary Considerations	5.65%
				Protective Measures	0.0%
		Effective Collaboration	0.57%	Chain of Command	0.0%
				On-Site Contractors and Local Community	0.57%
		Permitting Estimation	0.57%	Likelihood of Requiring a Permit	0.57%
Natural Capital	33.91%	Operational Space	6.52%	Land Resources	6.52%
				Mission Training Areas	0.00%*
		Natural Resources	0.65%	Impact on Site (Land Clearing)	0.65%
				Impact on Natural Resource Quality	0.00%*
		Water Requirement	3.92%	Volume Water/Weight of Waste Processed	1.96%
				Type of Water Required	1.96%
		Air Quality	4.56%	Relative Risk	4.56%
				Potential for Air Emissions	0.00%*
		Effluent Quality	4.56%	Relative Risk	4.56%
				Stormwater Impacts	0.00%*
		Pest/Vector Management	0.65%	Risks	0.65%
				Required Counter Measures	0.00%*
			5.88%	Solid	1.96%

		Residual Material Generation		Liquid	1.96%
				Hazardous	1.96%
		Climate/Weather Issues	0.65%	Sensitivity of Technology to Weather Conditions	0.65%
				Potential Risk due to Extreme Weather Events	0.00%*
		Utilization of Created Energy	6.52%	Potential for Recoverable Energy	6.52%
Built Capital	10.14%	Mobile Infrastructure	1.60%	Equipment	0.70%
				Generator Needs	0.36%
				NTV Use	0.54%
		Fixed Infrastructure	0.54%	Building Construction	0.27%
				Road Construction	0.0%
				Rail or Distribution Network	0.0%
				Sanitary Sewer	0.27%
		Re-Purposed Infrastructure	0.53%	Utilities	0.53%
		Computerized Capability	0.53%	Capacity	0.53%
		Electricity Required	5.35%	kWh/Volume	5.35%
		Fuel Required	0.53%	Gallons of Diesel Fuel/Ton Processed	0.53%
		Fuel Storage Needs	0.53%	Narrative	0.53%
		Maintenance Needs	0.53%	Effort Required	0.53%
Financial Capital	22.05%	Capital Costs	6.89%	Cost/Volume	6.89%
		Equipment Installation Costs	0.69%	Cost/Volume	0.69%
		O&M Costs	0.69%	Average Cost/Volume	0.69%
		Utility of Products	6.89%	Utility/Volume	6.89%
		Opportunity Costs	0.00%*	Capacity Limiting	0.00%*
		Miscellaneous Costs	6.89%	Upgrades/Features for Operation	6.89%
Performance	25.42%	Throughput	3.86%	Weight/Time	3.86%
		Processing/Retention	2.25%	Time	2.25%
		Pre-Processing	3.22%	Description	3.22%
		Post-Processing	4.18%	Description	4.18%
		Waste Reduction	6.44%	Percent Waste Remaining	6.44%

		Use of Product	5.47%	Type of Product and Uses	5.47%

***Note that criteria and metrics with weights of 0.00% were unweighted in the model.**

Table 3: Top three recommended technologies for Fort No-Land, Fort No-Money, Fort No-Water, and Fort Hood and accompanying metrics advocating for (Technology Strengths) or against (Technology Weaknesses) the technology's selection. Technologies are ranked by lowest percentage of metrics in the red range.

<table>
<tr><th></th><th colspan="2">#1 Technology</th><th colspan="2">#2 Technology</th><th colspan="2">#3 Technology</th></tr>
<tr><td rowspan="2">Fort No-Land</td><td colspan="2">Containerized Composting System</td><td colspan="2">Dehydrators</td><td colspan="2">Forced-Air Static Composting</td></tr>
<tr><td>Technology Strengths:
• 100% waste conversion to high value compost
• Low electricity requirement
• No necessary safety considerations for operation</td><td>Technology Weaknesses:
• High O&M needs and costs
• Low throughput (lbs/day) per unit
• High capital cost for number of units required
• Footprint within 0.25 acres, but additional space for operations required</td><td>Technology Strengths:
• Low O&M needs and costs
• Low risk to air and effluent quality
• Minimal space requirement per unit
• 90% food waste volume reduction
• Residual material can be used as feed for composting or anaerobic digestion</td><td>Technology Weaknesses:
• Low throughput (lbs/day) per unit</td><td>Technology Strengths:
• 100% waste conversion to high value compost
• Low electricity requirement
• High annual throughput (lbs/year)</td><td>Technology Weaknesses:
• Requires more than 0.25 acres
• Requires multiple pieces of equipment
• Requires multiple FTEs
• Requires one or two non-tactical vehicles (NTVs)
• Requires building construction for associated composting activities</td></tr>
<tr><td rowspan="2">Fort No-Money</td><td colspan="2">Industrial Garbage Disposal</td><td colspan="2">Dehydrators</td><td colspan="2">Windrow Composting</td></tr>
<tr><td>Technology Strengths:
• Low capital cost
• Low electricity requirement
• Low risk to air quality
• Minimal space requirement per unit</td><td>Technology Weaknesses:
• Does not truly divert waste but rather sends it to a waste water treatment plant
• High O&M needs and costs</td><td>Technology Strengths:
• Low O&M needs and costs
• Low risk to air and effluent quality
• Minimal space requirement per unit
• 90% food waste volume reduction
• Residual material can be used as feed for composting or</td><td>Technology Weaknesses:
• Low throughput (lbs/day) per unit</td><td>Technology Strengths:
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• High annual throughput (lbs/year)</td><td>Technology Weaknesses:
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• Requires multiple pieces of equipment
• Requires multiple FTEs
• Requires one or two non-tactical vehicles (NTVs)
• Requires building construction for associated</td></tr>
</table>

			anaerobic digestion			composting activities
Fort No-Water	**Forced-Air Static Composting**		**Windrow Composting**		**Containerized Composting System**	
	Technology Strengths:	**Technology Weaknesses:**	**Technology Strengths:**	**Technology Weaknesses:**	**Technology Strengths:**	**Technology Weaknesses:**
	• 100% waste conversion to high value compost • Low electricity requirement • High annual throughput (lbs/year)	• Requires multiple FTEs	• 100% waste conversion to high value compost • Low electricity requirement • High annual throughput (lbs/year)	• Requires multiple FTEs	• 100% waste conversion to high value compost • Low electricity requirement • No necessary safety considerations for operation	• Low throughput (lbs/day) per unit
Fort Hood	**Windrow Composting**		**Forced-Air Static Composting**		**Dehydrators**	
	Technology Strengths:	**Technology Weaknesses:**	**Technology Strengths:**	**Technology Weaknesses:**	**Technology Strengths:**	**Technology Weaknesses:**
	• 100% waste conversion to high value compost • Low electricity requirement • High annual throughput (lbs/year)	• Moderate O&M costs	• 100% waste conversion to high value compost • Low electricity requirement • High annual throughput (lbs/year)	• High O&M costs	• Low capital cost • Low risk to air and effluent quality • Minimal space requirement per unit • 90% food waste volume reduction • Residual material can be used as feed for composting or anaerobic digestion	• Low throughput (lbs/day) per unit • High electricity cost for number of units required

400

Figure Legends

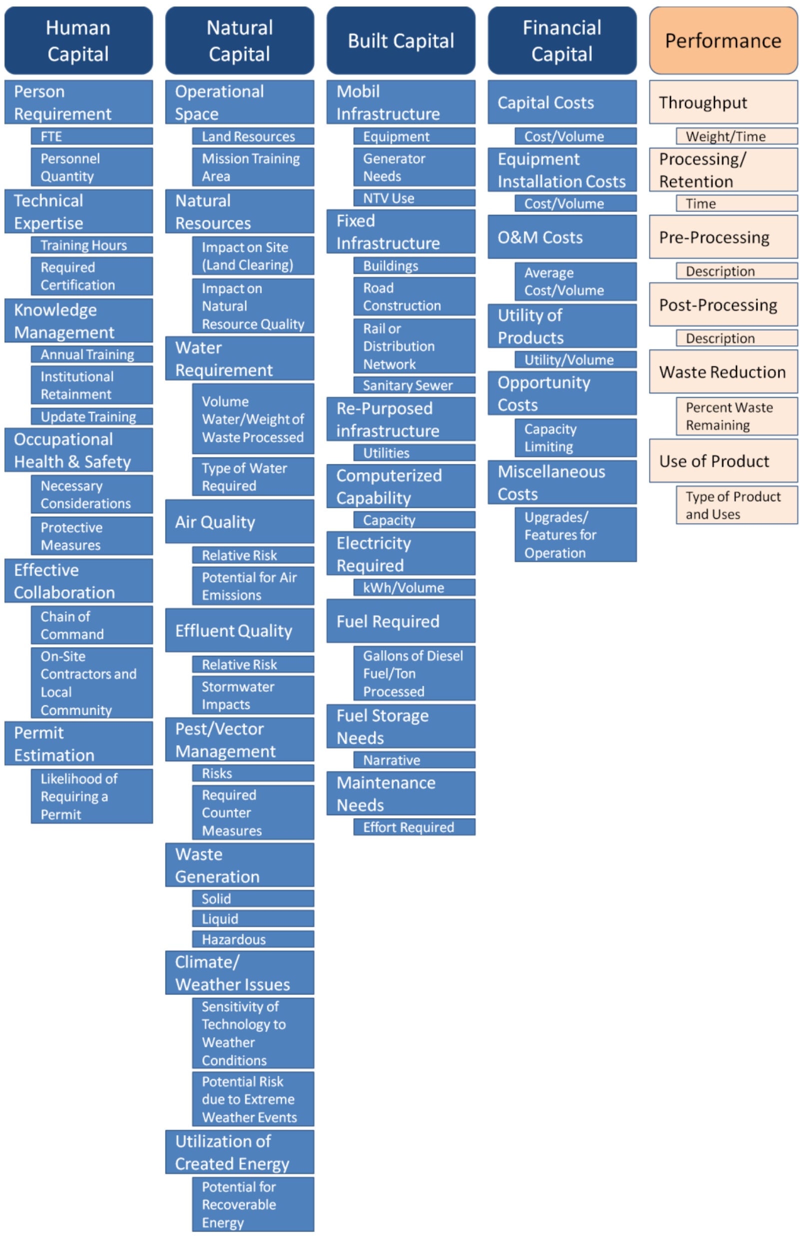

Figure 1. The structure of the decision model is reflected in the five objectives. Criteria are listed below each objective, and metrics below each criterion. For most criteria, a single metric is utilized.

Alternative Name	Max.	Avg.	R	Y	G	**Score**
Technology 1			0.000	0.000	1.000	1.00000
Technology 2			0.000	0.250	0.750	1.00000
Technology 3			0.500	0.000	0.500	0.27083
Technology 4			0.000	0.500	0.500	0.93750
Technology 5			0.000	1.000	0.000	0.33333
Technology 6			0.250	0.750	0.000	0.33333
Technology 7			0.500	0.500	0.000	0.00000
Technology 8			0.750	0.250	0.000	0.00000
Technology 9			0.750	0.000	0.250	0.33333
Technology 10			1.000	0.000	0.000	0.00000

Figure 2. Color mixing example for dashboard results summary table.

Alternative Name	Max.	Avg.	R	Y	G	Score
Containerized Composting System			0.046	0.166	0.788	0.69852
Dehydrator Company 2 (~800lb Capacity Model)			0.080	0.189	0.731	0.66884
Dehydrator Company 2 (~525lb Capacity Model)			0.080	0.189	0.731	0.66592
Dehydrator Company 2 (~300lb Capacity Model)			0.080	0.242	0.677	0.65611
Dehydrator Company 1 (~250lb Capacity Model)			0.080	0.242	0.677	0.65023
Dehydrator Company 1 (~650lb Capacity Model)			0.080	0.242	0.677	0.64199
Force-Air Static Composting			0.081	0.328	0.592	0.54342
Industrial Garbage Disposals			0.084	0.291	0.625	0.55271
Pulper (1250lb/hr Model)			0.126	0.245	0.629	0.56419
Pulper (1000lb/hr Model)			0.126	0.299	0.575	0.54554
Dehydrator Company 2 (~125lb Capacity Model)			0.134	0.189	0.677	0.62446
Windrow Composting			0.193	0.259	0.548	0.54142
Landfill/BAU			0.256	0.134	0.610	0.57573
Containerized Anaerobic Digestion System			0.301	0.074	0.625	0.46928

Figure 3. Overall Ranking of Technology Alternatives for Fort No-Land is shown in a screenshot from the dashboard. Results are sorted from lowest "R" (percent of scores in the red-range) to highest "R."

Alternative Name	Max.	Avg.	R	Y	G	Score
Industrial Garbage Disposals			0.082	0.297	0.621	0.52268
Dehydrator Company 2 (~800lb Capacity Model)			0.155	0.179	0.666	0.66757
Dehydrator Company 2 (~525lb Capacity Model)			0.155	0.179	0.666	0.66496
Dehydrator Company 2 (~300lb Capacity Model)			0.155	0.179	0.666	0.65551
Windrow Composting			0.180	0.174	0.645	0.55687
Force-Air Static Composting			0.193	0.173	0.635	0.57375
Dehydrator Company 2 (~125lb Capacity Model)			0.208	0.126	0.666	0.62402
Containerized Composting System			0.219	0.013	0.769	0.69795
Landfill/BAU			0.242	0.140	0.618	0.57573
Pulper (1250lb/hr Model)			0.262	0.242	0.496	0.53007
Pulper (1000lb/hr Model)			0.262	0.242	0.496	0.51824
Dehydrator Company 1 (~250lb Capacity Model)			0.277	0.132	0.590	0.64977
Dehydrator Company 1 (~650lb Capacity Model)			0.277	0.132	0.590	0.64114
Containerized Anaerobic Digestion System			0.346	0.051	0.603	0.43812

Figure 4. Overall Ranking of Technology Alternatives for Fort No-Money is shown in a screenshot from the dashboard. Results are sorted from lowest "R" (percent of scores in the red-range) to highest "R."

Alternative Name	Max.	Avg.	R	Y	G	Score
Force-Air Static Composting			0.006	0.262	0.732	0.57375
Windrow Composting			0.006	0.262	0.732	0.55687
Containerized Composting System			0.039	0.094	0.867	0.69795
Dehydrator Company 2 (~800lb Capacity Model)			0.039	0.127	0.835	0.66757
Dehydrator Company 2 (~525lb Capacity Model)			0.039	0.127	0.835	0.66496
Dehydrator Company 2 (~300lb Capacity Model)			0.039	0.180	0.781	0.65551
Dehydrator Company 1 (~250lb Capacity Model)			0.039	0.180	0.781	0.64977
Dehydrator Company 1 (~650lb Capacity Model)			0.039	0.180	0.781	0.64114
Dehydrator Company 2 (~125lb Capacity Model)			0.092	0.127	0.781	0.62402
Pulper (1250lb/hr Model)			0.143	0.164	0.694	0.53007
Industrial Garbage Disposals			0.143	0.291	0.567	0.52268
Pulper (1000lb/hr Model)			0.143	0.217	0.640	0.51824
Containerized Anaerobic Digestion System			0.210	0.182	0.608	0.43812
Landfill/BAU			0.275	0.141	0.584	0.57573

Figure 5. Overall Ranking of Technology Alternatives for Fort No-Water is shown in a screenshot from the dashboard. Results are sorted from lowest "R" (percent of scores in the red-range) to highest "R."

Alternative Name	Max.	Avg.	R	Y	G	Score
Windrow Composting			0.007	0.259	0.734	0.55687
Force-Air Static Composting			0.012	0.310	0.677	0.57931
Dehydrator Company 2 (~525lb Capacity Model)			0.092	0.137	0.771	0.66218
Dehydrator Company 2 (~800lb Capacity Model)			0.092	0.137	0.771	0.66162
Dehydrator Company 2 (~300lb Capacity Model)			0.092	0.137	0.771	0.64806
Dehydrator Company 2 (~125lb Capacity Model)			0.092	0.137	0.771	0.61985
Dehydrator Company 1 (~250lb Capacity Model)			0.099	0.137	0.764	0.64523
Containerized Composting System			0.120	0.062	0.818	0.67934
Industrial Garbage Disposals			0.135	0.291	0.574	0.52204
Containerized Anaerobic Digestion System			0.146	0.198	0.656	0.43939
Dehydrator Company 1 (~650lb Capacity Model)			0.168	0.068	0.764	0.62995
Pulper (1250lb/hr Model)			0.169	0.137	0.694	0.52481
Pulper (1000lb/hr Model)			0.238	0.068	0.694	0.50853
Landfill/BAU			0.262	0.141	0.597	0.57573

Figure 6. Overall Ranking of Technology Alternatives for Fort Hood is shown in a screenshot from the dashboard. Results are sorted from lowest "R" (percent of scores in the red-range) to highest "R."