AN ASSESSMENT OF EVALUATION METHODS APPLIED IN DECISION SUPPORT SYSTEMS FOR SUSTAINABLE URBAN MOBILITY PLANNING

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Abstract

The objective of this paper is to discuss procedures for assessing the impacts of different evaluation methods used in systems designed to sustainable urban mobility planning and management. The case studied shows a comparison of the points of view assumed by a small group of experts when using two particular systems. The evaluation methods used in those systems are: Pair-wise Comparisons and Scale of Points. The evaluation was conducted for groups of indicators devised for urban mobility monitoring, which were called Themes. The twenty Themes were also grouped in the following five general Categories: Transport and Environment, Transport Management, Transport Infrastructure, Transport Planning, and Socioeconomic Aspects of Transport. The main conclusions drawn from the application of non-parametric statistical methods for comparing the results of the evaluations suggest that the method Scale of Points could be the most indicated for evaluations with community members in general (experts or non-experts).

Keywords: Sustainable Urban Mobility, Multicriteria Evaluation, Evaluation Methods, Decision Support Systems

1 INTRODUCTION

several problems associated with urban mobility issues. The daily displacements from residential zones to workplaces, together with the constant relocation of activities, have produced an increase in the length and number of trips in the urban areas. The urban mobility issue, however, is broader and more complex than that single aspect and it produces several impacts in the quality of life of urban citizens.

The reliance on the automobile for a large proportion of urban trips has caused strong impacts in the traffic circulation. That was aggravated by an intense urban growth and development policies that ignore or under explore the use of more sustainable transportation modes, such as the non-motorized alternatives (i.e., walking and cycling) and transit. Some of the well-known consequences of those conditions are the increase in traffic congestion, high levels of energy consumption in the transportation sector, and growing pollution. Those problems are largely associated with the deficiency of urban planning instruments to effectively control and manage the urban mobility conditions, along with policies oriented to sustainable urban development.

Aiming to mitigate the problems aforementioned, researchers, planners and decision-makers are currently trying to develop more efficient strategies for comprehensively evaluating urban mobility conditions. This paper focus on two systems developed by Brazilian researchers, in association with Portuguese colleagues, for the assessment of urban mobility: PLANUTS, and the indicators approach developed by Costa (2003). They have many common aspects, given that Costa's work was the starting point of PLANUTS. The latter was recently developed with the objective of showing to the evaluators (either experts or community members) the actual mobility problems of the Brazilian medium-sized cities. This is done through an intense use of indicators, which in that case are essentially the same ones suggested and applied by Costa (2003).

However, PLANUTS and Costa's approach have more in common than only a list of indicators. Both works are based on Multicriteria Evaluation Methods to assess urban mobility, although using different techniques. While Costa used pair-wise comparisons to quantify the relative importance of the several criteria, the developers of PLANUTS decided to use a much simpler method, the scale of points. The explanation for that is associated with the fact that some of the potential 'clients' of PLANUTS (e.g., the community members without any specific knowledge of the technical aspects of multicriteria evaluations) may not feel comfortable with matrices and long lists of pair-wise comparisons.

The question arising from the use of those different approaches is simple: does the method affect the evaluation results? The present study looks for an answer to that question, breaking it down into two analyses. The first analysis examines if the two methods (one straightforward and the other one more complex) can influence the agreement levels among the evaluators. The second analysis looks further away and tries to verify if the results found somehow interfere in the final evaluation process, in terms of the preferences expressed in rankings.

2. URBAN MOBILITY PLANNING AND MANAGEMENT SYSTEMS

Some of the experiences developed for urban mobility planning and management and recently discussed in the international literature are: PROPOLIS - SPARTACUS (System for Planning and Research in Towns and Cities for Urban Sustainability), described in Lautso *et al.* (2002); SUTRA - Sustainable Urban Transportation; PLANUTS - a system for PLANning Urban Transportation for Sustainable development (Magagnin *et al*, 2005); and the system of indicators for urban mobility assessment developed by Costa (2003) and Costa *et al*. (2005).

All those studies clearly show that any system aiming at the assessment of urban mobility must consider the social, economic, and environmental dimensions of the problem. In addition, most of them are based on the use of indicators, which are applied to evaluate the urban mobility conditions, mainly through elements of the transportation system, but from the standpoint of sustainable development. Furthermore, indicators are constant references in the formulation of urban policies and plans aiming at the improvement of the quality of life of urban citizens. Therefore, they are key elements in the identification and assessment of the associated problems of congestion, spatial dispersion of activities, unplanned urban growth, transit deficiencies, and the increased number of private cars and of trips in general. They are also one of the main elements of the two systems studied here, briefly described in the sequence.

The first system considered in the present study was the work of Costa (2003), which considered 115 indicators of urban mobility. They were originally grouped in five Categories: Transport and Environment, Urban Mobility Management, Infrastructure and Technologies, Spatial Planning and Transportation Demand, and Socioeconomic Aspects of Transport. Those indicators were determined after a large search and comprehensive analysis of several systems, such as those described in UNCED (1992), UNCHS (1996), Bossel (1997), Lautso (1998), Dickey (2001), European Environment Agency (2000), Sustainable Seattle (1998), Direção Geral do Ambiente (2000), IBGE (2002), and SNIU (2002).

The second system, PLANUTS, is a Spatial Decision Support System aiming at the integrated and sustainable planning of urban areas with special attention to their mobility systems. It was also envisaged to facilitate participatory planning initiatives, in order to open up the planning process to several segments of the community usually not involved in it. Therefore, one of the goals of PLANUTS is to bring new elements for discussion and decision making in different phases of the processes of urban mobility planning and management, particularly in medium-sized cities. In summary, PLANUTS has the following characteristics: *i*) it allows the identification and assessment or urban mobility issues, *ii*) it provides tools to help users to visualize spatial attributes of the studied urban area, and *iii*) it helps in the process of participatory decision making. Exactly because of the latter aspect, the developers of the system tried to keep the evaluation method as simple as possible. That simplicity, however, would not be valuable if it affects the quality of the evaluation results. That was the motivation for the experiment described in the present work.

For better understanding the organization of both systems, we discuss here some of the main aspects of the multicriteria analysis theory, which is subjacent to them. The multicriteria analysis is a decision-making tool used to make a comparative assessment of alternative projects or heterogeneous measures. With the technique, several criteria can be concurrently taken into account in a complex situation. The method is also designed to help decision-makers to integrate different options resulting from the distinct opinions of the actors involved in the process. Several techniques can be used in the evaluation processes used to extract the information from the actors: Scales of Points, Distribution of Points, Criteria Ranking, and Pair-wise Comparisons, among others. The selection of the method to be applied in any particular context always depends on the analysis approach and on the actors involved. Some methods are very simple and other methods are more elaborate. Methods in the first group, such as the Scale of Points, suit probably better to community participation, while methods in the second group, such as Pair-wise comparisons, are more appropriate to experts. That is what we tried to verify with the experiment described in the next section.

3. METHODOLOGY

The experiment built to look for differences (or similarities) in the multicriteria evaluations obtained with the two systems (PLANUTS and Costa's) was based on the judgments of the same experts. The selection of a small group of only three experts to perform the task was justified by the fact that they were the developers of the systems. The five-points scale evaluations in PLANUTS are accessed through internet based forms. Costa, on the other hand, designed the pair-wise comparisons approach totally based on electronic spreadsheets directly delivered to each evaluator. As the experts know exactly the intrinsic differences of the methods, we assumed that their judgments should be essentially free from eventual influences of one approach or the other. In other words, one could expect that each evaluator would generate similar weights in both systems, despite the method used. However, the small number of evaluators also brings some potential problems. One of the most evident problems is the difficulty of generalizations based only on a small number of cases. Nevertheless, given that this experiment was a first attempt for comparing the results, that limitation was not taken into account at this point of the research. Details of the multicriteria methods applied and of the proposed experiment are presented in the following subsections.

3.1 The Method Based on a Scale of Points

The method based on a scale of points was developed by Osgood in the 1950s. It tries to represent the differences in the evaluators' preferences by means of a scale with seven degrees of importance, in which the lowest value (one) is associated to the concept *Insignificant* and the highest value (seven) refers to the concept *Important* (as in Figure 1). The weights are then directly derived from the scale values selected. Later, other authors adapted the method to different scales, as in the example of the five-points scale used by Findlay *et al.* (1988), Mendes *et al.* (1999) and Silva *et al.* (2004).

Insignificant	1	2	3	4	5	6	7	**Important**

Figure 1 Seven-points evaluation scale

The five-points scale was also the alternative adopted in PLANUTS. That choice was an attempt to keep the evaluation process as simple as possible, given that in a participatory planning process one can expect to have users with different backgrounds and distinct levels of knowledge about the urban mobility aspects being evaluated. The only difference in relation to the example of Figure 1 is in the concept words used. *Insignificant* was replaced by *The Least Important* and *Important* was replaced by *The Most Important*.

Another important aspect of the PLANUTS evaluation process is its availability in Internet. The information required by the evaluators (experts or non-experts) is provided by the system. The entire system is constituted by four modules for the evaluation of urban mobility aspects through Categories, Themes, and Indicators, as earlier proposed by Costa (2003). In the experiment designed for the present study, only the first module of PLANUTS was considered. That module allows the identification of the most important Categories and Themes for urban mobility planning, according to the evaluators. This is done in two phases: the first one only for Categories, and the second one for Themes. The other modules (II through IV), which are used to evaluate urban mobility indicators, were not analyzed in our study.

3.2 The Method Based on Pair-wise Comparisons

According to Saaty (1977, 1980, 1987 and 1990), who developed the Analytic Hierarchy Process, pair-wise comparisons constitute a reliable alternative for the attribution of weights to multiple criteria. Although more complex than other multicriteria evaluation methods, the pair-wise comparisons method is a powerful analysis tool for dealing whit complex decision making problems. In that evaluation process, the weights are derived from subjective judgments conducted in a square matrix *N* x *N*. The rows and columns of the matrix have the criteria being compared by the evaluator. Therefore, rows and columns have the same number of elements (*N*) organized in the same sequence, as shown in Figure 2.

	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5	Criterion 6
Criterion 1	1	1/2	2	2	3	1
Criterion 2	2	1	4	4	6	2
Criterion 3	1/2	1/4	1	1	2	1/2
Criterion 4	1/2	1/4	1	1	2	1/2
Criterion 5	1/3	1/6	1/2	1/2	1	1/3
Criterion 6	1	1/2	2	2	3	1

Figure 2 Matrix for pair-wise comparisons

Costa (2003) used the pair-wise comparisons method to select, from a very comprehensive list of indicators, the urban mobility indicators that should be used in Brazilian and Portuguese cities. The study relied on the judgments of experts of both countries. The entire process was conducted in electronic spreadsheets that contained the several matrices for pair-wise comparisons and also detailed instructions on how to conduct the evaluations. The evaluation process was divided in three phases: *i*) Categories, *ii*) Themes, and *iii*) Indicators. Only the results of phases *i* and *ii* were used in our study.

3.3 Comparing the Methods

Only three evaluators used both systems (described in sections 3.1 and 3.2) in order to allow a subsequent analysis of the results. The limitations of an analysis relying on such a small group were already discussed at the beginning of the present paper section. Other experiments with a larger number of evaluators and distinct groups shall be conducted in the future, when PLANUTS becomes fully operational. However, the results found in the present study are important because they can show if the judgments of the experts are somehow affected by the method they are submitted to. If the weights differ too much, the implications of those different values in the planning process have to be carefully analyzed.

Considering the characteristics of the evaluations carried out with the methods described in subsections 3.1 and 3.2 and the essentially qualitative nature of the analyses we planned to conduct with their outcomes, we choose to analyze the results using non-parametric statistical methods. Two aspects were particularly interesting for our study: the intensity of agreement among experts and the degree of similarity of the weights obtained with the two methods. So, we needed statistical methods that could be used to evaluate the data correlation or the level of agreement in the judgments. Thus, we selected Kendall's Agreement Coefficient to compare the level of agreement in the evaluations of the experts using the two methods described in section 3, and Kendall's Correlation Coefficient Method to check if the final results of both methods were similar in terms of ranking.

4. ANALYSIS OF RESULTS

As a first step of the analyses, the evaluation results were used to calculate the mean values of the weights found for Categories and Themes in each method. The weights found per expert in each system and the mean and standard deviation values are shown in Tables 1 and 2. Table 1 has the values found for the Categories while Table 2 has the values found for the Themes, along with the Categories they belong to.

Table 1: Weights found for the Categories per evaluator and per method

CATEGORIES	SCALE OF POINTS			PAIR-WISE COMPARISONS			Mean	Std Dev
	A	B	C	A	B	C		
TRANSPORT AND ENVIRONMENT	0.211	0.200	0.238	0.310	0.140	0.507	0.268	0.130
TRANSPORT MANAGEMENT	0.158	0.150	0.190	0.381	0.068	0.170	0.186	0.104
TRANSPORT INFRASTRUCTURE	0.158	0.150	0.143	0.062	0.068	0.070	0.108	0.046
TRANSPORT PLANNING	0.263	0.250	0.238	0.128	0.489	0.183	0.259	0.124
SOCIOECONOMIC ASPECTS OF TRANSPORT	0.211	0.250	0.190	0.119	0.235	0.070	0.179	0.070

The information contained in Tables 1 and 2 made possible to identify the results (or weights) per evaluator and per method that are within an interval considered as acceptable. We defined that interval as one standard deviation to each side of the mean value obtained per criterion. Therefore, the values in dark gray cells in Table 1 are below that interval, while (light) gray cells are associated with values above that interval. The other values of Tables 1 and 2 (in the non-colored cells) are within the specified interval.

An analysis of Table 1 shows that the evaluations were quite homogeneous in the method Scale of Points, while the method of Pair-wise Comparisons had a larger number of values outside the predefined interval. In the individual evaluation of the experts, evaluator 'A' had 80 % of the results within the acceptable interval in the first method against 40 % of the weights in the same interval (plus 40 % below it and 20 % above it) in the second method. The distribution of evaluations according to their relative position regarding the predefined interval is also presented in Figure 3, per evaluator and per evaluation method, in the form of pie charts. A similar analysis was also done for the Themes, and the results can be seen in Table 2 and Figure 4.

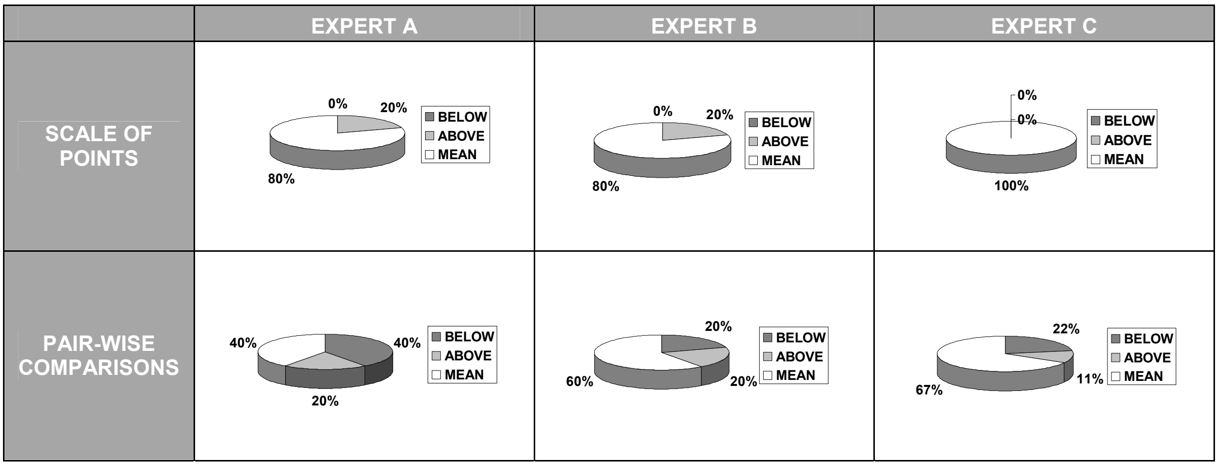

Figure 3 Distribution of the evaluations of Categories in relation to a predefined interval, per evaluator and per evaluation method

Table 2: Weights found for the Themes per evaluator and per method

CATEGORIES AND THEMES		SCALE OF POINTS			PAIR-WISE COMPARISONS			Mean	Std Dev
		A	B	C	A	B	C		
TRANSPORT AND ENVIRONMENT	ENERGY	0.188	0.200	0.313	0.300	0.512	0.309	0.304	0.116
	ENVIRONMENTAL IMPACTS	0.313	0.333	0.250	0.300	0.227	0.240	0.277	0.044
	AIR QUALITY	0.250	0.267	0.188	0.300	0.193	0.309	0.251	0.052
	NOISE	0.250	0.200	0.250	0.100	0.068	0.142	0.168	0.077
TRANSPORT MANAGEMENT	ECONOMIC STRATEGIES	0.231	0.333	0.231	0.170	0.105	0.410	0.247	0.110
	MONITORING	0.308	0.167	0.308	0.368	0.054	0.175	0.230	0.117
	MOBILIDADE URBANA	0.231	0.250	0.231	0.368	0.591	0.175	0.308	0.153
	NEW TECHNOLOGIES	0.231	0.250	0.231	0.095	0.250	0.240	0.216	0.060
TRANSPORT INFRASTRUCTURE	FLEET	0.188	0.250	0.231	0.069	0.585	0.100	0.237	0.185
	ROADWAY SYSTEM	0.313	0.375	0.308	0.210	0.132	0.300	0.273	0.087
	TRANSPORT SERVICES	0.250	0.250	0.231	0.412	0.151	0.300	0.266	0.087
	TRAFFIC	0.250	0.125	0.231	0.309	0.132	0.300	0.224	0.080
TRANSPORT PLANNING	URBAN ACCESSIBILITY	0.278	0.294	0.250	0.303	0.249	0.250	0.271	0.024
	URBAN GROWTH	0.278	0.294	0.250	0.178	0.548	0.250	0.300	0.128
	URBAN POPULATION	0.222	0.176	0.250	0.389	0.130	0.250	0.236	0.088
	TRIPS	0.222	0.235	0.250	0.130	0.073	0.250	0.193	0.074
SOCIOECONOMIC ASPECTS OF TRANSPORT	COSTS	0.188	0.222	0.250	0.224	0.522	0.188	0.266	0.128
	SOCIOECONOMIC IMPACTS	0.250	0.222	0.250	0.095	0.264	0.240	0.220	0.063
	ROAD SAFETY	0.313	0.278	0.250	0.286	0.115	0.240	0.247	0.070
	PUBLIC TRANSPORT	0.250	0.278	0.250	0.395	0.099	0.332	0.267	0.100

In Table 2 one can see that the three experts were once again very homogeneous in their judgments with the method Scale of Points. Only 10 % of the weights were outside the interval assumed as acceptable. In the method of Pair-wise Comparisons, that percentage was 45 %. A more detailed analysis was done per evaluator, as follows (see also Table 2 and Figure 4):

- Expert 'A' had 95 % of the results within the acceptable interval in the method Scale of Points against 40 % of the weights outside the same interval (30 %

above it and 10 % below it) in the method of Pair-wise Comparisons.

- Expert ‘B’ had only 10 % of the results above and 5 % of them below the acceptable interval in the method Scale of Points. Conversely, only 15 % of the weights are within that interval (25 % above it and 60 % below it) in the method of Pair-wise Comparisons.
- Expert ‘C’ had only 10 % of the results outside the predefined interval (5 % above and 5 % below) in the method Scale of Points. In the method of Pair-wise Comparisons, that evaluator had only 10 % of the weights above the predefined interval. When looking to the results of this expert in both methods, that is the most regular outcome of all three evaluations.

The analysis per evaluator allowed a comparison of the results found for each criterion using both methods. When looking to all values outside the acceptable interval in Table 2, for instance, only one criterion (Traffic) had weights in the same relative position (in that case, below the interval) for the same expert in both methods. That analysis approach focusing only on the mean and standard deviation values, however, was not enough for checking the intensity of agreement among experts and the degree of similarity of the ranks derived from the weights obtained with the two methods. This was done with the specific methods discussed in the following subsections.

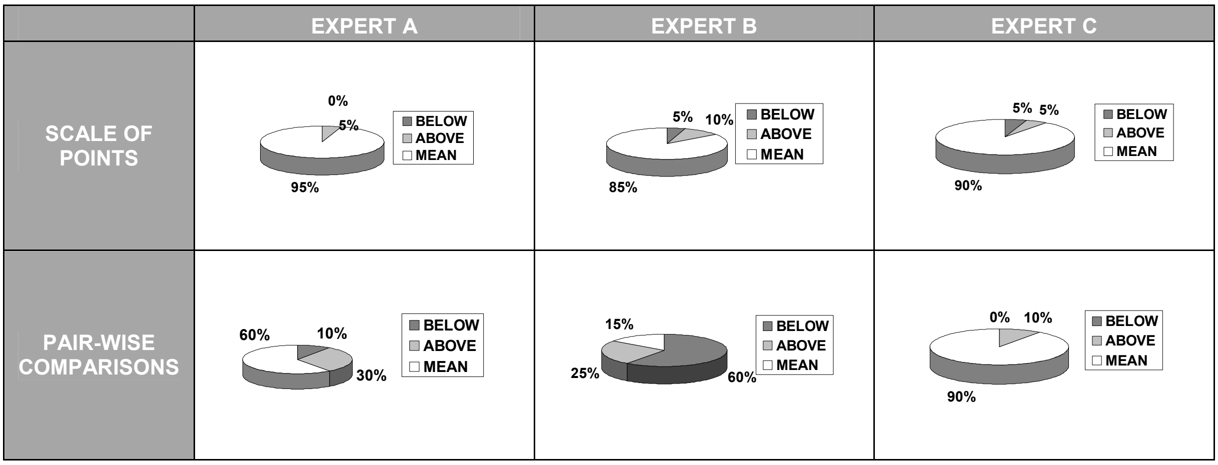

Figure 4 Distribution of the evaluations of Themes in relation to a predefined interval, per evaluator and per evaluation method

4.1 The Agreement among Experts

The Kendall’s Correlation Agreement makes possible to compare the intensity of the agreement observed in multiple sets of data, based on their ranking. The correlation coefficient (W) produced with the method varies from zero to one. The interpretation of the coefficient values is straightforward: zero indicates no correlation, one indicates total correlation, and the values in between show the intensity of the relationship as they approach zero (low correlation) or one (strong correlation). The application of the method in our study was done to verify the intensity of agreement among experts in each one of the evaluation methods described in section 3.

The first step in the calculation of the Kendall’s Correlation Agreement Coefficient was to organize the data according to their rankings. The mean values of the weights found per expert for Categories and Themes were used to do that. In the case of the

Categories, which are only five, for example, the first position was associated with the highest weight and the fifth position was given to the lowest weight, as shown in Table 3. In the case of the Themes, the ranking list goes from one (the highest value) to twenty (the lowest value), as shown in Table 4.

The ranking lists of Table 3 show the different positions occupied by the Categories *Transport and Environment*, *Transport Planning*, *Transport Management* and *Socioeconomic Aspects of Transport* in the different evaluation methods. While in the method Scale of Points the first position was occupied by the Category *Transport Planning*, in the method of Pair-wise Comparisons *Transport and Environment* was on the top of the list. The only criterion in the same relative position in both methods was *Transport Infrastructure*. The other three criteria occupied different relative positions (with two criteria sharing the same rank in one method), which do not allow a very direct descriptive analysis.

Table 3: Categories ranking in the different evaluation methods

CATEGORIES	WEIGHTS (mean value of the experts)		RANKING	
	SCALE OF POINTS	PAIR-WISE COMP.	SCALE OF POINTS	PAIR-WISE COMP.
TRANSPORT AND ENVIRONMENT	0.217	0.319	2	1
TRANSPORT MANAGEMENT	0.167	0.206	4	3
TRANSPORT INFRASTRUCTURE	0.150	0.067	5	5
TRANSPORT PLANNING	0.250	0.267	1	2
SOCIOECONOMIC ASPECTS OF TRANSPORT	0.217	0.141	2	4

The values in Table 4 are the mean values of the weights given by the experts. The columns three and four of Table 4 have the weights per Theme, while columns five and six have the weights per Theme already multiplied by the Category weights, what gives the Final Weights per Theme. Those were the values used for setting up the rankings shown in columns 7 and 8 of Table 4. Only the Themes Traffic and Urban Population occupied the same position in the two rankings, as highlighted in Table 4.

The results of the application of Kendall's Correlation Agreement Method, which were carried out to evaluate the intensity of agreement among experts, are shown in Table 5 and 6 for Categories and Themes, respectively. In the case of the Categories, the results in Table 5 showed a strong agreement of the experts in the method Scale of Points. That agreement was not so evident in the method of Pair-wise Comparisons, although the coefficient value found was not very low. Those results confirmed the homogeneity observed in the evaluations with the method Scale of Points in Table 1, as well as the dispersion of the results with the method of Pair-wise Comparisons.

Table 4: Individual and final weights per Theme, and Themes ranking in the different evaluation methods

CATEGORIES AND THEMES		WEIGHTS PER THEME		FINAL WEIGTHS		FINAL RANKINGS	
		SCALE OF POINTS	PAIRW. COMP.	SCALE OF POINTS	PAIRW. COMP.	SCALE OF POINTS	PAIRW. COMP.
TRANSPORT AND ENVIRONMENT	ENERGY	0.234	0.374	0.051	0.119	9	1
	ENVIRONMENTAL IMPACTS	0.298	0.256	0.065	0.082	3	4
	AIR QUALITY	0.234	0.267	0.051	0.085	9	3
	NOISE	0.234	0.103	0.051	0.033	9	14
TRANSPORT MANAGEMENT	ECONOMIC STRATEGIES	0.263	0.228	0.044	0.047	14	8
	MONITORING	0.263	0.199	0.044	0.041	15	10
	URBAN MOBILITY	0.237	0.378	0.039	0.078	16	5
	NEW TECHNOLOGIES	0.237	0.195	0.039	0.040	16	12
TRANSPORT INFRA-STRUCTURE	FLEET	0.216	0.251	0.032	0.017	19	18
	ROADWAY SYSTEM	0.324	0.214	0.049	0.014	12	20
	TRANSPORT SERVICES	0.243	0.288	0.036	0.019	18	17
	TRAFFIC	0.216	0.247	0.032	0.016	19	19
TRANSPORT PLANNING	URBAN ACCESSIBILITY	0.275	0.267	0.069	0.071	1	6
	URBAN GROWTH	0.275	0.325	0.069	0.087	1	2
	URBAN POPULATION	0.216	0.256	0.054	0.068	7	7
	TRIPS	0.235	0.151	0.059	0.040	5	11
SOCIO-ECONOMIC ASPECTS OF TRANSPORT	COSTS	0.222	0.311	0.048	0.044	13	9
	SOCIOECONOMIC IMPACTS	0.241	0.200	0.052	0.028	8	16
	ROAD SAFETY	0.278	0.214	0.060	0.030	4	15
	PUBLIC TRANSPORT	0.259	0.275	0.056	0.039	6	13

Table 5: Kendall's correlation Agreement (W) for the Categories

CATEGORIES	RANKING						W (Kendall's Coefficient)	
	SCALE OF POINTS			PAIR-WISE COMPARISONS			SCALE OF POINTS	PAIR-WISE COMPARISONS
	A	B	C	A	B	C		
TRANSPORT AND ENVIRONMENT	2	3	1	2	3	1	0,846	0,542
TRANSPORT MANAGEMENT	4	4	3	1	4	3		
TRANSPORT INFRASTRUCTURE	4	4	5	5	4	4		
TRANSPORT PLANNING	1	1	1	3	1	2		
SOCIOECONOMIC ASPECTS OF TRANSPORT	2	1	3	4	2	4		

Table 6: Kendall's Correlation Agreement Coefficient (W) for the Themes

CATEGORIES AND THEMES		RANKING						W (Kendall's Coefficient)	
		SCALE OF POINTS			PAIR-WISE COMPARISONS			SCALE OF POINTS	PAIR-WISE COMP.
		A	B	C	A	B	C		
TRANSPORT AND ENVIRONMENT	ENERGY	4	3	1	1	1	1	0.333	0.813
	ENVIRONMENTAL IMPACTS	1	1	2	1	2	3		
	AIR QUALITY	2	2	4	1	3	1		
	NOISE	2	3	2	4	4	4		
TRANSPORT MANAGEMENT	ECONOMIC STRATEGIES	2	1	2	3	3	1	0.144	0.128
	MONITORING	1	4	1	1	4	3		
	URBAN MOBILITY	2	2	2	1	1	3		
	NEW TECHNOLOGIES	2	2	2	4	2	2		
TRANSPORT INFRASTRUCTURE	FLEET	4	2	2	4	1	4	0.792	0.253
	ROADWAY SYSTEM	1	1	1	3	3	1		
	TRANSPORT SERVICES	2	2	2	1	2	1		
	TRAFFIC	2	4	2	2	3	1		
TRANSPORT PLANNING	URBAN ACCESSIBILITY	1	1	1	2	2	1	0.647	0.400
	URBAN GROWTH	1	1	1	3	1	1		
	URBAN POPULATION	3	4	1	1	3	1		
	TRIPS	3	3	1	4	4	1		
SOCIOECONOMIC ASPECTS OF TRANSPORT	COSTS	4	3	1	3	1	4	0.569	0.097
	SOCIOECONOMIC IMPACTS	2	3	1	4	2	2		
	ROAD SAFETY	1	1	1	2	3	2		
	PUBLIC TRANSPORT	2	1	1	1	4	1		

The W values for the Themes shown in Table 6 were calculated within the Categories. The Categories with the strongest agreement were: *Transport and Environment*, in the method of Pair-wise Comparisons; and *Transport Management*, *Transport Infrastructure*, *Transport Planning*, and *Socioeconomic Aspects of Transport*, in the method Scale of Points. The agreement was evident in the Themes of the Category *Transport and Environment* in the method of Pair-wise Comparisons, and in the Themes of the Category *Transport Infrastructure* in the method Scale of Points. On the other hand, some Themes, such as *Socioeconomic Aspects of Transport*, had a very low coefficient in one of the methods (W = 0.097 in the method of Pair-wise Comparisons). That W value suggests a very low level of agreement among the experts regarding the Themes of that specific Category with that particular evaluation method.

4.2 The Similarity of the Results Obtained

The Kendall's Correlation Ranking Method made possible to check if the final results of both methods were similar in terms of ranking. The correlation coefficient (τ) produced with the method is in the interval $-1 \leq \tau \leq 1$. The interpretation of the coefficient values is direct: zero indicates no correlation, and one (either positive or negative) indicates total correlation. Positive values indicate a direct relationship while negative values show an inverse relationship. The application of the method in our study was done to verify how similar are the results obtained with the evaluation methods described in section 3 in terms of ranking. The data used in the calculation and the results obtained are displayed in Table 7. The analyses of the results show a reasonable positive correlation in the case of the Categories, but a relatively low value for the Themes.

Table 7: Input data and results of the calculation of the Kendall's Correlation Ranking Method for Categories and Themes

CRITERIA		FINALWEIGHTS		RANKING		τ (Kendall's Coefficient)
		SCALE OF POINTS	PAIR-WISE COMP.	SCALE OF POINTS	PAIR-WISE COMP.	
CATEGORIES						
TRANSPORT AND ENVIRONMENT		0.217	0.319	2	1	0.600
TRANSPORT MANAGEMENT		0.167	0.206	4	3	
TRANSPORT INFRASTRUCTURE		0.150	0.067	5	5	
TRANSPORT PLANNING		0.250	0.267	1	2	
SOCIOECONOMIC ASPECTS OF TRANSPORT		0.217	0.141	2	4	
CATEGORIES AND THEMES						
TRANSPORT AND ENVIRONMENT	ENERGY	0.051	0.119	9	1	0,337
	ENVIRONMENTAL IMPACTS	0.065	0.082	3	4	
	AIR QUALITY	0.051	0.085	9	3	
	NOISE	0.051	0.033	9	14	
TRANSPORT MANAGEMENT	ECONOMIC STRATEGIES	0.044	0.047	14	8	
	MONITORING	0.044	0.041	15	10	
	URBAN MOBILITY	0.039	0.078	16	5	
	NEW TECHNOLOGIES	0.039	0.040	16	12	
TRANSPORT INFRA-STRUCTURE	FLEET	0.032	0.017	19	18	
	ROADWAY SYSTEM	0.049	0.014	12	20	
	TRANSPORT SERVICES	0.036	0.019	18	17	
	TRAFFIC	0.032	0.016	19	19	
TRANSPORT PLANNING	URBAN ACCESSIBILITY	0.069	0.071	1	6	
	URBAN GROWTH	0.069	0.087	1	2	
	URBAN POPULATION	0.054	0.068	7	7	
	TRIPS	0.059	0.040	5	11	
SOCIO-ECONOMIC ASPECTS OF TRANSPORT	COSTS	0.048	0.044	13	9	
	SOCIOECONOMIC IMPACTS	0.052	0.028	8	16	
	ROAD SAFETY	0.060	0.030	4	15	
	PUBLIC TRANSPORT	0.056	0.039	6	13	

5. CONCLUSIONS

The main conclusions drawn from the application of the non-parametric statistical methods for comparing the results of the evaluation carried out by experts with the methods Scale of Points and Pair-wise Comparisons were:

- The application of the Kendall's Correlation Agreement Method indicated a considerable difference in the evaluations using the methods Scale of Points and Pair-wise Comparisons for the analysis of Categories and Themes related to urban mobility. The results have shown more homogeneous evaluations in the method Scale of Points than in the method of Pair-wise Comparisons.

- Through the Kendall's Correlation Ranking Method we observed a positive correlation of the results obtained with the two evaluation methods for both Categories and Themes related to urban mobility, although not very strong (the coefficients were close to 0.337). That suggests that the adoption of any of the methods will not change very much the final ranking. An interesting outcome of the analysis was the fact that we found no cases of similar ranks in any of the methods, what is not very common in that sort of application.

In an overall comparison of the results obtained in the evaluations of the experts through the different methods, we found that the method Scale of Points produced a more homogeneous outcome. The reasons for that may be in two aspects: *i*) the method seems to be of easy interpretation and use by the evaluators; *ii*) the use of a scale of five points assures that the final weights resulting from the distinct evaluations are less divergent, i.e., the standard deviation has a small value.

The two aspects highlighted above suggest that the method Scale of Points could be more indicated for evaluations with community members in general (experts or non-experts). However, the analysis cannot be considered as definitive, given the small number of evaluators. Consequently, further analyses shall be conducted with more experts and also with community members to confirm if any significant change can be observed in the final outcomes of the evaluations when using the different evaluation methods trialed.

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