Multi-Criteria Evaluation of Metropolitan Transportation Planning Scenarios: Assessing Trade-Offs Between Business-As-Usual and Alternate Sustainable Community Designs

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ABSTRACT:

Metropolitan Planning Organizations (MPOs) are required by Federal law to develop a long-range Metropolitan Transportation Plan (MTP) at least every five years. This research focuses on assessing the trade-offs between business-as-usual MTP scenario of gasoline driven transportation infrastructure and suburban growth with two alternate sustainable community design scenarios in Chittenden County Metropolitan Planning Area (CCMPO). The CCMPO adopted its last long-range transportation plan in 2005 for a temporal horizon of 2005 to 2025 and is currently updating 2025 MTP to 2035 MTP. We implemented two focus groups with multiple stakeholder representatives of the regional transportation planning network and conducted numerous interviews to implement a participatory multi-criteria evaluation of 2035 MTP scenarios. Three MTP scenarios are evaluated on twelve decision criteria: operational performance, sustainable land-use, safety and accessibility, minimize time and total costs, protect built and natural environs, community development, access and mobility, transportation system efficiency, energy efficiency and conservation, improve alternate travel modes, public education and cost effective and inclusiveness. Our analysis reveals that the underlying expected value functions of all stakeholder representatives in the regional transportation planning network overwhelmingly reject business-as-usual MTP scenario. Instead, a more sustainable, growth contained community design scenario emerges with the highest expected value for all stakeholder groups. Formal implementation of sustainable community design scenario would, however, require CCMPO and regional transportation planning network actors to overcome a series of legal, political and economic challenges. We discuss the implications of these trade-offs, challenges and opportunities on the development and implementation of sustainable community designs.

1. INTRODUCTION

Metropolitan Planning Organizations (MPOs) are required by Federal law to develop a long-range Metropolitan Transportation Plan (MTP) at least every five years. This document must include the strategies, actions and projects that will lead to "an integrated multimodal transportation system to facilitate the safe and efficient movement of people and goods" (ISTEA § 134(g)(2), (h). The MTPs must also include planning for bicycle transportation and pedestrian walkways. Federal funds cannot be used for projects and services unless they are consistent with an adopted long-range plan. The MTP must also be financially constrained by a reasonably expected level of transportation funding. While safety, efficiency and development of integrated multi-modal transportation systems are key goals of current federal legislation governing the design of MTPs, this study focuses on assessing the trade-offs that are confronted by MPOs, and regional transportation planning networks, for designing MTPs in terms of weaning-off from the business-as-usual scenario of a gasoline-driven transportation infrastructure and suburban growth to alternate scenarios of sustainable transportation and community design visions.

We focus our empirical analysis on the MTP development process being undertaken at Chittenden County MPO (CCMPO). The CCMPO adopted its last long-range transportation plan in 2005 for a temporal horizon of 2005 to 2025. This plan, referred to as the 2025 MTP *(1)*, identifies the major transportation projects, programs and policies needed over the planning period, and establishes the vision and goals that will guide public decisions affecting transportation facilities and services in the CCMPO jurisdiction. The CCMPO is currently working on producing a 5-year update to 2025 MTP, which initially looked at an expanded horizon of 50 years covering the period 2010 to 2060 (2060 MTP); however, later on, rescaled back to 2010-2035 horizon. The 2035 MTP anticipates the utilization of 30 million federally funded transportation investments per year in its jurisdictional area.

For CCMPO, the MTP not only addresses current problems of congestion, accessibility and mobility but lays out the framework for the transportation system of the future. The MTP acknowledges today's fiscal, political and social realities while extending beyond the status quo to better integrate the disciplines of transportation and land use planning through regional collaboration. The MTP is the region's principal transportation planning document and sets regional transportation priorities. It should, therefore, also be the central mechanism for structuring effective investments to enhance transportation system efficiency. It should consist of short- and long-range strategies to address transportation needs and lead to development of an integrated, inter-modal transportation system that facilitates the efficient movement of people and goods. As mandated by the federal government, the MTP must both articulate and work towards the region's comprehensive long-range land use plans, development objectives, and the region's overall social, economic, environmental, system performance and energy conservation goals and objectives. It should also be consistent with the statewide transportation plan and the CCMPO should make special efforts to engage all interested parties in the development of the Plan (*1*).

Chasing this vision, initial workshops were organized by the CCMPO in 2009 and early 2010 to develop a short list of two to four scenarios, in addition to a baseline business-as-usual scenario, for the CCMPO transportation system boundaries. As a participatory research intervention in this process, we implemented a participatory Multi Criteria Decision Analysis (MCDA) study to elicit value trade-offs and generate multi-criteria expected value functions of multiple stakeholder groups (or governance network actors) for comparing the baseline with two alternate 2035 MTP scenarios. While Paulsen et al. *(2)* used "cumulative effects analysis" to describe MTP scenario development processes, we recommend that participatory MCDA approach could also be used as a complementary methodology for eliciting stakeholder values & goals and their weights on these values & goals when comparing alternate long-range transportation plans. A number of studies have been published that demonstrate the applicability of participatory MCDA for evaluating alternate policy and planning scenarios. *(3), (4), (5), (6), (7), 8), (9), (10)*. This body of literature has emerged in parallel to the participatory value focused decision analytic models *(11), (12), (13), (14), (15)*. Kiker et al.(*16)* present a broad review of studies that involve the application of MCDA for environmental decision making. Major limitations of participatory MCDA are discussed by Hisschenemoller and Hoppe(*17)*; Pellizzoni *(18)*; Shim et al.(*19);* Stirling *(20);* and Wittmer et al.*(21)*.

Section 2 describes research methods, especially participatory MCDA methodology that was implemented with the regional transportation governance network actor focus groups in the fall of 2010. A more detailed description of three MTP scenarios, twelve decision criteria, thirty six impact functions and stakeholder groups engaged in this participatory process is presented in Section 2 to elaborate our particular implementation methodology of MCDA. Section 3 presents results generated through the multi-criteria evaluation of transportation planning scenarios. Section 4 discusses implications of the results in terms of the trade-offs, challenges and opportunities that are faced by CCMPO, and other similar metropolitan planning organizations and regional transportation planning networks, in weaning-off from the business-as-usual scenario of a gasoline-driven transportation infrastructure and suburban growth to an alternate scenario of sustainable transportation and community design vision.

2. RESEARCH METHODOLOGY

2.1. Analytical Methodology

MCDA enables elicitation of value trade-offs as a structured participatory mechanism for groups of governance network actors to iteratively discuss incommensurate values and evaluate the weights on those values for choosing valuable actions. Building upon Norton and Noonan's*(22)* idea of alternate development paths/scenarios, as implemented by Zia et al.*(23)* a multi-criteria expected value function V_i for i^{th} scenario/development path in a set of m development paths is formally defined, as in

Equation 1:

$$V_{ik} = \sum_{i=1}^{n} w_{jk} x_{ijk} \qquad (1)$$

$$s.t. \sum_{j=1}^{m} w_{jk} = 1 \qquad (2)$$

Where w_j is a constant-sum weighting or Trade-Off *function* for j^{th} criterion in a set of m criteria (by a group of K stakeholders); and x_{ijk} is an "outcome" or "impact" function for i^{th} scenario on j^{th} criterion as perceived by a k^{th} stakeholder in a group of K stakeholders and among N scenarios.

For an individual or an institutional decision maker, the most valued scenario is the one with the highest expected value *Vi*. The real challenge is how to integrate/aggregate expected value *Vi* across groups of governance network actors for choosing a development path that reflects the pluralistic values of all affected stakeholders (More information on this can be found in Zia et al. (*23*). For this very reason, as argued by Martinez-Alier and Munda *(24)*, we propose the deployment of participatory and softer version of MCDA applications. In particular, we propose a continuous and iterative application of an open ended 8-step participatory procedure, as shown in Table 1.

TABLE 1: Procedural heuristic of participatory MCDA

Steps	Procedures
1.	Develop a group consensus on alternative scenarios/development paths
2.	Develop a group consensus on criteria (mutually exclusive and typically incommensurate)
3.	Individuals assign weights on criteria
4.	Perceived outcomes/impacts are measured for each alternative by each criterion and normalized
5.	Individuals participate in small group discussion to develop consensus on

	weights and outcomes/impacts
6.	Workshop level weights and impacts/outcomes are developed
7.	Workshop level weights and normalized outcome/impact functions are multiplied to measure expected value for evaluating design alternatives
8.	The evaluation process is repeated iteratively with different set of stakeholder representatives

2.2. Data Collection Procedures

For this project, we implemented participatory MCDA protocol shown in Table 1 by organizing two one-day focus groups on September 25 and 28, 2010 in Burlington. The focus group protocols were approved by UVM's Institutional Review Board. For each workshop, we brought together 8 to 10 participants representing different stakeholder groups in the regional transportation planning network (described by Koliba et al. *(26)* in more detail) who were engaged in short, medium and long range transportation planning processes. These stakeholders represented the CCMPO board members and technical staff, Regional Planning Commission(RPC), Vermont Agency of Transportation (VTRANS), United States, Department of Transportation (US DOT)/ Federal Highway Administration (FHWA), Chittenden County Transit Administration (CCTA), and Civil Society Organizations (CSOs), such as Smart Growth Vermont and Locomotion).

Each workshop was run from 8:30 am to 4 pm at the CCMPO's conference room and the eligible participants were paid a modest amount of compensation for devoting their time. Both the workshops had different set of participants, facilitated by the authors of this study. The proceedings of both the focus groups were audiotaped for post-workshop qualitative and quantitative data analysis. Most importantly, focus group participants were apprised of the three scenarios (described in section 2.3 below) and participatory MCDA procedure and then constant-sum weights for the 12 criteria (section 2.4 below) were elicited from them on an individual level. The impact functions (Xij) for three MTP scenarios vis-à-vis these 12 criteria were separately calculated either from the integrated transportation-land use models of CCMPO *(1)* or through expert interviews. Section 2.5 below shows the proxy variables and their estimated values for impact functions. Finally, limitations of this methodological approach are presented in section 2.6.

2.3. MTP Scenarios: Business-as-Usual (BAU) and Alternate Sustainable Community Designs

The CCMPO (25) developed three 2060/2035 MTP scenarios: loosely labeled as a (business-as-usual, BAU) trend scenario, a workshop scenario and a core scenario. As shown in Figure 1 below, the BAU Trend Scenario depicts a development pattern and density likely to be seen on the Chittenden County landscape should the current trends of the past 30 years persist 50 years into the future. The pattern could be described as single family or low density housing/commercial uses on large lots. This trend consumes land at

a high rate by spreading uses such as buildings, driveways and parking across large areas. The advantages of this type of development are solitude and elbow room for residents and workers in these areas. Disadvantages with this type of development pattern are that it often requires more spending on public services like roads, water, sewer, and emergency services which are more costly given the distances between houses/buildings as well as from town centers. Another disadvantage is the fragmentation of open land currently used for agriculture, forestry, and wildlife habitat *(1)*.

In contrast, the **Workshop Scenario** is representative of the recommendations generated at the Fall 2008 CCMPO Scenario Planning workshops (which were implemented by CCMPO with governance network actors groups prior to our intervention). The workshops were held around the county and resulted in 12 separate maps that, when closely examined, were variations on the same theme - a diffused centers pattern. Features include new clustered and higher density development assigned to areas adjacent to existing development; some additional build up of existing centers; and very limited development in rural areas. The differences between the 12 workshop maps varied only in where, and at what densities, the clusters were placed. The intensity and location of these centers impacts the provision of services to and within them. Advantages of this type of development include cost efficiencies on services like roads, water, sewer, and emergency services as well as the preservation of open space. This denser development and mixed use concentrated in smaller clusters may create a more urban atmosphere with less privacy and may be seen as a disadvantage by some. This type of development could require revisions to local zoning regulations in order to allow higher densities *(1)*.

Finally, the **Core Scenario** takes a radical departure from recent trends and concentrates growth in fewer places with a focus on sustainable community design. More specifically it would result in locating 45% of all new households over the next 50 years into Burlington and another 5% in Winooski. These cities have grown slowly over the last several decades making this scenario a dramatic reversal in historic trends. Such intensity of development in what have been slow growing places would require significant revisions of existing development regulations and public acceptance of high density zoning. This scenario will result in much denser neighborhoods in Burlington and Winooski, which may change the character of those municipalities and give them a more urban feel. The benefit of this type of development pattern would be significant cost savings in the provision of municipal services and contribute to more opportunities for taking buses or other public transportation and walking and bicycling. Areas outside the urban core would receive less growth and much of the rural areas would remain relatively open.

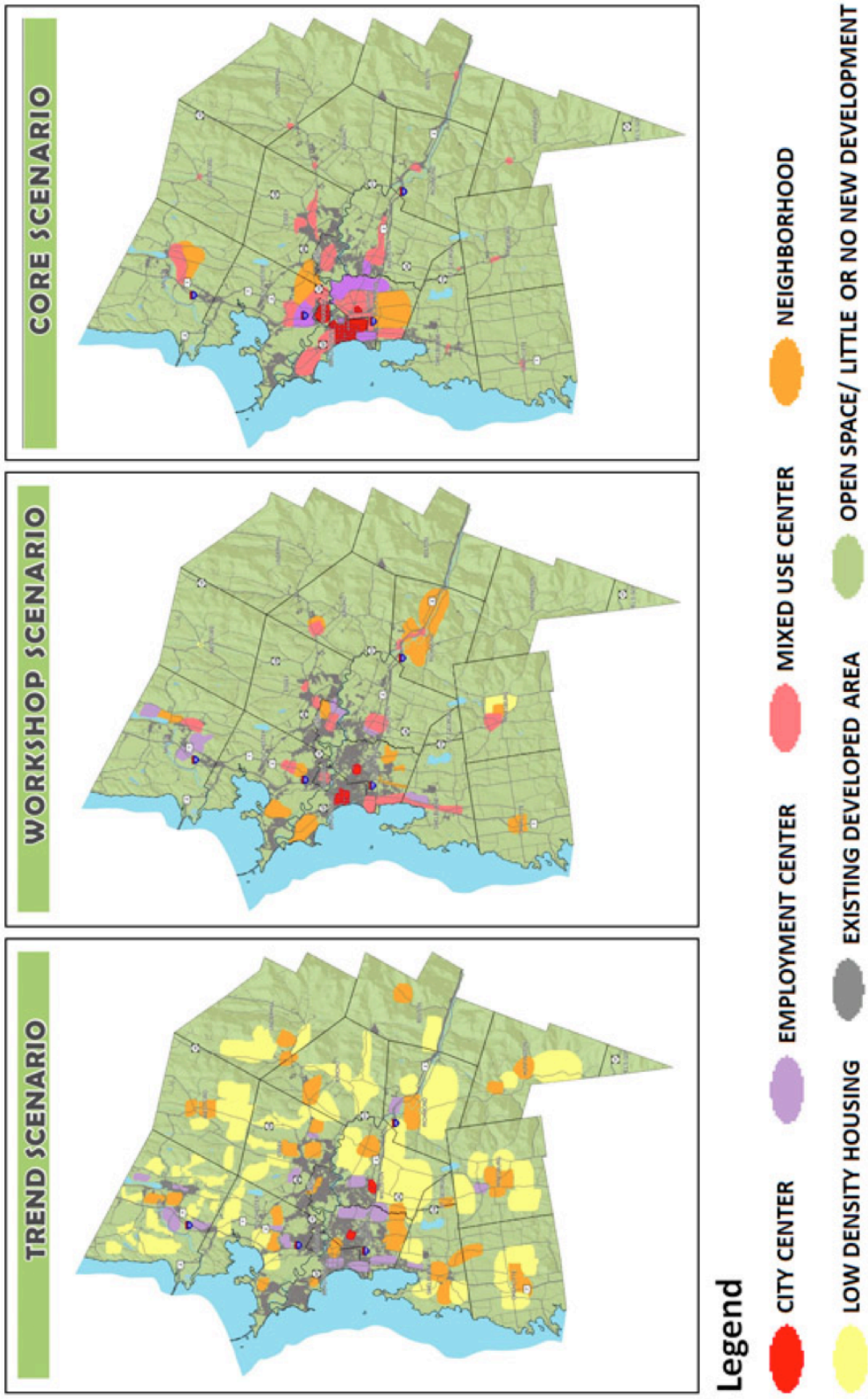

Figure 1: Trend, Workshop and Core Scenarios

2.4. Elicitation of Multiple Decision Criteria and their Weighting Functions for Different Stakeholder Groups

Stakeholder interviews, both individually and in focus group format, were used to elicit twelve decision criteria (described in Table 2) for evaluating 2035 MTP scenarios. Earlier, in 2005, CCMPO had used the same 12 criteria as MTP steering committee goals to develop 2025 MTP. Notably, there are some conflicting and complementary criteria that are included in Table 1. Some participants in focus groups argued for simplifying the 12 criteria and reducing the list by half. However, a consensus emerged that each of these 12 criteria represents important MTP goals that have been derived after longstanding negotiations and legal analysis. Given this consensus, we decided to elicit stakeholder weights on these twelve decision criteria.

TABLE 2: Decision Criteria elicited from MTP Steering Committee Goals Compiled from Planning Documents, Focus Groups and Interviews

Decision Criteria (C_j)	MTP Steering Committee Goal
1. Operational performance	Preserve and improve the physical condition and operational performance of the existing transportation system.
2. Sustainable land-Use	Reinforce sustainable land use patterns, such as growth centers, as set forth in local and regional plans.
3. Safety and accessibility	Create a transportation system that offers constantly improving safety, accessibility, flexibility, and comfort for everyone.
4. Minimize time and total costs	Establish a transportation system that minimizes the time and total cost of moving people and goods, allowing the region's economy to thrive.
5. Protect built and natural environs	Protect or enhance the region's built and natural environments
6. Community development	Create a transportation system that builds community, enhances neighborhood vitality, and minimizes noise, glare, and vibration.
7. Access and mobility	Provide levels of access and mobility that insure people and goods can travel when and where they need to go.
8. Transportation system efficiency	Consider ways to improve transportation system efficiency before increasing transportation capacity
9. Energy efficiency and conservation	Establish a transportation system that uses diverse sources of power and maximizes energy efficiency and conservation
10. Improve alternate travel modes	Develop a transportation system that features a variety of travel modes and encourages the reduction of single-occupant vehicle use
11. Public education	Educate the public—from children to seniors—about the implications of different development patterns and

	mode choice decisions
12. Cost effective and inclusive	Provide improvements to transportation facilities and services expeditiously through an inclusive and cost effective process

Weights were elicited through a constant-sum weight elicitation methodology. Participants were told to play a resource allocation game (sometimes also called "penny game"), where a fixed number of resources (e.g. 100 pennies) are to be allocated across the 12 decision criteria. Higher resource allocation represents more importance for a decision criterion. Table 3 shows the means and standard deviations of weights elicited from 14 participants in the two focus groups. Sustainable land-use is ranked highest, followed by energy efficiency and conservation. On the other hand, public education and cost effective and inclusive criteria are ranked lowest, as shown in Table 3.

TABLE 3: Elicited Weights

Variable (ranked in descending order)	N	Mean	Std. Dev.	Min	Max
1. Sustainable land-Use	14	13.30929	10.75414	0	40
2. Energy efficiency and conservation	14	12.73786	9.694752	1	40
3. Protect built and natural environs	14	10.52357	8.384744	3	30
4. Operational performance	14	10.45214	7.092395	0	30
5. Safety and accessibility	14	10.30929	8.187466	1	30
6. Improve alternate travel modes	14	7.737857	4.533184	1	15
7. Access and mobility	14	7.380714	4.785713	1	20
8. Community development	14	7.095	2.877533	3	10
9. Transportation system efficiency	14	6.452143	3.685385	1	10
10. Minimize time and total costs	14	5.880714	3.835359	0	10
11. Public education	14	4.880714	5.683239	0	20
12. Cost effective and inclusive	14	4.737857	3.649308	0	10

2.5. Imputation of Multiple Criteria Impact Functions

Table 4 presents impact functions that were imputed from the review of planning documents derived from the application of integrated transportation and land-use models and expert interviews. These impact functions (X_{ijk} from equation 1) represent the expected impact of pursuing scenario vis-à-vis twelve decision criteria. Each of the twelve impact functions was measured through a proxy variable, as shown in Table 4. Integrated land-use and transportation models used by CCMPO and V-Trans were used to measure the values of these proxy variables. For MCDA, these impact functions were

normalized using a linear normalization procedure (*25)*. Normalized values are also presented in Table 4.

TABLE 4: Impact Functions for MTP Criteria for three scenarios

Criteria	Proxy Variable	Trend Scenario	Workshop Scenario	Core Scenario	Trend Normalized	Workshop Normalized	Core Normalized
1. Operational Performance	Annual PM Peak Vehicle Hours of Delay	15.4	13.6	10.4	0.6753	0.7647	1
2. Sustainable Land Use	Land Consumed by Development (sq. miles)	124	25	25	0.2016	1	1
3. Safety and Accessibility	Average Projected Congestion in 2035 (vehicle crashes/year)	2883	2150	1994	0.6916	0.9274	1
4. Minimize time and	Average commute time to work in 2035 (minutes/day)	40	25	15	0.375	0.6	1
5. Protect built and natural environment	Weekday Daily Greenhouse Gas Emissions (tons of CO2)	3210	3050	2840	0.8847	0.9311	1
6. Community Development	Population Density (individuals per sq.mi) (539 sq. mi in CC)	394.9610	789.9220	1579.8441	0.25	0.5	1
7. Access and mobility	Percent Daily Trip Possible by Public Transit	51%	53%	58%	0.8793	0.9137	1
8. Transportation system efficiency	Transportation $s invested per capita in 2035	198	150	110	0.5555	0.7333	1
9. Energy	Gallons of Oil	300	220	160	0.5333	0.5333	1

efficiency	needed per person per year in 2035						
10. Improve alternate travel modes	Percent Daily Trips Made by Walking of Bicycling	4.30 %	5.00 %	8.30 %	0.5180	0.6024	1
11. Public education	Civic responsibility (Constructed Scale from 1 to 10)	6	8	8	0.75	1	1
12. Cost effective and inclusive	Projected Budget Shortfall	1	116	261	1	0.0086	0.0038

2.6. Methodological Limitations

While participatory MCDA is a powerful methodology in eliciting stakeholder expected value functions for alternative policy and planning designs that are contingent upon multiple weighted decision criteria, there are also significant limitations of such approaches that delimit the scope of findings of this study presented in the next section 3. Most importantly, we aimed for broader stakeholder *representation* in conducting focus groups that enabled us to estimate multi-criteria expected functions for diverse stakeholder groups. However, these findings could not be generalized to the entire population of citizens and policy makers who are engaged in this planning process. Externally valid and generalizable MCDA study would require implementation of surveys and additional focus groups, which was not undertaken for this study due to the limited resources made available by the sponsors. Further, a more intractable limitation concerns how much weight should be allocated to each stakeholder group. There is no optimal solution for this problem; however, in the analysis below, we make a simplified assumption that each stakeholder group that is represented in the focus groups is assigned equal weight. Practitioners in MPOs, who want to implement participatory MCDA for comparing alternate MTPs, could use sensitivity analysis to assess the robustness of the findings with unequal weights assigned to different stakeholder groups. Finally, a sensitivity analysis of estimated impact functions is also warranted for this study and applications of this approach in other MPO contexts.

3. RESULTS

The results from participatory MCDA are presented with emphasis on three aspects: In section 3.1, findings on the expected value functions, generated for each of the three scenarios by estimating equation 1, are presented. In section 3.2, we discuss the weighting function variability by stakeholder groups and its potential impact on expected

values. In section 3.3, we discuss the differences and similarities among the expected values estimated for different stakeholder groups represented in the focus groups.

3.1. Comparing Scenarios

Among the three scenarios, as shown in Figure 2, core scenario has the highest expected value of 94.87% points, followed by workshop scenario at 74.16% points. Least preferred scenario is the trend scenario at 58.14% points. Figure 2 shows the box plots of expected values, demonstrating that the core scenario is significantly a preferred scenario at the aggregate level for the stakeholder groups represented in the focus groups. Further, the BAU trend scenario received the least expected value at the aggregate level, thus implying that the BAU trend is not an acceptable scenario for the focus group participants.

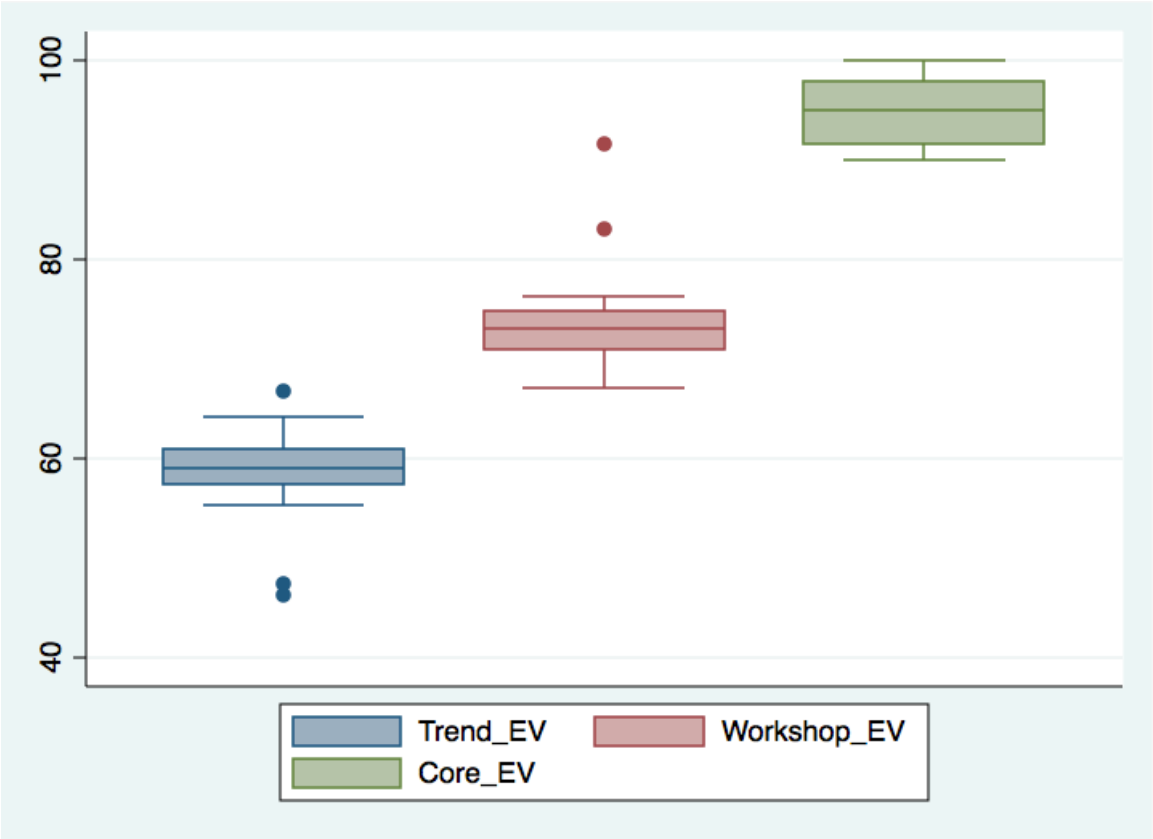

Figure 2: Boxplots of expected values from three scenarios

Despite small sample size (N=14) of this rather qualitative participatory study, this significant result shows the broader underlying consensus of the workshop participants for the core scenario. There are two significant trade-offs that appear to be made by the participants: First, core scenario entails higher upfront costs (as shown in the cost-effective impact factor in Table 4), which are traded-off by assignment of higher weights for sustainable land-use criterion. Second, core scenario implementation through

the planning process will require significant modifications in the current land-use and zoning practices in Chittenden County (especially Act 250 that governs the land-use and zoning practices in the state of Vermont). This second issue was explicitly raised by many participants during the focus group discussion and is further addressed in the discussion section 4.

3.2. Sensitivity of Weighting Functions to Variability

Despite the clear preferences derived in the above analysis, there are many complex factors that appear to reflect the variability in the assignment of weights on 12 decision criteria. Figure 3 below shows box plots of assigned weights for these 12 decision criteria. Many criteria display large variability, which means that aggregate results will need to be further dissected by each stakeholder group for a deeper analysis of stakeholder preferences and weights.

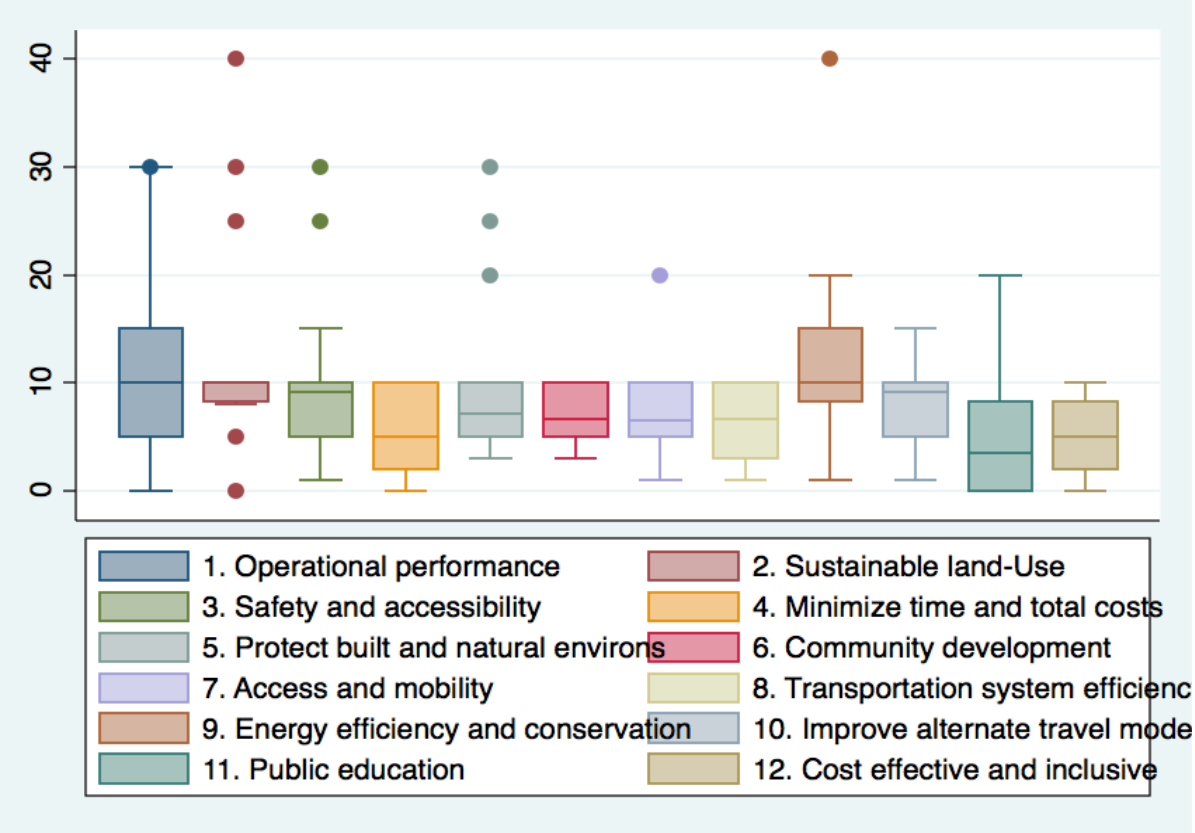

Figure 3: Boxplots of weights for decision criteria

To further assess this variability in the assignment of weights, analysis of variance between stakeholder groups was implemented. We found that the weights on following five criteria have statistically non-constant variance across different stakeholder groups: sustainable land-use; safety and accessibility; community development; access and mobility and transportation system efficiency. This implies that the usage of mean weight values in estimating expected value functions could ignore the uncertainty introduced by

large variability in the relative importance attached by different stakeholder representatives.

Further, Figure 4 shows variability of these weights by different stakeholder groups represented in the focus groups. While these are not statistically representative samples of each of the represented stakeholder groups (as explained in section 2.6), each of these stakeholder groups appears to have different distributional function for the 12 distribution criteria (represented on the x-axis in Figure 4).

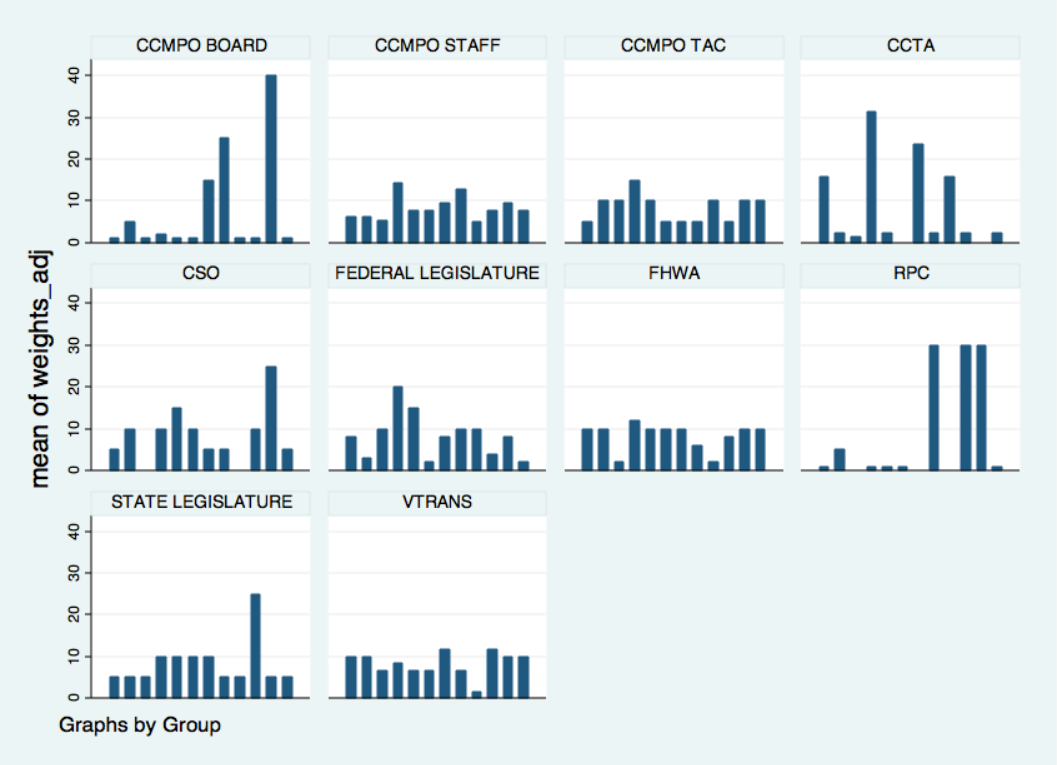

Figure 4: Distributional functions of average weights by stakeholder groups (x-axis represents 12 decision criteria in the same order as Table 2 for each stakeholder group)

3.3. Similarities and Differences among Network Actors

In terms of expected values for each of the three scenarios, we find that almost all stakeholder groups represented in the focus groups consistently display higher expected value for the core scenario, followed by workshop and trend scenarios respectively, as shown in Figure 5.

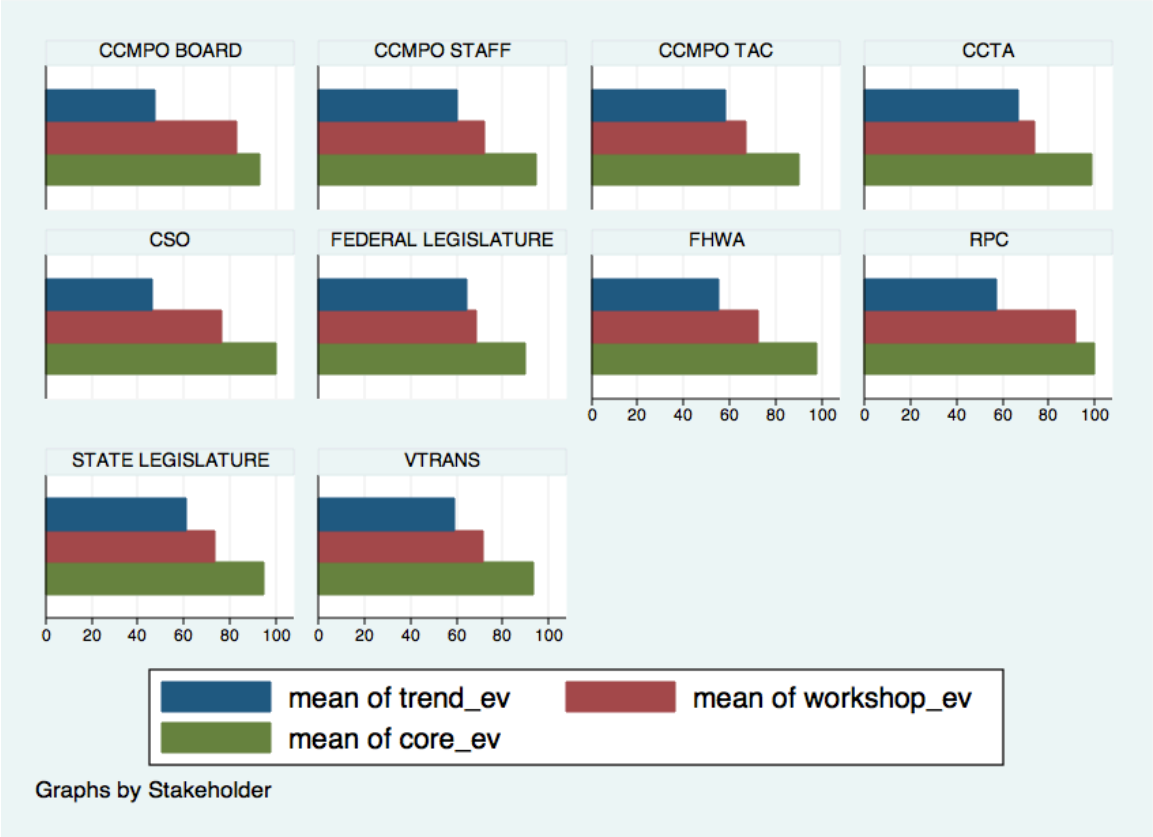

Figure 5: Expected values for each of the three scenarios by stakeholder groups

4. IMPLICATIONS OF THE FINDINGS

While participatory MCDA clearly recommended core (sustainable community design) scenario as the scenario with highest expected value across almost all stakeholder groups, the implementation of this scenario will require overcoming serious legal, political and economic challenges. Although the trend scenario assumes that "current trends of the past 30 years [will] persist 50 years into the future," this scenario imposes minimal (if any) additional strictures upon existing zoning and development, and for that reason imposes the least prohibitive capital costs. However, "this type of development pattern… requires more spending on public services like roads, water, sewer, and emergency services which are more costly given the distances between houses/buildings as well as from town centers". Further, the trend scenario assumes fossil-fuel driven land-use growth pattern and accumulation of green house gas emissions. In contrast, the **Workshop** scenario pivots on the concept of a "diffused centers pattern", which is intended to concentrate "urban sprawl" through mixed-use centers, the renovation and

upkeep of existing urban structures, and "very limited development in rural areas". The workshop scenario addresses the overextension of public services by restricting growth to these diffuse centers, allowing public works to funnel federal funds into more concentrated areas, leading to higher quality development of those areas; such focused distribution of funding would likely defray capital costs incurred by bolstering public transit and renovating infrastructure. In addition, less square mileage is lost to fragmented centers of population (as in the Trend scenario), and land is used more efficiently as a result. Several challenges arise, however: first, existing zoning and development regulations may not be amenable to higher density development and would therefore need revision to allow for this diffused centers scenario; second, decreasing the amount of space into which the metropolitan area can expand will naturally increase the population density of that area.

The **Core** scenario seeks to impose a rather radical structure upon the future growth of Chittenden County by "locating 45% of all new households over the next 50 years into Burlington and another 5% in Winooski", with the aim of creating a dense, urban-style population center in Burlington. The advantages to such a scenario are many: municipal services are not overextended into rural areas and infrastructure can be maintained/upgraded in a more expedient manner; public transit, biking, and pedestrianism provide viable alternatives to automobile congestion; and rural areas are "relatively open" and undeveloped, preserving Vermont's natural resources. Under the core scenario, high density housing would require major alterations to current zoning and development regulations, and "may change the character of those municipalities" into which such concentrated growth would be funneled; additionally, the Core scenario represents a "dramatic reversal in historic trends", which could represent a high cost of imposition in the form of community opposition, redirection of capital funds away from suburban and rural areas, and which may necessitate major infrastructure overhauls.

Though participatory MCDA clearly supports the core scenario as a planning template, the core scenario's radical departure from historical growth in the Burlington area could be a hard sell to average Vermont residents, policymakers, and developers (not explicitly included in the focus groups), all of whom would have to appreciably alter their present courses in order to realize such a scenario. On the other hand, participatory MCDA findings clearly disfavor the trend scenario; so, by process of elimination, the alternative scenario best suited to compromise could very likely be the Workshop scenario in 25-year planning horizon. In many ways it is the lowest common denominator between an undesirable lack of change (Trend) and a prohibitively rapid imposition of change (Core); the Workshop scenario also has the benefits of a ready-made support network, having been proposed by the CCMPO 2009 survey groups, and tangible, potentially data-rich implementation in the form of completed multi-use facilities. Though it does not promote idealized benefits on par with the Core scenario or cost virtually nothing in the short term like the Trend scenario, the Workshop scenario eliminates the need for wholesale sweeping multi-departmental reform while reducing urban sprawl; moreover, it has an inherent flexibility that would allow each diffuse center to retain its regional identity without compromising large landmasses to unfettered development or incurring massive public works costs. On the other hand, core scenario

would reflect best the weighted judgment of stakeholder groups represented in the focus groups conducted for this study. CCMPO(*1)* is planning to release 2035 MTP in 2013 and it has two more years of public deliberation to continue to discuss the practical challenges in making a sound judgment.

A participatory MCDA of 2035 MTP planning process of CCMPO reveals that different stakeholder groups have different value trade-offs, yet the ranking of a sustainable community design scenario emerges as the most desirable scenario. In this study we have demonstrated that participatory MCDA could be effectively used to understand stakeholder value trade-offs and to estimate multiple stakeholder expected value functions on multiple decision criteria, given the estimated impacts of alternate scenarios from integrated transportation-land-use models. This type of stakeholder participatory process enables transparent discussion about comparing the pros and cons of alternate sustainable community designs as they evolve through innovative technological and collaborative planning processes.

5. CONCLUSIONS

A participatory MCDA methodology was implemented as part of the 2035 MTP planning process in CCMPO. Multiple stakeholder representatives from regional transportation planning network were engaged in individual and group interviews to elicit trade-offs between baseline and two alternative sustainable community design scenarios. The planning scenarios were scored according to their impact functions generated from integrated transportation and land-use models and weights elicited from the multi-stakeholder participants of two focus groups. Based on multi-criteria expected value scores estimated for different stakeholder groups, the core scenario scored better than BAU trend and workshop scenarios. More broad data collection and sensitivity analysis of impact functions and stakeholder weight functions is warranted in a future study. Despite these limitations, we demonstrated in this study that a participatory MCDA methodology could be applied to compare alternate transportation planning scenarios that contain different visions of sustainable communities. By explicitly engaging multiple stakeholders in interactive discussions, participatory MCDA can make effective use of the transportation-land use scenario information that is generated by integrated models in long term MTP planning processes.

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