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A structured decision approach for integrating and analyzing community perspectives in re-use planning of vacant properties in Cleveland, Ohio

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A structured decision approach for integrating and analyzing community perspectives in re-use planning of vacant properties in Cleveland, Ohio

An integrated GIS-based, multi-attribute decision model deployed in a web-based platform is presented enabling an iterative, spatially explicit and collaborative analysis of relevant and available information for repurposing vacant land. The process incorporated traditional and novel aspects of decision science, beginning with an analysis of alternatives, building on this analysis with a workshop to elucidate opinions and concerns from key decision-makers relevant to the problem at hand, then expanded by extracting and compiling fundamental objectives from existing planning efforts and previously published long-term goals. The model was then constructed as an open-source, web-based software platform for use as a process for exploring, evaluating, comparing, and optimizing fundamental, strategic, and means objectives. The resulting beta model, MURL-CLE, is intended to allow all interested parties, from stakeholders to decision makers, to consider alternative options for reuse of vacant land in a neighborhood in Cleveland, OH and to do so in a deliberative, transparent, and defensible process. The beta model is intended to be a platform for growth as a decision science tool and to provide a reproducible mechanism for considering any complex decision that attempts to incorporate multiple competing objectives and to allow an iterative process, as opposed to a prescribed solution or ranking of alternatives, for community decision making.

Keywords

Vacant land, decision support, community perspectives

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INTRODUCTION

The US foreclosure crisis and legacy blight in both urban and suburban areas have led communities to demolish structures that are unsightly, are perceived as a haven for criminal activity, or pose other safety risks in the communities where they exist. Analysis of the typical reasons for abandonment by White (1986) and O'Flaherty (1993) indicated that property taxes, timing of foreclosure, maintenance and condition of premises, and regional development patterns all contribute to abandonment and perhaps over-zealous use of demolition. Increased demolition has left tens of thousands of vacant lots across landscapes in cities like Detroit, MI and Cleveland, OH (Goodman 2005). This has brought with it a widespread change in the structure of urban neighborhoods, which on a block-by-block basis can often have a higher proportion of vacant than occupied housing. Typically, there is no particular coordination of demolition activities in cities in the US. Demolition is generally arbitrated on economic factors alone, environmental and social or cultural factors that relate to the potential for redevelopment are rarely considered (Bell and Kelso 1986; Cunningham 2006). In a study of demolition permit applications in Chicago, Dye and McMillen (2007) found that smaller, older homes that were near public transportation and traditional neighborhood centers were disproportionately selected for demolition, which may work against sustaining or developing vigorous neighborhoods in the future. The literature is consistent in recommending careful analysis of the social, economic, and environmental costs or benefits (e.g., improved public safety, irreparable structural deficiencies, reduction of impervious surfaces and stormwater runoff) of demolishing buildings (O'Flaherty 1993; Dye and McMillen 2007; Power 2008; Bullen and Love 2010). By restoring or refurbishing through adaptive reuse (Bullen and Love 2010), buildings can offer multiple benefits after thoughtful investments and updates are made. For engaging in this careful analysis, the literature is also consistent in recommending development of Decision Support Tools (DSTs), specifically those that enable or widen stakeholder engagement in decision processes at the community level.

Regardless of public policy and urban planning initiatives that include demolition as a part of an agenda for urban renewal, there are increasing amounts of neighborhood residential areas converted to vacant land without a well-defined vision for its reuse. While removal of blighted properties may satisfy some objectives toward urban renewal, uncoordinated demolition may have an overall negative impact on the fundamental objectives that urban renewal is seeking to achieve. As part of a response to this situation, several U.S. municipalities and counties have established land reutilization corporations, commonly referred to as land banks. Some examples of U.S. cities with established land banks (other than Cleveland) include Indianapolis, Louisville, Milwaukee, Philadelphia, Dallas, and San Diego. These land banks are intended to acquire foreclosed or vacant properties and clear titles, to consolidate or aggregate properties, and to maximize the potential reuse or redevelopment of these resources. Typically, these land banks can coordinate with neighborhood groups and provide an administrative process to clear the land titles, generally provide much-needed accounting for exactly where and how much vacant land there is, and finally, make this portfolio of land available to interested buyers that may optimize the value of vacant land (Cunningham 2006). The nascent effort to catalogue and market vacant land resources is concurrent with an emerging movement towards leveraging available land towards environmental restoration and management imperatives. Some strategies that may leverage vacant land portfolios include using vacant lots that are retrofit with or used as part of green infrastructure (GI). GI is defined as infrastructure that uses natural hydrologic features to manage water as a sink for stormwater runoff *and* to provide environmental and community benefits (USEPA 2010). Strategies for reuse of vacant land that support these greater goals of sustainable development inherently include multiple, complex, compounding and confounding decisions and this process of making decisions should include both decision maker and stakeholder participation. Developing or enhancing GI includes options that must be weighed in context with the entire suite of potential alternatives including the simplest one, which is to do nothing other than to preserve the resource of vacant land until a decision can be made. Under this "holding strategy," these properties are held for future use and economic growth, but not without cost. Processes for considering and understanding complex decisions such as this are needed and an experimental process to support such an effort was undertaken and is described herein.

Environmental and economic problems in the city of Cleveland are typical of the types of problems facing many legacy cities around the US. These problems include deteriorating infrastructure, shrinking urban residential populations, declining industrial and commercial tax bases, poverty, crime, and environmental degradation. In addition to having large amounts of vacant land, Cleveland's assets include the city's geographical location on major transportation routes, strong and vibrant communities, irreplaceable historical buildings, the expansive GI network of Cleveland Metroparks, and plentiful fresh water resources such as Lake Erie and the Cuyahoga River. The city itself, through ownership of vacant properties via the City of Cleveland Land Bank Program, is in the difficult position of considering how best to manage or use this new resource of vacant land. Repurposing vacant land does not constitute a single decision, but many smaller decisions that are arrived at on the basis of multiple, interacting objectives. Each alternate land use or option will include potential advantages and disadvantages, and requires negotiation and cooperation between a large and diverse group of citizens, stakeholders, and decision makers in order to arrive at the best use (or reuse) of limited resources. For urban areas in decline that wish to "re-imagine" whole neighborhoods, development of thorough and transparent processes for making decisions related to the use or reuse of land resources are becoming critically important. Frequently, there is an abundance of data and information known about vacant properties or land targeted for reuse, yet there are few structured approaches to guide reuse of vacant lots. For a logical and transparent decision process, a system is needed that incorporates the information and data known about the land with community involvement to select sustainable alternatives. The structured decision making process (SDM) (Gregory et al. 2012) espouses following prescribed decision steps combined with analytical tools for integrating factual or technical information with stakeholder perspectives. SDM facilitates practical adaptation of available information within a structure to instill methodological rigor and promote credibility. The aims of this paper are twofold: 1) present the USEPA developed beta-version of the decision analysis tool Maximizing Utility for the Reuse of Land (MURL; www.clemurl.org), and 2) evaluate current Cleveland land use information in light of the SDM process, and suggest how it can be tailored to SDM for land reuse planning for a single neighborhood in Cleveland, specifically Slavic Village.

APPROACH AND TOOL DEVELOPMENT

Decision-Making Approach

An SDM approach is beneficial for addressing multi-stakeholder, multi-objective problems in order to promote clarity, transparency, rigor, and inclusiveness. The following steps describe the main features in the approach (Gregory et al. 2006):

- Define the decision context – Determine and map the economic, environmental, and social drivers, governance structures, regulatory considerations, and stakeholder concerns relevant to the decision problem;
- Identify objectives and preferences – Clarify the values and success measures important and meaningful to decision-makers, and prioritize those with more importance;
- Identify alternatives - Create a range of alternatives intended to meet objectives, reflective of differing perspectives;
- Evaluate consequences – Rank alternatives through quantitative modeling of the problem;
- Conduct sensitivity and value of information analysis – Identify model components most sensitive to new information and determine the value of new information for better decision-making.

Each decision problem is different and the level of effort for each step should be adapted to the needs of the problem, available time, and resources. The general approach is iterative, given that as understanding of the problem improves changes to prior steps may be required. In practice, it is unusual for one pass through the process to be sufficient for decision-making (Gregory et al. 2012).

Consistent with SDM, MURL incorporates a value-focused thinking approach to decision-making (Keeney 1992). A value-focused approach first asks what stakeholders value and then finds decision alternatives that retain or enhance those values. This is opposed to an alternatives-focused approach that first asks what decision alternatives are available. Thus, a key component of MURL is development of fundamental (ends) and means objectives that reflect stakeholder values. An objective statement includes a decision context, an object, and a direction of preference. The terms “maximize” and “minimize” are often used to indicate direction of preference (Tables 1-2).

Table 1. Results of survey preference elicitation for fundamental objectives based on an importance ranking of each fundamental objective from lowest (1) to highest (9). The Importance column presents the fraction of the maximum possible priority score such that if all responses for an objective were 9, the Importance would be 1. The Weight column scales Importance to sum to 1. Weight is (w_k) used in Equation 1.

Objective	1	2	3	4	5	6	7	8	9	Responses	Importance	Weight (w_k)
Maximize Social and Cultural Opportunities	1	0	1	0	1	1	3	0	0	7	0.57	0.111
Maximize Environmental Safety and Quality	1	2	2	0	1	1	0	0	0	7	0.35	0.068
Maximize Economic Health and Energy Efficiency	2	0	1	0	1	0	0	2	1	7	0.56	0.108
Maximize Educational Opportunities and Facilities	0	1	0	3	1	0	2	0	1	8	0.58	0.113
Maximize Neighborhood Recreation and General Quality of Life	0	0	0	0	1	1	1	1	3	7	0.84	0.163
Maximize Neighborhood Crime Prevention and Safety	0	1	0	2	1	1	0	2	1	8	0.64	0.124
Maximize Transportation Efficiency	1	0	2	1	0	1	1	0	2	8	0.58	0.113
Maximize Preservation of Historic Architecture and Landmarks	0	3	1	0	1	1	0	2	0	8	0.50	0.097
Maximize Sustainability	2	0	0	1	1	2	1	1	0	8	0.53	0.102

Table 2. Example results of survey-based preference elicitation for means objectives associated with the Maximize Neighborhood Crime Prevention and Safety fundamental objective. Importance is the fraction of the maximum possible importance a sub-objective could be given.

Maximize Neighborhood Crime Prevention and Safety	Importance
Maximize safety standards in local zoning codes	0.69
Maximize safety standards in building codes	0.69
Maximize lighting along public streets	0.77
Maximize areas open to surveillance (i.e. windows, porches) along public streets	0.74
Maximize security patrols in business districts	0.86
Maximize police presence/visibility in residential areas	0.86
Maximize video surveillance	0.71
Maximize education programs for safety precautions	0.63
Maximize education programs for crime deterrence	0.69
Maximize accurate information on crime levels	0.71

MURL embodies a process that establishes a methodology and a platform for considering all options toward these objectives and allows participants in this process to weigh and consider those options. Fundamental objectives are refined to a point that decision criteria can be established that provide a measure of how well the objective is being met. Means objectives are actions intended to affect the decision criteria connecting "means" to a fundamental objective. Objectives were developed as per Keeney (1992), that were intended to be:

- Complete, so that all of the important consequences of alternatives in a decision context can be adequately described in terms of the set of fundamental objectives;
- Non-redundant, so that the fundamental objectives should not include overlapping concerns;
- Concise, so that the number of objectives and sub-objectives should be the minimum appropriate for quality analysis;
- Specific, such that each objective should be specific enough so that consequences of concern are clear and criteria can readily be selected or defined; and
- Understandable, so that any interested individual knows what is meant by the objectives.

Tool Development

A requisite model approach was used to develop the decision tool in a way that attempts to contain everything that is essential for solving the issue at hand (Phillips 1982). This approach provides direct and explicit links between what stakeholders prefer and value (fundamental objectives), a mechanism for achieving those preferences and values (means objectives), and the metric for measuring how well those preferences and values are being met. MURL provides an evaluation of alternatives in terms of which "best" satisfy the fundamental objectives. The subjectivity of judging "best' is contextual, and in MURL this is computed and ranked with multi-criteria decision analysis (MCDA) methods. MURL specifically employs multi-attribute value theory (MAVT), which relates preference to the decision criteria. MURL can also use multi-attribute utility theory (MAUT) (not shown in this paper), which like MAVT quantifies preference as a function of criteria input, but also allows for uncertainty in the measures of the criteria (Raiffa 1968; Keeney 1992; Morgan and Henrion 1990; Pratt et al. 1995; Clemen 1996; Drummond and McGuire 2001; Brent 2003).

Many of the criteria used in MURL are derived from geospatial data, and have little uncertainty associated with them (e.g., the location of bus stops). Thus, for the pilot project phase of MURL, value functions are used in the absence of uncertainty. In the MURL approach, stakeholder preferences for different alternative outcomes of a particular decision criterion are represented through a value function. The value function translates the criterion from its original scale (e.g., distance from bus stop in meters) to a common 0-1 value scale (e.g., if a bus stop is a few meters from a parcel than the value might be 1 while if the bus stop is greater than 1,000 meters from the parcel the value maybe 0) placing all criteria on the same scale and therefore making them directly comparable. Decision alternatives are compared through a MAVT-based score of the alternative impacts on the decision criteria. The MURL Score for each alternative is calculated as

$$score_j = \sum_{k=1}^{K} w_k \sum_{i=1}^{I_k} v_i(x_{i,j})/I_k \qquad (1)$$

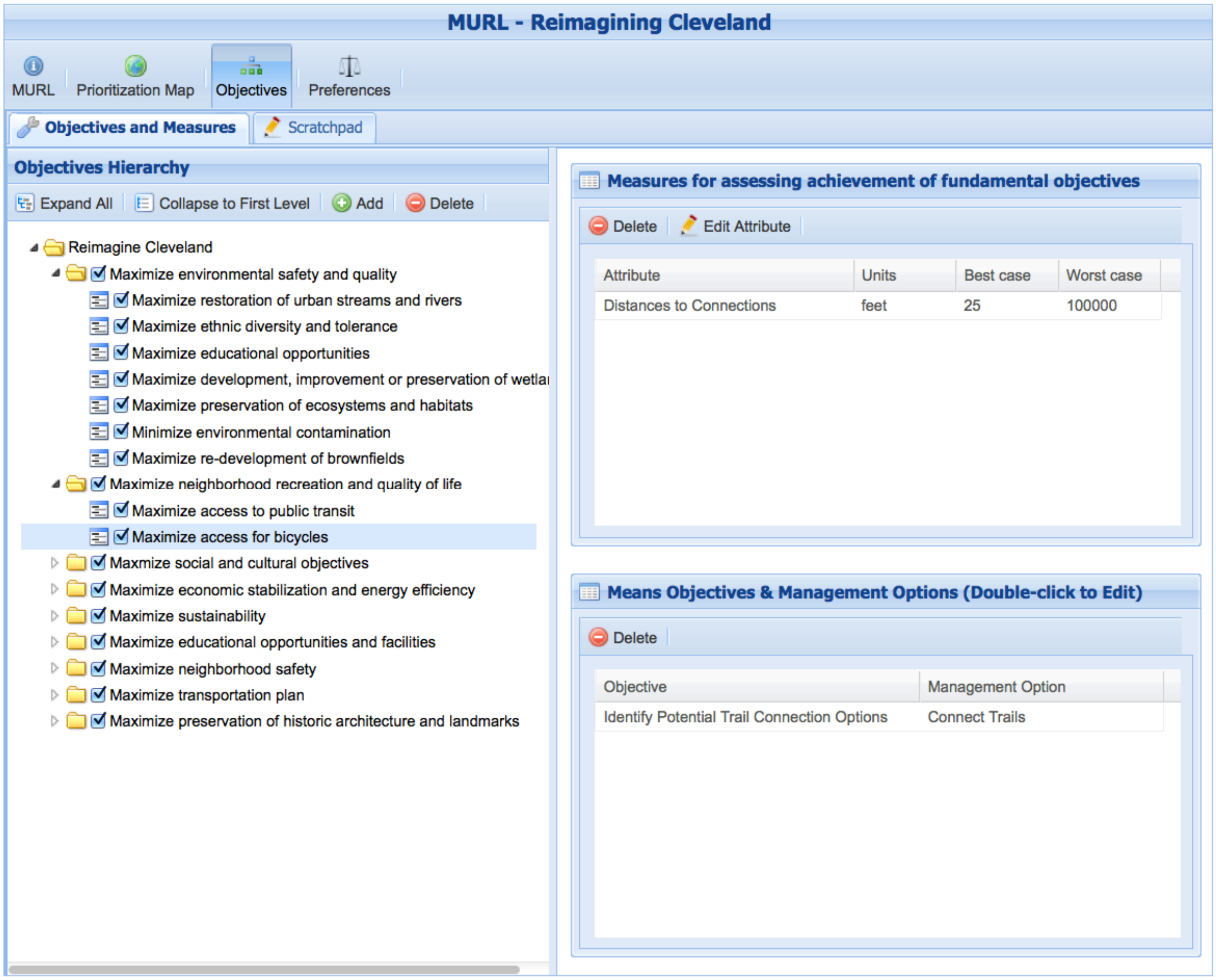
where:

j	is a policy alternative or decision option
k	is a fundamental objective
K	is the number of fundamental objectives
w_k	is the preference weighting of a fundamental objective
i	is a criterion
I_k	is the number of criteria for subobjective k
v_i	is the value function for criterion i
$x_{i,j}$	is the decision option j's magnitude impact on criteria i

The MURL Score is calculated (Equation 1) by predicting the change in the criteria ($x_{i,j}$) produced by the decision alternatives, normalizing the predicted decision criteria by their value function (v_i), and calculating the sum weighted by the stakeholder objective preference (w_k). The MURL Scores can therefore be used as a basis for policy and decision making based on decision alternative ranking.

The first step in developing the inputs to calculate MURL scores (Equation 1) is development of an objectives hierarchy based on stakeholder input (Figure 1).

Figure 1. Screen shot of MURL interface for development of objectives hierarchy. Fundamental objectives are listed to the left. Associated sub-objectives (highlighted) are linked with a means objective (lower right), and a measurable criterion attribute (upper right). Means objectives are the method selected to achieve a fundamental objective and measurable criteria attribute or attributes that quantify the achievement.



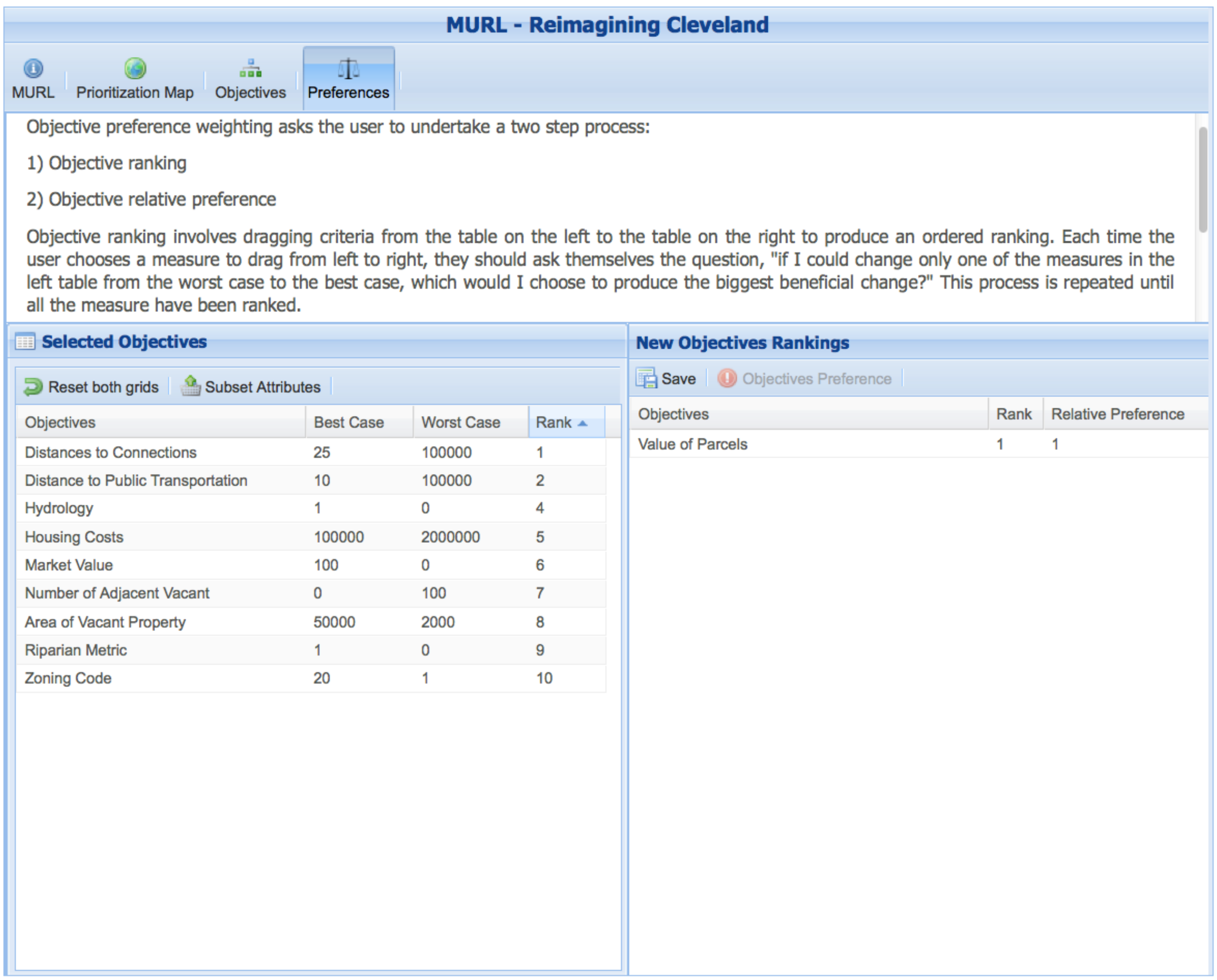
The objectives hierarchy tool asks the user initially to develop broad objectives that are then refined to be specific enough that criteria, means objectives, and associated decision options may be specified. MURL requires that criteria and decision options be added or modified only through the objectives hierarchy so that it is clear what specific objective the criteria or decision options address. Given a set of objectives, stakeholder preferences for these objectives can be elicited and translated into weights (w_k) that sum to 1.

Determination of objectives preference is accomplished through a technique known as swing weighting. Swing weighting is an elicitation process which uses a series of steps to help the user first rank the decision criteria associated with objectives and then consider the relative importance of each decision criterion as compared to the one immediately preceding it in the overall rankings. There are both simpler and more complex approaches for evaluating stakeholder preferences; swing weighting provides a nice balance between ease of use and theoretical soundness (von Winterfeldt and Edwards 1986). Though the process requires thought and work on the users part, it can help the user resolve or refine their thinking about overall ranking vs. relative importance. Swing weighting asks the user to undertake a two-step process:

1. Decision Criteria ranking
2. Decision Criteria relative preference

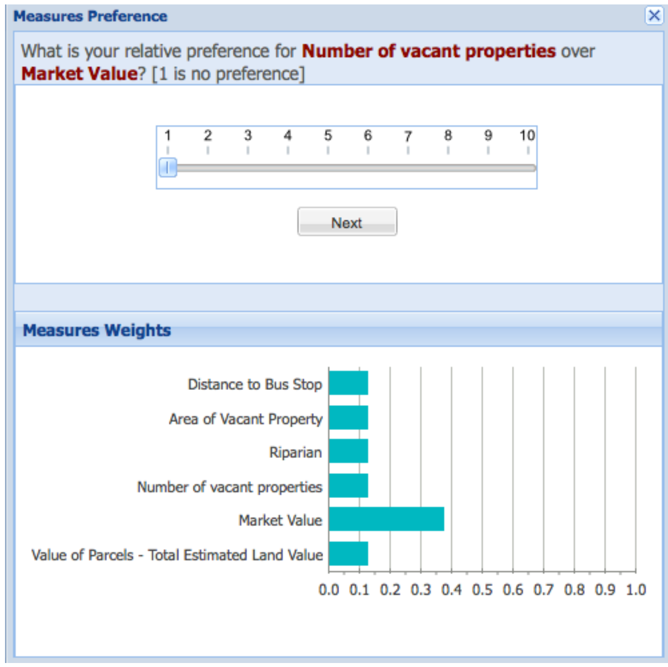
The user is asked to pick one objective-linked criterion, which would result in the largest beneficial change (Figure 2).

Figure 2. Swing weights criteria ranking tool. Criteria for fundamental objectives are populated on the left-hand side of the tool. The user then preferentially ranks the objectives on the right-hand side. This is Step 1 of the ranking process.



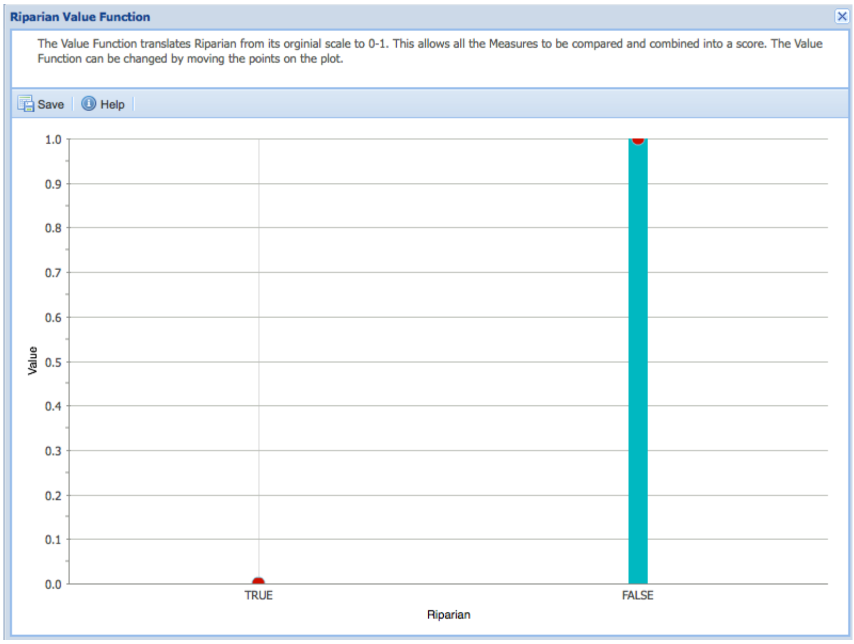
That criterion is then ranked highest. The process continues, choosing sequentially, resulting in a complete ranking of the criteria. The MURL elicitation process then asks the user to provide a relative preference for one criterion over another starting with the lowest rank criterion and moving to the highest ranked criterion (Figure 3).

Figure 3. Swing weight relative preference tool. Step 2 of the ranking process allows the user to better characterize the relative preference between objectives after the initial Step 1 ranking.



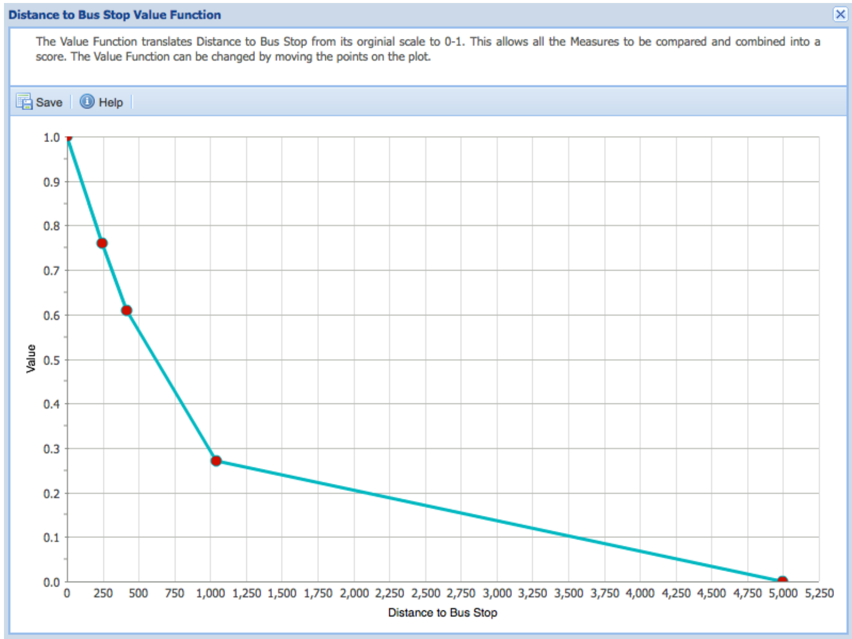
The relative preference (Step 2) elicitation approach reduces sensitivity to the overall decision criteria (Step 1) ranking. For example, if the user had difficulty in choosing among the criteria in the Step 1 ranking, a relative importance weight (Step 2) near one can be assigned, giving the two criteria nearly equal weight. The process starts by eliciting relative weights for the lowest and 2nd lowest ranked criterion. The process is then repeated to assign a relative weight of the 3rd lowest-ranked criterion to the 2nd lowest ranked criterion, the 4th to the 3rd, etc., until the highest and 2nd highest ranked criteria are assigned relative weights. Relative Preference scores and Criteria Importance Weights (always summing to one) are automatically generated as part of this process. The current status of the weighting scheme is displayed in a bar chart to provide the user with a dynamic visualization of their choices (Figure 3). These objective preference weights are then used in combination with criteria value functions (Figure 4) to calculate a MURL score that can be used to rank decision alternatives.

Figure 4. The Riparian value function is an example of a categorical variable, which is in this case the extent to which a riparian zone is valued by stakeholders. While this function is discrete, value functions can also be continuous (see Figure 5).



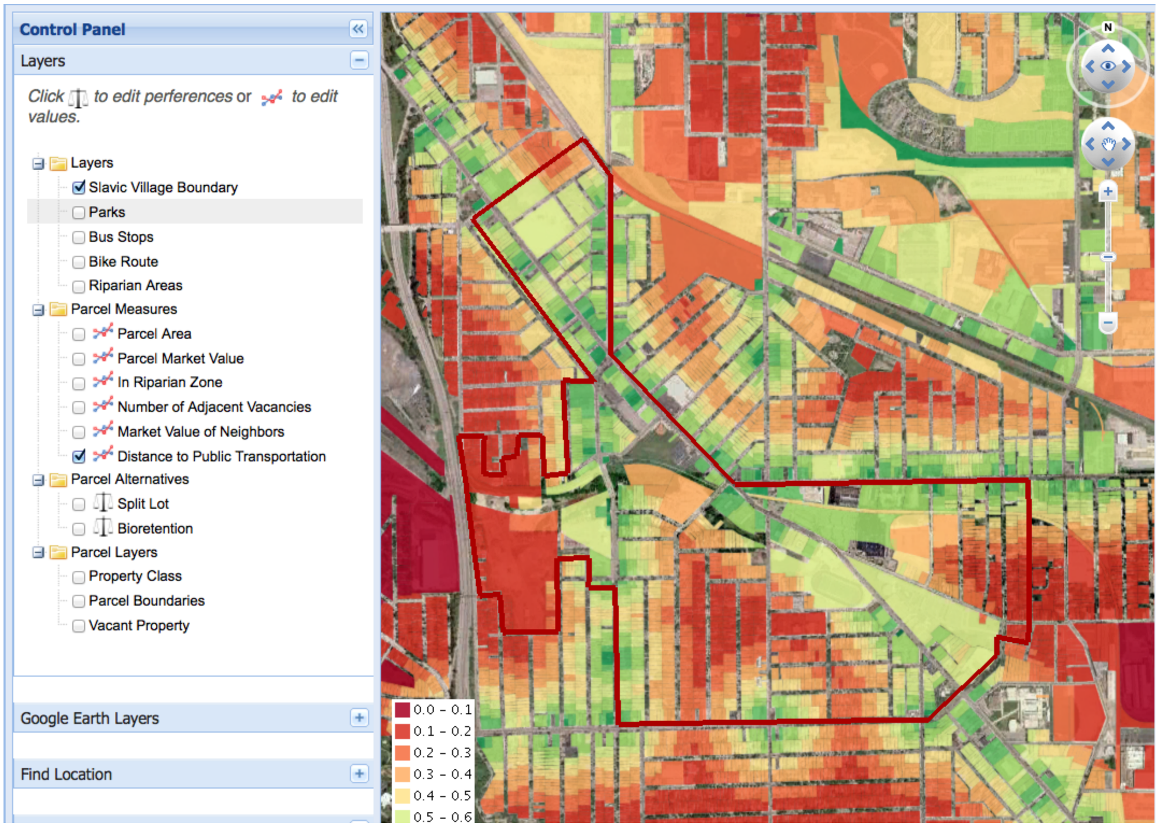
The value function for a criterion, $v_i(x_{i,j})$ (Equation 1), specifies a numeric score for each possible level for that criterion that represents the "relative desirability" of each outcome. Figure 5 provides examples of the MURL user interface that allows a user to drag points on the chart to change the shape of a continuous value function for a criterion.

Figure 5. Distance of parcel to bus stop is an example of a value function for a continuous criterion. As an interface, this function can be altered to investigate the impact on the overall decision and hence is a useful, visual way to communicate preference and priority among stakeholders and decision makers.



The basic decision analysis tools within MURL (objectives hierarchy development tool, value function elicitation tool, and objectives preference elicitation tool) are implemented in a web-based application. The open-source nature of the web application software used in MURL is intended to allow organic growth of a decision support process beyond the original scope and intent of this research once the basic concepts of SDM have been demonstrated. The open source tools used to create MURL include the R statistical programming language (www.r-project.org), PostgreSQL relational database management system (www.postgresql.org), OpenLayers for presentation of GIS information (www.openlayers.org), Geoserver as the GIS backbone (www.geoserver.org), and the ExtJS Javascript library for the web user interface (www.sencha.com).

Figure 6. Example of the MURL mapping tool interface. Displayed is the "Distance to Public Transportation" valuation for each parcel. See Figure 5 for the "Distance to Public Transportation" value function that was applied to the "Distance to Public Transportation" criteria to generate this map.



The MURL mapping tool is a visual interface for geospatial data, criteria data, criteria valuation, and MURL scores for each decision option (Figure 6). The visual interface also facilitates modification of the basis for particular decisions. In particular, the spatial criteria valuation can be updated through modification of the associated value function by clicking on the icon. Saving changes to the valuation function results in an updating of the underlying criteria value map as well as the associated MURL score map for a decision alternative. The decision criteria that are included in a MURL score for a particular decision alternative can be modified by clicking on the icon. This brings up a dialog window that allows the user to add or delete the criteria included in the score (Figure 6). Once such a decision analysis-based model is constructed and implemented, the model is evaluated in one of two ways, which depends on the nature of the input. If the inputs are uncertain and specified probabilistically, then a global sensitivity analysis can be performed that identifies the most important factors of the output prioritization. The other option for sensitivity analysis is to change the value of one model input factor at a time. This is similar to performing an iterative "what-if" analysis, and can be helpful when evaluating possible model output for extreme cases. In effect, global sensitivity analysis would identify important inputs, and uncertainty analysis would indicate if there is sufficient confidence in the prioritization, and value of information could be used to determine how much data would adequately reduce uncertainty if the level of confidence is not sufficient in the prioritization.

ILLUSTRATION OF *MURL* EAMPLE INTEGRATION AND ANALYSIS OF CLEVELAND LAND REUSE PERSPECTIVES

Objectives Development and Preference Ranking

The MURL prototype was applied to the evaluation of alternative land use options for vacant properties in Slavic Village, a neighborhood in the City of Cleveland, OH. A one-day introductory workshop was held in Cleveland, OH to establish a constituency for the project and to ensure that there was interest and investment in model development. With regard to stakeholder input, ideally an explicit and formal process to interact with different stakeholder groups is conducted to elucidate goals and objectives. During the initial workshop with City Departments, it became clear that stakeholders and decision makers in Cleveland had already invested a significant effort to produce a general list of objectives for re-purposing vacant land, had begun to consider alternatives, and had constructed a long-term plan and convened a committee to begin making these difficult decisions.

Rather than starting over and asking these stakeholders and decision makers to work through a process of defining objectives, the research team decided to extract the fundamental objectives, where possible, from the existing plans and reports that the City had already produced. This approach of using approved policy documents for objective development is often termed the gold standard method (Parnell 2007) as opposed to the more time and resource intensive platinum standard of formal elicitation interviews with stakeholders. For the purpose of this pilot project, objectives were defined using the aforementioned gold standard approach based upon interactions between U.S. EPA and Cleveland city government decision-makers, EcoCity Cleveland (2010), Cleveland Urban Design Collaborative (Cleveland Land Lab 2008), and The City of Cleveland's City Planning Commission's 2020 Citywide Plan (Cleveland 2011b). The overall objective of the decision making process was to maximize improvements to the economic, environmental and social aspects of land use (or reuse) decisions in support of the greater Slavic Village Community Development Corporation (CDC). An initial objective hierarchy was identified that included nine fundamental objectives (Table 1) with a total of 157 sub-objectives (sub-objectives not shown).

Stakeholder preferences for these objectives were elicited and refined through an iterative process with an on-line survey (Preference Step 1) for an initial broad based rapid preference assessment that can be followed by the online MURL swing weighting preference-updating tool (Preference Step 2) when developing alternative preferences for evaluation. The rapid assessment survey allows stakeholder preferences to be collected in a resource efficient manner potentially incorporating a broader spectrum of stakeholders than can be typically gathered in an elicitation workshop. The survey was administered on-line to a group of eight land use managers in local CDCs. The CDCs have the mission of seeking partnerships and providing assistance toward the greater goal of building and maintaining each of Cleveland's neighborhoods. The CDCs that voluntarily participated in this application of MURL were similar in terms of their demographics and the types of challenges encountered. This on-line survey approach was used to quickly rank the set of objectives that could be used to test the MURL methodology and to gain a better understanding of how on-line surveys should be designed to facilitate ranking of stakeholder objectives efficiently for the first MURL preference step. The limited survey that was done was for proof-of-concept, and the survey results were not intended to support conclusions regarding actual community preferences or objectives beyond their use in development of the beta version of MURL. The survey results form a baseline in MURL against which the user can begin to investigate the impact of values and alternatives on fundamental objectives.

The survey results (Table 1) indicate that the *Neighborhood Recreation and General Quality of Life* objective has the highest priority (Importance score of 0.84 in a normalized ranking from 0-1) for the survey respondents, with the *Neighborhood Crime Prevention and Safety* objective the next highest priority (0.64). *Environmental Safety and Quality* was the lowest priority objective (0.35) for this survey. These preferences may reflect the interest of the participating CDCs in economic development and safety in these urban core neighborhoods, which have experienced a great deal of hardship in the past. The outcome of this limited survey also points out the primacy of economic opportunity as a driver for social and environmental change.

The survey also elicited the importance or relevance of potential means objectives associated with fundamental objectives. Table 2 highlights the means objective preference elicitation for the *Maximize Neighborhood Crime Prevention and Safety* objective from Table 1. The importance of police patrols is evidently seen as important to maintaining overall safe neighborhood environs. Yet, other factors that would directly involve land use decisions or educational approaches to public safety were ranked lower in relative importance.

Scoring and Evaluating Alternatives

The scoring of a decision alternative with MURL (Equation 1) is described at the parcel level with an example involving two objectives, each with a single associated criterion that measures how well the objective is met. Although *Maximize Environmental Safety and Quality* was ranked lowest overall in terms of importance (Table 1), we use this objective with the categorical decision criterion (yes – no) of *In Riparian Zone*, and *Maximize Transportation Efficiency* with the decision criterion of *Distance from Parcel to Public Transportation* (a continuous variable measured in units of length). The *In Riparian Zone* data is derived from an overlay of parcel boundaries and a riparian zone data layer, and each parcel is accordingly assigned a true (in a riparian zone) or false (not in a riparian zone) status. The *Distance from Parcel to Public Transportation* is derived from a distance calculation made between parcel boundaries and a data layer of municipal bus stops. The value functions for *In Riparian Zone* and *Distance from Parcel to Public Transportation* are presented in Figures 4 and 5, respectively.

The importance of *In Riparian Zone* (the criterion for *Environmental Safety and Quality*) is 0.35 and 0.58 for *Distance from Parcel to Public Transportation* (the criterion for *Transportation Efficiency*) (Table 1). Scaling these two values to sum to 1 results in objective weights of 0.38 and 0.62 for *In Riparian Zone* and *Distance from Parcel to Public Transportation*, respectively. Based on this derived information, imagine Parcel A in a riparian zone and 250 meters from a bus stop. The value for *In Riparian Zone* is set to 0 (Figure 4). The implied assumption in setting the affirmative to 0 is that protection of a riparian zone supports the fundamental objective *Maximize Environmental Safety and Quality.* The value for *Distance from Parcel to Public Transportation* is 0.75 (Figure 5). Applying the objective weights produces a score of (0.0)(0.38) + (0.75)(0.62) = 0.47. Alternatively, imagine Parcel B, which is not in a riparian zone and 1,000 meters from a bus stop produces a score of (1.0)(0.38) + (0.29)(0.68) = 0.56. Under this set of objective preferences, Parcel B would be ranked higher than Parcel A.

Evaluation of alternatives can be demonstrated through examples selected from the "Re-Imagining Cleveland Vacant Land Reuse Pattern Book" (Kent State 2009), and include:

1. Status quo: take no action on parcel;
2. Split vacant lot among two adjacent owners;
3. Convert parcels adjacent to residences and schools to community gardens;
4. Use parcel as bioretention for managing stormwater;
5. Develop a pocket park as a community garden or a passive green space with seating.

To illustrate how decision alternatives can be evaluated and compared, consider a vacant parcel with 3 occupied parcels surrounding it (Figure 7) with 3 potential decision alternatives (status quo, split-lot, and bioretention), evaluated against four objectives. Table 3 provides the criteria basis for each sub-objective and Figure 7 provides basic parcel characteristics relevant to this example.

Figure 7. Illustration of Vacant Parcel Alternatives example. A vacant parcel adjacent to occupied parcels has three alternatives under consideration that must be evaluated using criteria that measure the attainment of fundamental objectives.

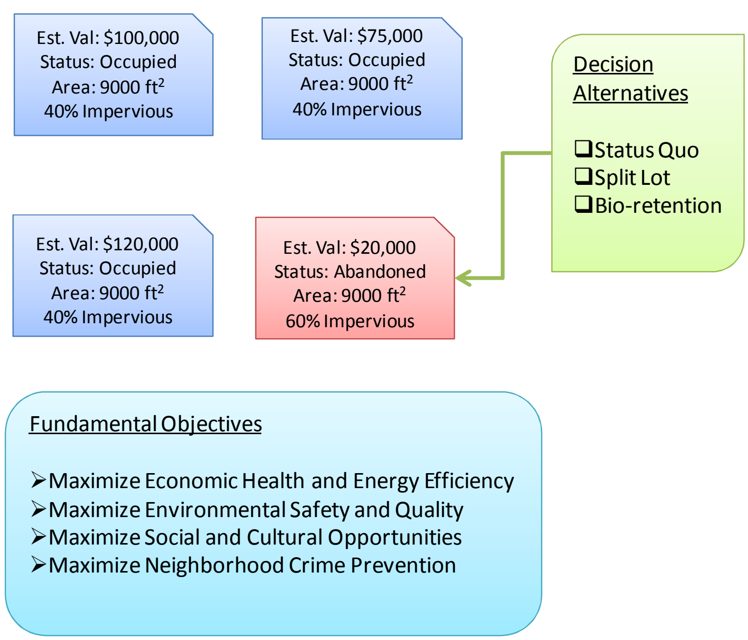


Table 3. Criteria Basis for illustrative example. The example uses four of the nine identified major objectives listed in Table 1. Each criterion is assumed to be linked to a sub-objective of the higher order fundamental objective listed.

Criteria	Assumptions	Units
Maximize Economic Health and Energy Efficiency		
Demolition costs	Abandoned property will be removed for split lot and bioretention options	$10,000 if structure on property ($)
Construction costs	Estimated (Kent State, 2009)	Cost ($)
Property Value Impact	15% reduction in estimated values if not improved 15% increase in value of neighboring parcels if improved	Depressed value of adjacent parcels ($) Increased value of adjacent parcels ($)
Maximize Environmental Safety and Quality		
Aesthetics	Stakeholder judgement	High/Medium/Low
Runoff	Equal to vacant lot impervious area for split lot For bio-retention, include impervious areas from adjacent lots	Reduction in available Run-off surface area (ft^2)
Maximize Social and Cultural Opportunities		
Parcel ownership	Assigning active ownership to properties is beneficial.	Yes/No
Maximize Neighborhood Crime Prevention and Safety		
Reduce crime	Presence of a vacant structure increases crime.	Yes/No

We assumed that the existence of the abandoned structure depresses the value of neighboring parcels; the split lot option reduces runoff by the area of impervious surface that is removed; the bioretention option redirects flow from the impervious portions of neighboring parcels as well as the target parcel. Given the criteria definitions in Table 3, the impacts of the decision alternatives on each criterion were estimated in Table 4. Table 5 provides the objective weights based on the objective *importance* from Table 1, normalized for the subset of objectives considered in this example.

Table 4. Decision Alternative Impacts on Criteria $(x_{i,j})$. Results are generated from conditions defined in Table 3.

Objectives & Measures	Status Quo	Split Lot	Bioretention
Maximize Economic Health and Energy Efficiency			
Demolition Costs	0	\$10,000	\$10,000
Construction Costs	0	\$5,000	\$29,000
Property Value Impact	-\$44,250	\$44,250	\$44,250
Maximize Environmental Safety and Quality			
Aesthetics	0	0.5	1
Runoff		5400 ft^2.	16,200 ft^2
Maximize Social and Cultural Opportunities			
Ownership	0	1	1
Maximize Neighborhood Crime Prevention and Safety			
Crime	0	1	1

Table 5. Development of MURL alternative scores. Scores are the sum of the value functions $v_i(x_{i,j})$, weighted by stakeholder preference (w_k). Value functions generate normalized scores from criteria ($x_{i,j}$) with user defined functions (assumed here). See Figures 4 and 5 for examples. Italicized objective weights are re-scaled for the smaller set of objectives in the vacant parcel example and divided by number of sub-objective criteria (I_k).

Objectives & Criteria	**Objective Weight** w_k	**Criteria Value Function** $v_i(x_{i,j})$		
	From Table 1	**Status Quo**	**Split Lot**	**Bioretention**
Maximize Economic Health and Energy Efficiency	**0.108**			
Demolition Costs	*0.088*	0.5	0.2	0.2
Construction Costs	*0.008*	0.5	0.3	0.05
Property Value Impact	*0.088*	0.0	1.0	1.0
Maximize Environmental Safety and Quality	**0.068**			
Aesthetics	*0.083*	0.0	0.5	1.0
Runoff	*0.083*	0.0	0.2	1.0
Maximize Social and Cultural Opportunities	**0.111**			
Ownership	*0.270*	0.0	1.0	1.0
Maximize Neighborhood Crime Prevention and Safety	**0.124**			
Crime	*0.300*	0.0	1.0	1.0
MURL Score		**0.09**	**0.76**	**0.85**

The normalized criteria values are calculated by applying value functions (assumed in this example) to each of the measured criteria. This provides the scaled component (i.e., the $v_i(x_{i,j})$) of the MURL score equation (Equation 1). The MURL score is calculated by multiplying the objective *weight* by the criteria *value* and then summing for each decision alternative. Comparing the MURL scores indicates that the preferred decision option for this parcel is to convert the parcel to a bioretention basin for managing stormwater (Table 5). The bioretention decision option appears to dominate the status quo, but the split lot option has a MURL score close enough to warrant further investigation through sensitivity analysis. A sensitivity analysis on the impact of the objective weights and the criteria value functions on the MURL scores could reveal whether the bioretention decision option is a clear choice or whether, for example, the objective weights gleaned from the survey should be updated and refined using the MURL swing weight elicitation tool.

DISCUSSION

The long-term fundamental goals for redevelopment expressed in the Cleveland Planning Commission's "Connecting Cleveland; 2020 Citywide Plan" are laudable; however in the immediate term economic considerations and realities tend to greatly outweigh the city's greater ambitions. Therefore, environmental improvement and restoration – which were drivers for the development of MURL – are likely subordinate to making vacant lot space more productive in terms of economic stabilization or improvement. Another assumption that we subjectively impose on this model is that restoration of vacant lots may center on GI. This can take the form of plant-soil systems (e.g., rain gardens) or engineered approaches to realign the local urban hydrologic cycle to emphasize rainfall capture by preventing runoff formation and by providing infiltration opportunities. A lack of familiarity with GI and the services that it can render (stormwater management, green space where there was once none, increased pollinator activity, etc.) may have contributed to a more or less singular focus on economics and safety. In terms of economic interests, the survey respondents recognized the potential to increase the financial value of vacant land by siting a business or residence there, but may not have recognized the intrinsic value in the use of vacant land as a stormwater sink. In the latter case, vacant land becomes part of the regional sewer system with the intent to prevent stormwater from entering combined sewers and treatment plants. This latter arrangement utilizes vacant land as a key ingredient in the management of combined sewer overflows, providing a forum to potentially elevate market value of vacant land for services thus rendered.

On the matter of safety, perceptions of land use with regard to crime are divergent and largely anecdotal. A business or residence in good condition and that provides recognized, real services to the local community is likely to be viewed in a positive light, though building a new business or residential development on vacant land may not be feasible due to overall depressed economies throughout urban core areas. If we apply our normative perspective that GI is a reasonable holding strategy to stabilize the vacant landscape, it is often perceived that tall grasses, trees, and other natural features may provide cover for criminals to hide or conduct illicit trade, among other undesirable social behaviors. A rare field example of this uncertainty in how GI may or may not contribute to safety shows that this is a complex issue that requires further study. The work of Gorham et al. (2009) indicates that increased green space from Houston, TX community gardens (a form of GI) was a potential driver for maximizing the perception of safety, which may influence a community-supported decision making process. Though there were no significant differences in actual numbers of property crimes committed near gardens or in other randomly selected areas, residents of the community garden areas perceived their respective neighborhood areas to be safer due to the presence of community gardens. Studies such as this could be used in targeted educational efforts to connect potential methods for environmental improvement to stated preferences for land use. For the same reasons, the work of Gorham et al. (2009) requires replication in other areas with different demographics to help make clear connections between actual shifts in land use to, for example, GI and the social and economic response that may follow its implementation.

CONCLUSIONS

The process for developing and applying a rigorous and thorough decision support tool or process to any complex problem begins by defining the decision context and establishing fundamental objectives. Ideally, this process is tailored to the specific site or problem being addressed. MURL represents a generic process that was tailored to repurposing vacant land in Slavic Village. To accomplish tailoring of a generic process to a specific site or problem workshops, meetings, interviews, and literature reviews are conducted. As this process unfolded for MURL, the research team learned that much of the groundwork needed to develop fundamental objectives had already been done and published by decision makers and stakeholders in Cleveland. We realized that the ideal decision support process should place a minimal burden upon the stakeholders and decision makers. Decision-making is hard work, but MURL provides stakeholder value elicitation tools coupled with an underlying rigorous SDM framework that conveniently provides trade-off analysis of decision alternatives. Stakeholder value preference structuring can be achieved by extracting fundamental objectives from existing programs, organizations, and publications and using the resulting objective hierarchy as a starting point for the more traditional approach of elucidating the decision context and objectives from workgroups and interviews. Surveys can be designed and used to further refine fundamental objectives and to develop strategic objectives. This substructure then forms the default conditions for GIS-linked visualization and optimization software to support further understanding and exploration of potential alternative land uses or means objectives. In this way, we are tailoring a tool to support decision making using existing progress and momentum to establish and refine objectives and placing that into a systematic method that allows all stakeholders access to and participation in a process to weigh and consider reuse of the resource that is vacant land in an urban environment.

While our intent was to develop a process to consider or optimize options for the reuse of existing vacant land, this same approach could be expanded further to consider the demolition of vacant or foreclosed properties to combat blight. Power (2008) argues that a focus on renovation coupled with highly selective demolition would be a more sustainable approach than large-scale demolition when a holistic accounting for energy use for each approach is taken into account. The most sustainable solution or path for “re-imagining” a neighborhood in decline may hinge initially on the decision to demolish rather than to renovate or retrofit structures, which is, in and of itself, a complex decision based on many smaller decisions with multiple, interacting objectives, each under a state of uncertainty. Further refinement or development of this decision-making process could be done to include the initial decision of whether or not to demolish or leave vacant structures in place as part of “re-imagining” or optimizing land use for a geographical unit at the neighborhood, city, or regional scale. In Cleveland, specifically, two land banks hold vacant lots or lots with structures. The Cleveland Land Bank holds vacant lots and lots with vacant structures greater than 3000 sq. ft, whereas the Cuyahoga County Land Bank holds vacant lots with structures under 3000 sq. ft. When a structure on a lot is demolished, the vacant lot is transferred to the Cleveland Land Bank for disposition. Under this arrangement, the first step in the decision making process will be to determine which land bank will have control of the property and therefore act as decision maker regarding demolition. To consider whether to demolish a structure, stakeholders may need to work with multiple land banks and an expansion of the SDM process described herein could be used.

MURL is scale-independent in theory while in practice the data requirements and stakeholder population grows as the scale grows. At the neighborhood scale, the stakeholder group is narrowly defined compared to a regional scale, but the use of a refined survey approach may help to alleviate this hurdle. Geospatial data also becomes more difficult to collect and manage as the scale increases, but again this hurdle is being lowered over time as federal, state, and local government agencies develop interoperable geospatial data products.

It is important to highlight the fact that MURL is a tool or platform on which stakeholders may consider and compare disparate options; however, it is not meant to result in a "master plan" or to rank alternatives in a static way. As a process, the intent is to inform decision makers as they weigh alternatives – not to dictate the optimal alternative on a site-by-site basis, but rather to compile, compare, contrast, and consider options with the relevant information that is available and with some idea of the uncertainty involved and how that may affect a desired outcome. Information with an unacceptable level of uncertainty can be identified and either omitted from the analysis or highlighted as an area needing further study or refinement. Stakeholders and decision makers can apply this tool individually or in concert to consider options and to investigate, in a defensible process, how objectives may compete or interact and to interpret the results as part of an open conversation held in a visual and intuitive GIS-linked format.

Fundamental to the MURL approach to decision analysis is the iterative learning and decision framing philosophy that occurs as objectives and associated values are elicited. Though a score is calculated that is a valuable guide to ranking decision options, the process of understanding values, designing decision options, evaluating decision options in a manner that is directly and explicitly tied to objectives, and generally thinking hard about the decision problem at hand in a rigorous decision framework is invaluable in moving towards sustainable decisions for the reuse of vacant land.

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