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Identifying potential conflict in land-use planning using a values-centered *e*-participation tool: A Canadian case study in aggregate mining.

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Abstract

An innovative e-participation tool is used to facilitate the articulation of value-laden assumptions, and to identify key points of likely conflict in an aggregate mining controversy in Ontario, Canada. The expert model developed using 'Public to Public Decision Support System (P2P-DSS) reflects a perspective that differs significantly from public perceptions in terms of the social values that influence rejection of a permit amendment application. By facilitating two-way communication about values assumptions P2P-DSS generates a novel dataset that can support pro-active conflict management and contribute to a shared understanding between government decision-makers and public citizens.

1. Introduction

Consideration of public preferences is a key aspect of democratic decision-making and planning [1] [2]. For some citizens, providing input online reduces barriers to participation, particularly when mobility, travel costs, motivation and opportunity costs pose restrictive burdens to engaging in traditional participatory processes [3]. The significance of online participation, or *e*-participation is sure to rise in-step with increased access to high-speed internet [4] [5].

Typically, municipalities use *e*-participation tools that replicate aspects of real-world services into online spaces, increasing service delivery efficiency [6]. However, with advancements in Information and Communications Technology (ICT), online platforms are capable of much more than replicating traditional participatory experiences. Design features unique to online spaces can be leveraged to add innovative services and generate new datasets by extending citizen sourcing for new forms of co-creation between the public and formal decision-makers [2] [7] [8]. By moving beyond traditional participatory goals and leveraging a wider variety of societal resources, new types of information can be harnessed to inform policy-making on critical social issues, representing a key aspect of the transition to government 3.0.

This paper explores how advancements in participatory modeling and online decision support can provide novel avenues to facilitate decision-making in complex societal issues. The authors present a case study in which an interactive online platform is used to identify potential values conflicts between formal decision-makers and citizens. These strategic insights are useful for government agencies and professional decision-makers who wish to use *e*-participation to better understand citizen perspectives on controversial decisions.

2. Integrating values for decision-making and environmental conflict management

2.1. Contextualizing values research for decision-making and conflict management

Interpersonal conflicts arise when the physical presence of an individual, a group, or an activity, impinges on the expectations, goals, or well-being of another individual or group [20]. Social values conflicts, on the other hand, arise from disagreements over values, and require no physical contact between groups. Disputes can also combine interpersonal and values conflicts, with individual or group actors both impacted directly by another decision-maker's actions, and opposed to the action because it threatens a prioritized value [20]. Values are distinct from and foundational to various emergent psychological phenomena with which they are often conflated [21], such deeply held beliefs are evaluative, motivational, and linked to affect. Some are complementary, meaning that outcomes that support one value have a positive impact on a closely related one. Other values are contradictory, meaning that achieving a goal associated with a focal value comes at

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a cost to another. In the latter case, value trade-offs are necessary when deciding on a course of action or preferred outcome [21] [22]. Key characteristics that distinguish interpersonal from values conflicts include that values are trans-situational, while goals in interpersonal conflicts are context specific, goals are frequently articulated explicitly, while values typically influence decision-making outside of conscious awareness, and goals, knowledge, and options can be readily changed, but values are deeply held and thus more stable in the absence of facilitated and conscious efforts. Finally, while decision-makers may have uneven access to information or opposing goals, values are universally held [21] [22] [23]. While everyone has values, the relative importance of specific values, known as a values framework, varies between individuals and groups and differences in these frameworks can lead to conflict [22]. Distinguishing between instrumental (based on cost-benefit analysis) decision-making and values-based decision-making is also crucial, particularly when values are perceived to be sacred [24]. Not managing the influence of sacred values can exacerbate conflict if compromises based in instrumental incentives are proposed where values-based decisions are relevant [24].

While conflict can arise from different values frameworks, explicitly addressing values in decision-making leads participants to be more satisfied with decision outcomes, results in social learning, and can achieve key goals of participatory decision-making [23] [25] [26]; it is thus a robust area of study in the decision sciences [23] and environmental management [27]. Values research has the potential to improve outcomes in regulated environmental management conflicts through the development of facilitated approaches to address values frameworks while connecting governments, regulatory bodies, and citizens on issues of shared interest [28].

2.2. Integrating values in planning and decision-making

Integrating citizen values for participatory planning is facilitated by numerous techniques. Fuzzy Cognitive Mapping (FCM) can be used to develop common understandings of complex systems, support the exchange of information and foster co-operation between stakeholder groups [29]. FCM approaches model the behavior of interrelated systems from the perspective of any individual or group [30]. On a Fuzzy Cognitive Map, concepts are graphically represented as nodes, for which causal relationships to other nodes are represented with weighted arcs. As nodes can represent any type of concept, including physical phenomena, events, actions, or values, this method can be used to investigate social dynamics in complex planning issues [29]. FCM has been used to support participatory natural resources management [31] [32] group decisions [33] and Integrated Ecosystem Management [34]. However, creating a Fuzzy Cognitive Map requires in-person interviews or workshops. Participants must sufficiently grasp system dynamics to feel confident generating a map, and the task adds time and budgetary burdens to existing planning procedures. Moreover, aggregation of individual FCMs into a group perspective relies on experts to simplify data by representing only the variables that are most often identified [35]. These drawbacks can limit the ability for non-experts to participate in FCM approaches, reduce the information collected from each participant, and constrain institutional up-take of FCM activities [35].

Another method, Public Participation Geographic Information Systems (PPGISs) integrates values data in a spatially explicit format, and can be useful for identifying conflict potential. PPGIS techniques can be operationalized for analytic purposes in Spatial Decision Support Systems (SDSS). For instance, [36] used a SDSS to integrate local community values and expert knowledge into decision-making frameworks for strategic planning. [37] used participatory GIS to better understand local preferences for tourism and development planning. Participatory mapping of values was used by [38] and [39] to assess conflict potential in land-use planning, and PPGIS surveys were used by [40] to understand stakeholder values for marine and coastal areas planning and management.

2.3. Identifying conflict potential with *e*-participation

Conflicts may emerge when actors hold incompatible values frameworks that impact their perception of a decision context and their preferences. Alternatively, actors may disagree about how specific outcomes will impact prioritized values. Depending on the source and nature of disagreement conflicts may be minor and easily resolved or involve protracted and heated disputes [9]. Anticipating conflict provides formal decision-makers with opportunities to proactively target management strategies and to respond to stakeholder concerns. Early identification of conflict potential enables government actors to allocate social resources and facilitate communication between stakeholder groups [38] reducing the likelihood of long-term legal costs and improving relations between government decision-makers and citizens. Conflict prediction has thus been applied to various environmental cases under regulatory purview. Participatory mapping was used by

[9] to identify conflict potential in seven environmental and natural resources sites, and by [41] to identify potential conflict loci in development, mining, and land-use decisions. Moreover, potential disputes rooted in conflicting participant perspectives have been identified by combining multiple FCMs [29]. Herein, the authors examine the collection of values data from experts and citizens using a novel participatory values-based modeling approach. The online software program, Public to Public Decision Support System (P2P-DSS) uses interactive tools and visual cues in a shared modeling space. Values data input by participants is analyzed to identify clusters of disagreement about the values-laden assumptions of formal decision-makers and citizen participants. Clusters of disagreement, known as 'protests' are interpreted as hot-spots for potential conflict because they emerge from elements of a decision for which stakeholders do not share a common view.

3. Case Study: The Jigs Hollow dispute

3.1. Land use conflicts

Conflicts frequently arise when land-use activities have the potential to negatively impact aspects of the social or physical environment, and when the trade-offs between competing uses are viewed differently by individuals or groups [9]. These conflicts are particularly difficult to manage when the competing perspectives center around differing social values frameworks. In these challenging contexts, multiple government and regulatory decision-makers are tasked with making key decisions that distribute the benefits and burdens of development across time and space [10]. Developing ways to anticipate the conditions that are likely to lead to conflict can provide professionals with information to minimize controversy, costs, and delay, through strategic communications, pro-active responses to citizen concerns, and conflict management [9].

3.2. Aggregate mining

Clays, rocks, sands and marls, collectively known as *aggregates*, are a foundational input for modern living, providing the key ingredients for urban infrastructures. The mining of aggregates is of public interest both because of what can be built and because of the conflicts that frequently result from their extraction. While the beneficial outcomes from urban living are widespread, the impacts of aggregate extraction are highly localized, and since aggregates must be mined where they are found, the locations are inflexible [11] [12]. These qualities make decision-making about competing land-use options in aggregate rich regions particularly prone to controversy, as the competing needs of regional governments, local communities and dependent industries conflict. Resistance to extraction activities can be characterized as a 'Not In My Backyard' (NIMBY) reaction [13], however this description risks unfairly dismissing legitimate concerns of impacted citizens to important asymmetries in the distribution of the benefits and burdens of urban development. Seeking greater understanding of how disparate values generate controversy in these cases is an important step towards managing conflicts for more creative and democratic decision-making.

3.3. Study site

The Township of Woolwich (Woolwich) is located in the Region of Waterloo in Ontario, Canada. Woolwich has an approximate population of 25,000, across 10 small communities. It is a rural region with a strong agricultural economy [14] [15]. In 2012 Preston Sand & Gravel Company (Preston) received approval to extract aggregates from an approximately 36 hectares site known as Jigs Hollow pit [16]. The existing permit restricts Preston to extraction with a 1.5meter buffer above the groundwater table. In 2014, it became clear that the water table was higher than expected and Preston initiated efforts to amend the permit to allow below-water-table extraction [16]. The amendment application has generated considerable controversy related to a variety of citizen concerns [17] [18]. For instance, below-water-table extraction has a larger impact on the immediate activities at the site as well as generating long term landscape changes. Large and more invasive equipment is required, meaning that daily operations may be more disruptive to the local community, and unlike the 2012 permit which required Preston to restore the site to its agricultural quality following the end of mining activities, this is not possible for below-water-table extraction, and the land would instead be transformed into a naturalized lake [16].

3.4. Exploring the Jigs Hollow conflict with participatory values-centered support

P2P-DSS is an online interactive participatory modeling software program. Formal decision-makers use P2P-DSS to create a model of a decision or issue from their own perspective, and that model is used as the basis for collecting citizen input about preferred decision outcomes. In 2017 the authors used P2P-DSS to gain insights into citizen resistance to the Jigs Hollow permit amendment application.

Over the course of two meetings a decision-maker with a professional interest in the Jigs Hollow amendment built a model of the decision context. The model consists of relevant contextual information, available options, and a values-framework that expresses which social values motivate selection of a focal option. The process of model development and algorithms that are used to operationalize the website features are described in detail in [42]. This section briefly reviews the steps taken to build an expert model, with reference to the expert model developed in the Jigs Hollow case study.

Three options to accept the amendment were included in the expert model: (1) accepting the amendment as it was proposed by Preston (2) accepting the amendment but adding operational conditions to limit the day to day impacts of mining activities on local citizens and (3) accepting the amendment but adding timeline conditions on the extraction activities. In order to probe the drivers of public resistance to the project the model included four options to reject the amendment, each addressing a feasible public concern: (4) rejection of the amendment due to concerns about groundwater (5) rejection of the amendment to avoid potential negative impacts to surface water (6) rejection for protection of prime agricultural land and (7) rejection based on a desire to preserve the heritage and aesthetic value of the rural landscape.

Using an interactive feature designed specifically for this purpose, the expert embeds in the model an expression of what social values would likely motivate an individual to choose each option (Figure 1). Ten values are provided in the model template, and as the expert creates options, they also select the values that they believe are important to that option. The expert calibrates how important that value is by moving a toggle feature from the left (less important) to the right (more important). For example, in Figure 1 the expert has made explicit their assumption that choosing to reject the amendment based on concerns about negative impacts to groundwater is motivated by a values framework that prioritizes environmental protection and security, with environmental protection dominating the choice. The remaining eight values are considered irrelevant to this selection.

The expert then creates proposals by combining options. Proposals can include single options or feasible combinations of options, and are decision outcomes under consideration. The weighted values associated with each option on a proposal are combined to create a values framework for that focal proposal [42]. In the Jigs Hollow model, the expert identified eight proposals in total. Seven of these proposals were created with only one option and therefore were identical to the options listed above. One of the proposals combined two options such that accepting the amendment with both timeline and operational considerations added was under consideration. More combinations were possible with this model; for instance, it is possible to reject the amendment to protect both groundwater and surface water, rather than for one single reason. The decision-maker did not choose to create those proposals during the modeling process, leaving it to public participants to create further proposals if they were so inclined during the participatory process.

Public participants who wish to provide input to decision-makers first rank the proposals from most to least preferred by moving proposals displayed on the graphical user interface from left (most preferred) to right (least preferred). After submitting a first ranking, the user is shown a pie chart, known as the ‘mirror’, that summarizes their values framework derived by combining the values assumptions embedded by the expert with the ranking submitted by the public participant [42]. If the ranking and the values mirror are both consistent with the user’s self-perception and preferences, they are invited to re-submit the preference ranking as is, thereby providing the formal decision-maker with preference information about the full spectrum of proposals under consideration. If, however, the user feels that their values are not reflected in the mirror, they can change the values framework using a variety of interactive features. The user can re-rank their preferences, create new proposals and add them to the ranking, and they can change values assumptions that were previously provided by the expert. The latter function is known as a values protest, and it allows the participant to reconcile their preferences and values input without changing the proposal rankings. All of these interactions result in real-time changes to the values mirror in order to support the user in creating a proposal ranking that harmonizes with their values before submitting their final input.

In 2017, participants provided their input on the Jigs Hollow amendment application using P2P-DSS. These volunteers also completed a written survey about their experience using the system. An overview of the research project and system parameters is beyond the scope of this paper however it is provided in [42]. While an in-depth analysis of the ranked preferences is similarly beyond the scope of this paper, it is important to note that rejecting the amendment was the most preferred option for the participants and accepting the amendment was the least preferred option [43]. Participants who lived in the Woolwich community were more likely to rank rejection to protect the rural aesthetic landscape as higher than other participants, while protecting productive agricultural land was more important than aesthetic reasons for participants living

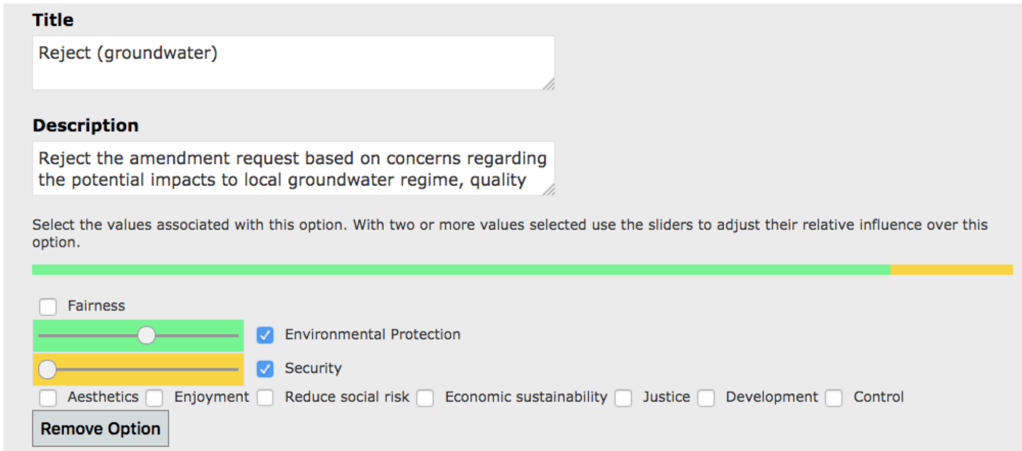

Figure 1. Values embedding feature showing the social values associated with the Reject (groundwater) option in the Jigs Hollow expert model

outside of Woolwich Township [43]. Herein the authors explore the values protests collected using P2P-DSS.

4. Identifying potential values-centered conflict using P2P-DSS

4.1. Methods

In 2018, the authors recruited study participants from the Woolwich and surrounding communities using local newspaper advertisements, social media, snowball recruitment methods, and email lists at the University of Waterloo. Ultimately, fifteen participants volunteered to take part in the study. Five of the participants identified themselves as being residents in or near Woolwich community, while ten were residents of Kitchener, Waterloo, Mississauga, and Toronto, Ontario. The latter ten volunteers identified as University students. Each of the volunteers used P2P-DSS to provide their input on the Jigs Hollow mining amendment proposal in a controlled laboratory setting. Participants were given brief instructions on how to use the interactive elements to learn about the amendment, create proposals, rank proposals from most to least preferred, and protest the values assumptions that were embedded in the expert model. P2P-DSS recorded every interaction with time stamps, including movement of proposals, proposal creation, and values protests. After using the system, the volunteers completed a written survey about their perceptions and experience using P2P-DSS, which have been summarized in [42], and an in-depth analysis of the submitted proposal rankings is provided in [43]. This paper will focus on responses from participants who chose to alter the model parameters by changing the options-values associations originally input by the domain expert.

Values protests involve three possible interactions. First, if the expert did not model a focal value as relevant to the selection of a specific option, the participant can protest that assumption by clicking on the protest button for the option and adding a check mark to the box beside the value. Second if the expert modeled a focal value as relevant to the selection of a specific option, and the participant disagrees with this assumption, it can be deselected by removing the check mark. In the first case the influence of a value for that option is changed from a weight of ‘0’ to a weight of ‘1’. In the second case the weight is changed from ‘1’ to ‘0’. Once selected, the influence of the value can also be changed by moving a toggle feature to the left to reduce the relative weight of the focal value and to the right to increase the weight. Compare Figure 2 to Figure 1; the values associated with rejecting the amendment due to concerns about groundwater impacts have been protested and altered to include reduction of social risk and control as motivating values, with reduction of social values being equal to environmental protection, and control weighted at 1. The precise numerical weight assigned to a value is relative to the full spectrum of values associated with the option and is determined using an algorithm described in [42].

The P2P-DSS database records each protest including the original weight assigned to the value and subsequent weights selected as the user interacts with the toggle feature. The authors aggregated the protests associated with options and values to identify aspects of

Figure 2. Values protest features showing additional values added to the Reject (groundwater) option

the decision problem for which the expert model and participant perspectives diverged.

4.2. Results

Seven participants protested one or more options-values assumptions. All of the protests originated from participants who lived within 20km of the Jigs Hollow site. A total of 36 protests were recorded, with an additional two protest interactions that resulted in the participant calibrating the values assumptions to their original state, resulting in no change to the model. The protests that did not result in a model change are important as they demonstrate that the participant is exploring how their values interact with the options, however only protests that resulted in a change are considered in this analysis.

The number of protests varied greatly across participants with one participant registering a single protest, two participants submitting two protests each, one participant protesting four assumptions, one participant submitting eight protests, another inputting nine protests, and a final participant submitting 10 protests.

The protests collected for each option, the values that were the focus of the protests, and the original and new weights for each value are shown in Table 1. The only option to receive zero protests is to accept the amendment. Rejecting the amendment to protect agriculturally productive land received the highest number of protests.

4.3. Discussion of results

Patterns of protest can indicate aspects of the decision problem for which the formal decision-maker and public participants do not have a shared view of the issue. This approach is similar to combining FCMs [29] or analyzing spatially embedded values data [38], however it does not require the analyst to discard any inputs provided by the participants, nor is there a requirement for participants to learn complex problem structuring or mapping techniques. In this section, key observations from the collected protests are discussed.

The lack of protests for 'accept' can be interpreted in two ways. First, the participants may agree with the original calibration of the expert model in which 'accept' was motivated in equal measure by values associated with development and economic sustainability. It is also possible, however, that acceptance was sufficiently unpopular that participants did not explore the values that drive this option, focusing more on options that were under consideration for more preferred positioning.

The values calibrated for rejection of the amendment to protect high quality agricultural land have the highest potential for conflict because the greatest number of values are protested for this option. The public participants view the protection of agricultural land to have a positive correlation with environmental protection, reducing social risk and providing greater security, whereas the expert did not model these values as relevant. While the expert did associate this option with development and economic sustainability, the protests reflect the view that they have a greater influence than reflected in the expert model.

Protecting the rural aesthetic landscape is associated with aesthetic values and economic sustainability for public participants but not for the

Table 1. Summary of values-assumptions protests collected in the Jigs Hollow case study

Option	Value protested	Change to value calibration weight
Accept	-------	
Accept (timeline)	Development	Increase from 1 to 8
	Economic sustainability	Decrease from 4 to 2
	Environmental Protection	Increase from 0 to 1 Increase from 0 to 4
	Fairness	Decrease from 4 to 2
Accept (operational)	Environmental protection	Increase from 0 to 1
	Fairness	Decrease from 4 to 0 Decrease from 3 to 1
Reject (Groundwater)	Control	Increase from 0 to 6
	Economic sustainability	Increase from 0 to 1
	Environmental Protection	Increase from 7 to 10 Increase from 7 to 11
	Security	Increase from 1 to 4 Increase from 1 to 7
Reject (River)	Enjoyment	Increase from 1 to 2 Decrease from 1 to 0
	Environmental Protection	Increase from 7 to 10 Increase from 7 to 10
	Fairness	Increase from 0 to 1
	Security	Increase from 0 to 1 Increase from 0 to 1
Reject (Agricuture)	Development	Increase from 1 to 2 Increase from 1 to 7
	Economic sustainability	Increase from 1 o 3 Increase from 1 to 2
	Environmental protection	Increase from 0 to 1 Increase from 0 to 2 Increase from 0 to 9
	Reduce social risk	Increase from 0 to 1
	Security	Increase from 0 to 1 Increase from 0 to 3
Reject (Aesthetic)	Aesthetic	Increase from 0 to 1
	Enjoyment	Increase from 5 to 8 Increase from 5 to 8
	Economic sustainability	Increase from 0 to 1
	Environmental protection	Decrease from 8 to 0
	Fairness	Increase from 5 to 8

formal decision-makers. Associating the rural landscape with positive aesthetics may reflect a place attachment that would suffer in light of a significant aesthetic change. Associating this option with economic sustainability may reflect a belief that heritage and farm aesthetics have positive impacts on rural tourism and the popularity of the local farmers' market economy.

Protests that reduced or eliminated values associations are also informative. First, the formal decision-maker characterized the inclusion of timeline conditions as positively correlated with fairness values. One participant viewed this association as overstated, reducing its impact. In the case of rejection for aesthetic reasons, the formal decision-maker strongly correlated this option with protection of the environment, whereas a protest interaction removed the association entirely.

By examining the number of protests recorded for each option clusters can be identified, indicating a lack of shared understanding about specific aspects of the decision problem. Moreover, analysis of the values that are protested, and the changes recorded can better inform decision-makers about where their own perspectives are not shared with the public. In the Jigs Hollow case study, the research participants have a different view of what motivates rejection of the amendment, particularly in terms of protecting agricultural landscapes. It is notable that, for the most part, the public participant protests are similar in the direction of change. The only instance in which participants moved a value assumption in different directions was the association between rejection for river protection and enjoyment.

5. Future research directions

This research summarizes a first case study using P2P-DSS to examine real-world perceptions of a controversial planning and management decision context. New case studies are required with larger participant groups in order to further understand the protest patterns that emerge using this program. Moreover, long term studies of the up-take of this information are needed in order to examine how this new dataset can be integrated into formal decision-making to improve decision outcomes, to contribute to strategic conflict management, and to foster new communication strategies between government and citizens.

6. Conclusions

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This paper presents a new type of citizen data collected using an innovative *e*-participation tool to better understand decision-making in a controversial mining application. A shared interactive online space for formal decision-makers and public participants facilitates the articulation of value-laden assumptions, and identification of points of dissonant perspectives between experts and citizens. This information can be useful to formal decision-makers and planners who wish to better understand the motivations of citizens who support or reject policy and management decisions. Moreover, this information can be used to tailor communications and conflict management initiatives with citizens.

Existing approaches to values-based decision-making demonstrate the crucial role that values research can play in social decisions and conflict. However, most interactive online spaces continue to rely on in-person interviews, workshops, or values-surveys prior to engaging in the participatory online activity, reducing their impact on *e*-democracy and *e*-participation approaches. The P2P-DSS tool, however, uses participatory modeling and visual interactive cues within a software environment to prompt the user to deeply consider their own values in order to generate values-relevant data as part of an online interactive space. The potential to integrate the values framework mirror and protest functions into various online surveys lend this approach well to providing support for *e*-government decision-making support.

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