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CAN NATIONAL SURVEY DATA BE USED TO SELECT A CORE SET OF INDICATORS FOR MONITORING THE SUSTAINABILITY OF URBAN MOBILITY POLICIES?

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WORKING PAPERS

2009/11

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Titolo: CAN NATIONAL SURVEY DATA BE USED TO SELECT A CORE SET OF INDICATORS FOR MONITORING THE SUSTAINABILITY OF URBAN MOBILITY POLICIES?

ISBN: 978 88 8467 547 7

Prima Edizione: Novembre 2009

Via Is Mirrionis, 1
09123 Cagliari
Tel./Fax 070291201
www.cuec.it

Can national survey data be used to select a core set of indicators for monitoring the sustainability of urban mobility policies?

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Abstract

The gradual expansion of urban transport systems brings a series of undesirable socio-economic and environmental impacts that affect the quality of life in cities. Assessing the performance of transport policies is therefore crucial for attaining a sustainable urban development. Adopting an integrated expert-led and participatory-based "bottom-up" approach this paper deals with the issue by examining the feasibility of using citizens' opinions to select a core set of indicators for monitoring the sustainability of urban mobility policies. A national survey has been carried out to gather citizens' perceptions over a basic conceptual framework of dimensions and objectives of urban mobility policies in order to provide a ranking of the associated performance indicators. The results showed that different sets of performance indicators may be chosen according to city size and transport modes mostly used by citizens.

Keywords*:* Urban mobility; Sustainability indicators; Participation; National survey on mobility of Italians
JEL Classification: Q56, Q58, L98

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1. Introduction

In reaction to an increase over time in population, city sizes, movement of people and goods, transport systems and infrastructures have gradually expanded, contributing to the decline in quality of life and environmental degradation in urban areas all over the world. Traffic congestion, air emissions, exhaustion of non-renewable resources, noise pollution, urban sprawl and accidents are just few of the numerous side effects of urban transports systems that affect individuals living in cities. For these impacts to be mitigated, effective measures and co-ordinated urban mobility policies (e.g. the promotion of alternatives to private vehicular travel, the adoption of urban charging schemes, a better traffic management, the diffusion of carpooling and carsharing practices) are key elements of a sustainable development strategy. However, the implemented policies might have heterogeneous outcomes in terms of sustainability: some policies may work against or reinforce each other, while others may improve or worsen the existing situation. Regular monitoring of policy impacts is therefore required. On the other hand, appraising the sustainability of urban mobility policies still remains a difficult task for policy makers. Which dimensions have to be considered and which indicators have to be used in the assessment?

In the last two decades, several indicator frameworks have been proposed for measuring progress toward sustainability in transportation and other infrastructure systems1. A general "environment-oriented" approach is adopted by a number of these studies and research initiatives. This is the case of TERM (Transport and Environment Reporting Mechanism), which annually produces an indicator-based report for monitoring the sustainability of transport related environmental pressures in European countries (EEA 1999, 2009). Also the OECD (2001, 2007), provides a core-set of sustainable development indicators, out of which some are specifically referred to road transport activities.

On a more urban level, specific mobility indicators systems have been proposed by the European Community and other international institutions by adopting a multidimensional approach that takes into account multiple impacts of transport activities. Numerous projects have been developed within the Fifth European Union Framework

1 See Jeon and Amekudzi (2005) and Litman (2008) for a review.

Programme[2] to promote the Land Use and Transport Research (LUTR). PROPOLIS, for instance, is an EC research project that develops integrated land-use and transport policies able to define sustainable long-term urban strategies (Lautso et al. 2004). Urban sustainability is here considered in terms of environmental, social and economic dimensions, each of which comprises a set of indicators used to measure the sustainability of a set of policy options in seven European cities. Set of urban mobility indicators belonging to different sustainability dimensions have been also developed by ADB and EMBARQ (2006) by cooperating with local stakeholders in selected partner Asian cities within the Partnership for Sustainable Transport in Asia (PSUTA). A more limited scientific literature deals with the subject. A number of methodological and applied studies develop indicators centred around mobility issues (Zhang and Guindon, 2006; Barker, 2005; Frei, 2006), while other studies adopt a more integrated perspective in which multiple dimensions of sustainability are considered (Imran and Low, 2003; Nicolas et al, 2003; Costa et al, 2005; Litman, 2008).

This paper contributes to the existing literature by examining how citizen opinions (collected through a national survey) can be used to select a core set of indicators for monitoring the sustainability of urban mobility policies. Adopting an integrated "top-down" (expert-led) and "bottom-up" (participatory-based) approach, indicators are ranked and selected by means of a multidimensional framework that considers major environmental, economic and social impacts of transport and by using public opinion over the different sustainability issues. The use of a participative method offers the following advantages: (1) according to their needs and concerns citizens can give a better contextualised understanding of local issues (Reed et al, 2006); (2) involving the people in the evaluation process can increase public acceptability of the policies implemented (Booth and Richardson, 2001; Banister, 2008); and (3) it provides a valuable opportunity for community empowerment and education on transport sustainability themes (Fraser et al., 2006).

The structure of the paper is as follows. In the next section, we develop a basic framework of dimensions and objectives of sustainable urban mobility policies (SUMPs) that is used to define a first set of performance indicators. Section 3 presents the findings of a national survey conducted to gauge citizens' priorities over the suggested

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[2] Under the *Energy, Environment and Sustainable Development* thematic belonging to the *City of Tomorrow and Cultural Heritage Key Action.*

dimensions and objectives of SUMPs. Results are disaggregated by city of residence and transport mode mostly used by respondents. These data are then used in Section 4 to rank the initial set of performance indicators and select the most relevant among them.

2. A framework for assessing the sustainability of urban mobility policies

2.1. Dimensions of sustainable mobility

Despite its relevance for policy agendas, there is yet no standard way in which transport sustainability is considered (Mebratu 1998, Gudmundsson 2003, Jeon and Amekudzi 2005). Current studies tend to "develop appropriate indicators for measuring sustainability in terms of particular needs identified and captured in unique definitions of sustainability" (Jeon and Amekudzi 2005: 33). Three reasons are adduced (Gudmundsson, 2003) for explaining the vagueness of the sustainable mobility concept: 1) the difficulty in identifying the critical limits for a sustainable use of the environment (*environmental sustainability problem*); 2) the difficulty in defining the optimal contribution of each sector of the economy to solving each sustainability problem (*economic allocation problem*); 3) the difficulty in independently assessing the sustainability of mobility, due to the links of transport activities with other activities, location choices and lifestyles (*social inter-linkage problem*). Further, it has to be considered that any sustainable transport consideration may cause a conflict between collective and individual interests. What is sustainable for someone may not be sustainable for others. What is considered as being a collective improvement in the quality of life, might not mach all individual interests, causing a problem in balancing the two forces. Not everyone might agree to adapt its lifestyle in order to reach sustainability goals. As an example, many individuals might prefer using cars (for their convenience in terms of independence, speed and comfort) and tolerating pollution, congestion and noise, rather than using public transportation.

On the other hand, "while the definitions of sustainable transportation reveal there is no standard way in which transportation is being considered, there seems to be a consensus that progress must occur on at least three fronts: economic development, environmental preservation, and social development" (Jeon and Amekudzi 2005: 33). The concept of sustainable transportation has therefore to be framed as a tripartite framework that simultaneously balances and accounts for these different dimensions of sustainability (WCED 1987, OECD 1997, Litman 2008, Isfort 2006, Nicolas *et al.* 2003). This means that any sustainable transportation evaluation should consider the possible impacts of mobility on the environment (e.g. noise, air and water pollution, resources depletion, habitat loss and global warming), the economy (e.g. in terms of direct and indirect transportation costs impacting on the community) and society (e.g. human health impacts, accessibility, equity, and safety problems). These three dimensions have an equal relevance for measuring progresses towards a sustainable transportation. Connections between issues and integrated solutions might not be in fact easily found when adopting a narrowly defined sustainability (Litman, 2008). For example, if this is considered only in terms of air pollution emissions, decision-makers could decide to solve pollution problems by imposing the use of more efficient vehicles. On the other hand, this solution would not reduce congestion or mobility problems faced by non-drivers which, in turn, could result increased (Litman, 2004).

2.2. Main objectives of sustainable urban mobility policies (SUMPs)

According to the sustainability "pillars" described above, a conceptual framework of specific urban mobility policy dimensions and objectives has been defined in the first phase of this research. The structure adopted is inspired to the well-known theme/sub-theme framework elaborated by UNDESA (2001) to assist national policy decision-making and performance measurement. Following a top-down approach, the three major dimensions of social, environmental and economic sustainability have been articulated into a set of SUMPs objectives, each of which was later linked to one (individual or composite) performance indicator (Section 2.3). This phase has been preceded by an extensive review of the indicator systems developed by the scientific community and by various national and international organisations in the fields of sustainable transport, sustainable urban development and sustainable urban mobility. Appendix A describes briefly some of these works. Our choice of key urban mobility policy objectives (displayed in table 1) and logics behind is outlined in the following paragraphs.

Table 1. Recommended dimensions and objectives of sustainable urban mobility policies (SUMPs)

SUMPs DIMENSIONS		**SUMPs OBJECTIVES**
Social sustainability:	*Accessibility:*	Increase the alternatives to mobility
		Facilitate non-motorized
		Facilitate private motorized
		Facilitate public transport mobility
	Liveability:	Reduce space consumption
		Reduce noise
		Improve air quality
		Increase safety
Environmental sustainability		Reduce greenhouse gas emissions
		Reduce land consumption
		Reduce transport waste
Economic sustainability		Reduce public transport costs
		Reduce private transport costs

In order to better define a set of mobility policy objectives connected to the social sphere of sustainability, two basic sub-dimensions have been identified within the suggested framework: city liveability and urban accessibility to services and activities. Being influenced by numerous factors, accessibility is a "slippery notion" (Gould, 1969) that can be operationalised in several ways (Geurs and Wee, 2004; Litman, 2008). We therefore articulated this theme with a set of policy objectives directed at facilitating urban transport and developing alternatives to physical mobility. City liveability can instead be improved through mobility policies aimed at reducing some major impacts of the transport system. One of the main problems characterizing urban areas is for instance the dramatic reduction of public space caused by the invasion of private motorized vehicles. It is in fact estimated that an automobile requires roughly 150-400 square feet when parked and 1,500 square feet when traveling at a moderate speed (30 mph, assuming 50 vehicles per lane-mile), whereas a bicycle occupies 10-20 square feet when parked and about 50 square feet when ridden at 10 mphA, and a person requires 10 square feet while standing and 20 square feet when walking (VTPI, 2008). Another problem affecting the quality of city-living is the high level of unwanted sounds and vibrations caused from transport. Motor vehicles are in fact a major source of various types of noise, including engine acceleration, tire-road friction, horns, breaking and vehicle theft alarms. The quality of the local air is a further critical element for city liveability which is strongly affected from transports. The use of motorized vehicles is in fact responsible for producing various dangerous pollutants, including fine particulates (PM_{10}), carbon monoxide (CO), nitrogen oxides (NOx) and non-methane volatile compounds (NMVOCs). Another important issue related to urban liveability is citizens' safety. Individuals may remain injured and killed as a result from vehicle collisions and traffic accidents represent one of the major health dangers for citizens.

Within the environmental dimension, we took into account the objectives of reducing greenhouse gas emissions, transport waste and land consumption. The transport system is a major contributor to climate change and global warming as the burning of non-renewable fossil fuels (e.g. diesel and petrol) releases high levels of carbon dioxide (CO_2) in the atmosphere. According to the European Commission (EC, 2001), 739 million tonnes of CO_2 emissions were released from the transport sector in 1990 and a further substantial increase is forecasted for 2010 when 1113m tonnes will be produced (84% of this increase is attributable to road transport). The phenomenon is particularly severe at the city level, as urban transport accounts for 40 % of carbon dioxide emission from road vehicles (EC 2001, 2006). A part from generating dangerous emissions, motor vehicles produce also various waste materials which need to be adequately disposed, such as used tires, oil, batteries, and other harmful liquids resulting from motor vehicle production and maintenance (e.g. anti-freeze, break fluid and cleaners). Another type of environmental impact concerns the amount of land consumed by transport infrastructures. It is in fact estimated that "transport infrastructure, mainly roads, occupies 25-30% of land in urban areas" and also that "land-use for transport infrastructure… is likely to increase by 2030 due to the expected strong growth in transport activity" (OECD, 2002: 41).

The economic dimension is the third major component in our framework. This dimension is broken down into two objectives related to the affordability of the transport system: reducing public and private mobility costs.

2.3. A core-set of urban mobility indicators for policy assessment

The next step of this research involved linking each policy objective to a specific parameter. In particular, the set of performance indicators has been selected according to their direct relevance to the objectives, their exhaustiveness (i.e. every SUMPs objective has its specific indicator) and adopting an efficiency criterion (i.e. avoiding any redundancy) [3].

The *Availability of public and private services accessible via telephone and computer* is the indicator chosen to represent the possible alternatives to physical mobility. The rationale behind this measure is that the spread of a 'virtual mobility' reduces the use of private motorized vehicles, (Banister and Stead, 2004; Banister, 2008). The ease of reaching destinations is another important factor that has to be accounted within any socially sustainable urban policy. This objective is measured with distinct indicators according to the modal split of trips: 1) a road *congestio*n indicator appraises the easiness of travel by private motorized transportation (car and motorcycle); an index of *walkability and "Cyclability"* approximates the ease of travel by "slow-mobility"*;* while the ease of travelling by public transport is represented by the *Quantity/quality of public transport services*. The goal of reducing space consumption can be assessed by measuring the *Number of motorized vehicles per* km^2, and the *Kilometres of vehicle travel density*. Improving city liveability requires also reducing transport noise, having a cleaner air and increasing safety. The first objective is measured with the *Percentage of population exposed to transport noise levels exceeding the national standards*, the second is approximated by *Transport emissions* (levels of PM_{10}, NMVCOs, NOX, CO generated by transport activities), while the latter is measured with the number of *Death and injuries from transports*. Turning to the measurement of the environmentally sustainable transport objectives, we suggest using the following indicators: *CO_2 emissions from transports*, *Land occupied by transport infrastructures* and *Transport waste*. Finally, the objective of reducing mobility costs can be measured with the *Annual average travel expenditure from households* for their private mobility and their use of public transports.

[3] Some of the indicators suggested in this paper (e.g. the walkability and cycling index) need to be further defined for being used in applied case-studies but this goes beyond the objectives of this paper and is left for further research. Here we are interested in investigating if national survey data can be used to select a set of policy performance indicators reflecting citizens' perceptions on sustainability issues.

Table 2. Recommended indicators for monitoring the sustainability of urban mobility policies according to their objectives

SUMPs OBJECTIVES	INDICATORS
Increase the alternatives to mobility	Public and private services accessible via telephone and computer
Facilitate non-motorized transportation	"Cyclability" and walkability index
Facilitate private motorized transportation	Congestion
Facilitate public transport mobility	Quantity/quality of public transport services
Reduce space consumption	Consumption of public space by parking and travelling (Vehicles- and Vehicles*km per km^2)
Reduce noise	Percentage of population exposed to transport noise levels exceeding the national standards
Improve air quality	Main air pollutants from transport: PM_{10}, NMVOCs, NO_X, CO
Increase safety	Death and injuries from traffic accidents
Reduce greenhouse gas emissions	Greenhouse gas emissions (CO_2) from transports
Reduce land consumption	Land occupied by the transport infrastructures
Reduce transport waste	Waste generated by transport activities
Reduce public transport costs	Households expenditures for public transport
Reduce private transport costs	Households expenditures for private transport

3. Using a National Survey to detect public opinion on transport policies

This study advocates a participative approach for ranking SUMPs dimensions and objectives based on the use of public opinion over major environmental, social and economic sustainability issues. To be sustainable, urban transport policies must necessarily focus on human needs and seek ways to meet them. According to their needs, perceptions and concerns, citizens can provide relevant and valuable information for assessing the success of public policies. If citizens, for instance, feel transport safety is one the most important issues, elected officials and planners should then check if the implemented urban mobility polices have reduced or not the number of deaths and injuries from transport. Involving the people in the evaluation process can also be part of a general sustainability strategy based on public acceptability of the policies implemented. Besides, the use of a participatory approach can convince individuals to change their behaviour towards mobility (e.g. reduce private vehicles use) and commit themselves to the sustainable mobility paradigm (Banister, 2008).

The demoscopic survey has been conducted in cooperation with Isfort4 over the period April 2008 - February 2009 by means of "Audimob", an Observatory on the mobility of Italians. The questionnaire was telephonically administered to a representative sample of the Italian population (3,680 individuals aged between 18 and 80 years). Respondents were not directly asked to rank the whole set of objectives and sustainability dimensions (a difficult question for a phone interview) but had to prioritize the importance of each SUMPs dimensions and objectives defined in tables 1 and 2 according to the following scale: 1) Priority; 2) Important but not priority; 3) Useful but not urgent. The average score of responses5 has been used to rank citizens' preferences.

The sections below describe the results of the survey for the whole sample, according to the size of cities where respondents live and the preferred mode of transport.

3.2.1 Results for the whole sample

Assessing policies performance while considering population needs and opinions requires a knowledge on which dimensions of urban mobility policies are most important for citizens. According to the demoscopic survey (see table 3), the majority of citizens interviewed feels that transport policies should mostly promote *environmental sustainability* through a reduction of atmospheric pollution, land consumption and transport related waste. The second most-important priority is to

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5 We used the scores 4, 2, 1 for the categories "Priority", "Important but not priority", "Useful but not urgent", respectively.

improve urban *liveability* by increasing the amount of space for walking and cycling, reducing transport noise, improving air quality and safety. The third concern is the *economic dimension* (the reduction of private and public mobility costs for citizens) while a lower relevance is given to the *urban accessibility* issue (facilitate the use of the public transports, cars, bicycles, and walking).

Table 3. Ranking of sustainability dimensions

SUMPs DIMENSIONS		Average value	Ranking
Environmental sustainability		2.88	**1**
Social sustainability: liveability		2.82	**2**
Economic sustainability		2.77	**3**
Social sustainability: accessibility		2.50	**4**

Table 4 lists the objectives of urban mobility policies according to the relevance given by citizens. Among them, the reduction of greenhouse emissions has the highest priority, followed by the need of reducing private mobility costs, improve air quality, increase safety and reduce transport waste. The remaining objectives belong to the four different dimensions of sustainability and stand at a lower positions (they all have an average value below 3). In particular, the enhancement of a "virtual mobility" is the less critical issue for respondents. This outcome can have two possible explanations: many jobs are not suitable for being performed from home (for instance, service activities typically require face-to-face contacts) and people may still prefer to go out and buy what they need.

Table 4. Ranking of sustainability objectives

SUMPs OBJECTIVES		Average value	Ranking
Reduce greenhouse gas emissions		3.33	**1**
Reduce private transport costs		3.28	**2**
Improve air quality		3.20	**3**
Increase safety		3.09	**4**

Reduce transport waste		3.04	**5**
Reduce noise		2.79	**6**
Facilitate public transport mobility		2.78	**7**
Reduce public transport costs		2.76	**8**
Reduce land consumption		2.69	**9**
Facilitate non-motorized transportation		2.47	**10**
Reduce space consumption		2.43	**11**
Facilitate private motorized transportation		2.29	**12**
Increase the alternatives to mobility		2.24	**13**

3.2.2. The influence of the urban scale

As expected, a key element emerged regarding citizens' opinion towards urban transport policies: the size of cities where respondents live affects the type of answers given to the survey. The extent of negative externalities generated by the transport system changes in fact according to the urban scale (e.g. there might be higher or lower transport-related pollution levels as well as different safety and accessibility problems), influencing the priority given by citizens to the different sustainable urban mobility policy dimensions and objectives. On the whole, the majority of people living in small cities (up to 50.000 inhabitants) are mostly concerned about *economic sustainability*, those living in medium-sized cities (up to 50.000 inhabitants) are mostly worried about *urban liveability*, while citizens residing in-and-around big cities (with more than 250.000 inhabitants and in the metropolitan belt[6]) give more relevance to *environmental sustainability* issues[7]. If we look at the specific ranking of SUMPs objectives (see table 5), reducing private mobility costs is crucial in small cities, lowering the amount of greenhouse gas emissions has the highest priority in medium cities and in the metropolitan belt, while improving air quality is the primary concern

[6] Municipalities of various dimension belonging to the same Local Labour System of big cities.
[7] The average values given to the SUMPs dimensions are available upon request.

in large large-sized urban centres. Unexpectedly, the issues of non-motorized transportation and the erosion of public space stand at bottom positions for citizens, regardless of city size.

Table 5. Objectives of sustainable urban mobility policies: citizens' evaluations according to the urban scale

SUMPs OBJECTIVES	**Urban scale**							
	Small cities		**Medium cities**		**Big cities**		**Metr. belt**	
	Av. value	**Rank.**	**Av. value**	**Rank.**	**Av. value**	**Rank.**	**Av. value**	**Rank.**
Increase the alternatives to mobility	2.24	**12**	2.24	**13**	2.21	**13**	2.32	**13**
Facilitate non-motorized transport	2.48	**10**	2.57	**10**	2.42	**12**	2.40	**11**
Facilitate private motorized transport	2.21	**13**	2.29	**12**	2.47	**11**	2.32	**12**
Facilitate public transport mobility	2.60	**9**	2.73	**7**	3.18	**4**	2.92	**7**
Reduce space consumpt.	2.37	**11**	2.48	**11**	2.53	**10**	2.48	**10**
Reduce noise	2.65	**8**	2.73	**6**	3.09	**7**	2.98	**6**
Improve air quality	3.04	**4**	3.23	**3**	3.52	**1**	3.32	**2**
Increase safety	3.04	**3**	3.04	**5**	3.21	**3**	3.17	**4**

Reduce greenhouse gas emissions	3.26	**2**	3.34	**1**	3.44	**2**	3.43	**1**
Reduce transport waste	3.00	**5**	3.05	**4**	3.14	**6**	3.08	**5**
Reduce land consumpt.	2.70	**7**	2.66	**8**	2.72	**8**	2.68	**9**
Reduce public transport costs	2.82	**6**	2.64	**9**	2.67	**9**	2.77	**8**
Reduce private transport costs	3.31	**1**	3.30	**2**	3.18	**5**	3.28	**3**

3.2.3. Results by transport mode mostly used

The relevance of the objectives for respondents changes if data are disaggregated by preferred8 transport modal choice: car (as a driver), bicycle, or public transports (bus, tram, and tube). On the whole (considering SUMPs dimensions), the majority of car drivers feels that urban mobility policies should be addressed to improve economic sustainability, those using the bicycle as a favourite means of transport are mostly worried about urban liveability, while individuals preferring public transports give more relevance to the environmental issues[9]. In particular, as shown in table 6, car users perceive the reduction of private mobility costs as the most important objective (however, the objective "Facilitate private motorized transportation" stands at the last position), while public transport- and bicycle users prioritize the reduction of greenhouse emissions from transports.

8 Used more than twice a day

[9] See note 7.

Table 6. Objectives of sustainable urban mobility policies: citizens' evaluations according to the transport mode mostly used

SUMPs OBJECTIVES	**Transport mode**					
	Car		**Bicycle**		**Bus, tram, tube**	
	Av. value	**Rank**	**Av. value**	**Rank**	**Av. value**	**Rank**
Increase the alternatives to mobility	2.35	**12**	2.06	**12**	2.12	**13**
Facilitate non-motorized transport	2.49	**10**	3.44	**2**	2.63	**9**
Facilitate private motorized transport	2.35	**13**	1.75	**13**	2.16	**12**
Facilitate public transport mobility	2.85	**7**	2.74	**9**	3.47	**3**
Reduce space consumption	2.45	**11**	2.61	**11**	2.45	**11**
Reduce noise	2.71	**8**	2.89	**7**	3.22	**4**
Improve air quality	3.17	**3**	3.38	**3**	3.48	**2**
Increase safety	3.11	**4**	3.01	**6**	3.07	**7**
Reduce greenhouse gas emissions	3.34	**2**	3.50	**1**	3.66	**1**
Reduce transport waste	3.07	**5**	3.04	**5**	3.19	**5**
Reduce land consumption	2.66	**9**	2.85	**8**	2.77	**8**
Reduce public transport costs	2.85	**6**	2.70	**10**	2.56	**10**
Reduce private transport costs	3.41	**1**	3.10	**4**	3.09	**6**

4. Selecting objectives and performance indicators

The demoscopic survey represents a unique and precious source of information enabling local authorities to select a key set of indicators apt to assess the performance of sustainable urban mobility policies while taking into account population needs and concerns. As displayed in table 7 (obtained by merging table 4 with the indicators suggested in Section 2.3), indicators can in fact be ranked according to the relevance given to the sustainability objectives to which they are associated. This information may well be exploited to give a different weight to the sustainability concerns within each policy evaluation.

The exact number of indicators that should be used in policy evaluations is discretionary and strictly dependent on the budget constraints faced by local authorities. Collecting the data involves a costly process and local authorities could decide to select the indicators according to the most important objectives coupled to each SUMPs dimension[10], use only a set of indicators above a given threshold or choose a certain number of "more important" indicators (e.g. the first 10 indicators). Identifying a threshold value may however be seen as less discretionary than selecting a given number of indicators if the threshold is defined by looking at discontinuities in the data (i.e. a sharp difference in average values between objectives). In this case, the number and types of indicators selected is more strictly dependent upon citizens' evaluations. The higher the difference between the score of the last of the selected indicators and the score of the first of the non-selected indicators, the lower the arbitrariness of the choice. Accordingly, in the examples below (see tables 8 and 9) we choose for instance a threshold value of 3.00 to select a smaller set of indicators. It is straightforward that the threshold score can be lowered (raised) according to the amount of resources available to finance data collection and processing.

Table 7. Ranking of performance indicators for the whole sample

SUMPs OBJECTIVES	**Av. value**	**Rank ing**	**INDICATORS**
Reduce greenhouse gas	3.33	**1**	*Greenhouse gas emissions (CO_2) from transport*

[10] Four indicators will be selected in this case (for the whole sample): *Greenhouse gas emissions*, *Main air pollutants from transport*, *Households expenditures for private transport*, and the *Quantity/quality of public transport service.*

emissions			
Reduce private transport costs	3.28	**2**	*Households expenditures for private transport*
Improve air quality	3.20	**3**	*Main air pollutants from transport: PM_{10}, NMVOC, NO_X, CO*
Increase safety	3.09	**4**	*Death and injuries from transports*
Reduce transport waste	3.04	**5**	*Waste generated by transport activities*
Reduce noise	2.79	**6**	*Percentage of population exposed to transport noise levels exceeding the national standards*
Facilitate public transport mobility	2.78	**7**	*Quantity/quality of public transport services*
Reduce public transport costs	2.76	**8**	*Households expenditures for public transport*
Reduce land consumption	2.69	**9**	*Land occupied by the transport infrastructures*
Facilitate non-motorized transportation	2.47	**10**	*Walkability and "cyclabilty" index*
uce space consumption	2.43	**11**	*Consumption of public space by travelling and parking*
Facilitate private motorized transportation	2.29	**12**	*Traffic congestion*
Increase the alternatives to mobility	2.24	**13**	*Public and private services accessible via telephone and computer*

Depending on the mobility policy that needs to be assessed, the choice of indicators may as well reflect the opinions of a particular group of citizens that use specific transport modes. If the policy concerns public transports, for instance, local authorities can choose the indicators (see table 8) according to the most important issues raised by those which typically use public transportation services (listed in table 6). In this case, indicators selection and ranking will be different from the ones obtained by considering other type of preferences, such as those expressed by car users. Two indicators must in fact be specifically taken into account to reflect public transport user's preferences: the *Quantity/quality of public transport services* and the *Percentage of population exposed to transport noise.*

Table 8. Core set of performance indicators based on transport modal choices

INDICATORS[a]	**Ranking by transport mode**		
	Bus, tram, tube	**Car**	**Bicycle**
Greenhouse gas emissions (CO_2) from transport	**1**	**2**	**1**
Main air pollutants from transport	**2**	**3**	**3**
Quantity/quality of public transport services	**3**	**-**	**-**
Percentage of population exposed to transport noise levels exceeding the national standards	**4**	**-**	**-**
Waste generated by transport activities	**5**	**5**	**5**
Households expenditures for private transport	**6**	**1**	**4**
Death and injuries from transports	**7**	**4**	**6**
"Cyclability" and walkability index	**-**	**-**	**2**

[a] Indicators with an average value over 3.00

According to the survey, citizens have different needs in terms of sustainable mobility depending on the size of cities where they live. This is because the extent of transport impacts is largely dependent on the scale of urban environments and affects the quality of life of individuals in different ways. As shown in table 9, the number and relevance of indicators depicting the sustainability of urban mobility policies varies for small- medium- and big cities (indicators are selected according to the objectives listed in table 5). For instance, the following indicators become crucial for measuring SUMPs performance in big cities compared to smaller ones: the amount of *Waste generated by transport activities,* the *Quantity/quality of public transport services* and the *Percentage of* *population exposed to transport noise levels exceeding the national standards*. We therefore suggest selecting the indicators by specifically considering the size of the urban environments in which transport policies have to be applied.

Table 9. Core set of performance indicators according to the urban scale

INDICATORS[a]	**Ranking by urban scale**			
	Small cities	**Medium cities**	**Big cities**	**Metropolitan belt**
Households expenditures for private transport	**1**	**2**	**5**	**3**
Greenhouse gas emissions (CO_2) from transport	**2**	**1**	**2**	**1**
Main air pollutants from transport	**4**	**3**	**1**	**2**
Death and injuries from transports	**3**	**5**	**3**	**4**
Waste generated by transport activities	**-**	**4**	**6**	**5**
Quantity/quality of public transport services	**-**	**-**	**4**	**-**
Percentage of population exposed to transport noise levels exceeding the national standards	**-**	**-**	**7**	**-**

[a] Indicators with an average value over 3.00

5. Conclusions and future research

Given the growing interest in addressing urban transport sustainability, this paper used national survey data to select a core set of indicators for monitoring the sustainability of urban mobility policies. In particular, the methodology applied revealed that different sets of performance indicators may be chosen according to city size and transport mode mostly used by citizens. Obviously, there is no clear-cut criterion to select a particular set of indicators but the choice is largely dependent on local authorities, their policy objectives and their ability to effectively address local transport problems and citizens' needs. These can in fact decide to adopt the indicators according to the city size where the transport policy is implemented, depending on the preference expressed by a particular category of transport users, or use a combination of the two data sources. On the other hand, the absence of definite criteria is implicit in the vagueness of the sustainability concept as "the precise meaning of sustainable, and what it embraces, varies depending upon who is using it and in what context" (Bell and Morse, 1999, p.5).

The next step of this research is to further characterize the indicators suggested in Table 2 for conducting an empirical evaluation of transport sustainability policies in specific urban areas.

In order to have a better understanding of how the community can be involved in identifying the most relevant indicators, in the future we also aim to replicate the analysis through a participated multi-criteria technique (Clark et al., 1998; Vatn, 2009). Adopting this type of approach will enable to weight the SUMPs dimensions and objectives through a panel of national and local stakeholders and select a set of indicators that can be compared with the ones obtained by using citizen evaluations. The aim is to check potential inconsistencies in results and investigate the possibility of producing a single participative procedure that involves both citizens and stakeholders in the definition of performance indicators.

APPENDIX A

Table 1A: Comparison between studies						
Author	**Focus**	**Geo. Scale**	**Key transport-related indices/ indicators**			**Brief description**
			Tot.	**Sustainability dimensions/categories**		
				Explicitly considered	**Mostly represented**	
Nicolas et al. (2003)	Sustainable urban mobility	Urban	19	Economic, Social, Environmental, mobility	Economic, mobility	Develops a set of indicators for measuring the sustainability of Lyon's urban travel system (estimations are mainly based on households' travel survey data). It discusses the conditions for reproducing this approach on other urban areas.
Costa et al (2005)	Sustainable urban mobility	Urban	24	Transportation and environment, mobility management, Infrastructure and transportation technologies, Spatial planning and transportation	Environmental	Employing multicriteria analysis, this study identifies a set of indicators (and their relative importance) suitable for monitoring the urban mobility conditions of selected cities in Brazil and Portugal.

				demand, Socio-economic		
Zhang and Guindon (2006)	Sustainable urban transport	Urban	4	-	-	Suggests a methodology for quantifying land-use/urban-form based indicators based on remote-sensing technology, basic statistics, spatial analysis and modelled processes.
Frei (2006)	Sustainable urban mobility	Urban	8 = 1 index	Mobility	Mobility	With the aim of monitoring mobility conditions in medium-sized cities, this study develops a so called "Sample Mobility Index" (composed of indicators related to walking, vehicle-use and cycling). The index is compute for the city of Assis (Brazil).
Imran and Low (2003)	Sustainable urban transport	Urban	47	Economic, social, environmental, transport activity.	Environmental	Reviews the adequacy/deficiency of transport planning in Lahore (Pakistan) and recommends some measures for developing a more sustainable urban transport system.
Barker (2005)	Sustainable urban transport	Urban	1	Mobility	Mobility	Evaluates the sustainability of the transportation system in San Antonio (Texas) using 'vehicle travel miles' as a key indicator.
Lautso et al (2004)	Sustainable urban transport	Urban	35	Economic, social, environmental	Social	Describes 'PROPOLIS', an EU project that evaluates the sustainability of different transport policy options in 7 EU urban regions. It employs an integrated approach based on land-use transport models, spatial disaggregation of the data, economic/social evaluations, and multicriteria analysis.
ISFORT (2006)	Sustainable urban mobility	Urban	18	Mobility (accessibility),	Mobility	A core set of indicators (disaggregated by themes and sub-themes) is suggested as a tool

				environment and health		for assessing the effectiveness of urban mobility policies. Indicators are meant to measure: 1) progresses towards a more sustainable urban mobility system; 2) negative impacts of the transport system on heath and environment.
Häkkinen *(2007)*	Sustainable urban development	Urban	42	Urban transport, urban design, urban management, urban environment	Mobility	Describes 'TISSUE', an EU project aimed to produce an harmonized set of indicators that could be generally used for assessing the sustainability of an urban environment. Indicators are identified from the analysis of several national, international and European initiatives, and by taking into account a number of urban development-related concerns
Litman (2008)	Sustainable transport	-	34	Economic, social, environmental	Environmental	Litman suggests a number of best practices for selecting sustainable transport indicators, describes examples of indicators sets used in previous studies and provides a list of recommended indicators disaggregated by relevance and dimensional category.
EEA (2000-2007)	Sustainable transport	National	40[a]	Transport, environmental	Environmental	Annual reports describing TERM, an indicator-based reporting mechanism developed by the EEA for monitoring the integration and effectiveness of transport and environment strategies in the EU.

[a] not all indicators are published every year

Acknowledgements

This research has been promoted and funded by Isfort, an Italian private research body specialized in the transport sector (http://www.isfort.it/), and partially co-funded by the University of Sassari (Italy). The authors are grateful to Eleonora Pieralice (Isfort) for data processing.

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Finito di stampare nel mese di Novembre 2009
Presso **studiografico&stampadigitale Copy Right**
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ISBN 978-88-8467-547-7