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Criteria for assessment of welfare impacts within regional planning of transport systems

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ABSTRACT

This paper presents Finnish experience in defining criteria for assessing the potential welfare impacts of a transport plan or policy. These criteria are to be used co-operatively by the planners and decision-makers. An important issue is the link between the formation of the objectives and the actual evaluation of impacts, as well as the underlying values and views that influence the selection of planning methods and practises. The criteria were drafted based on a literature review and discussions with Finnish transport authorities. These preliminary criteria were created and put into order by using the Analytic Hierarchy Process (AHP). The process involved active co-operation with the national transport authorities, as well as with other interest groups. The draft criteria were prioritised based on the opinions of selected representatives of national and regional authorities and transport planners.

In this paper we focus on the priorisation process of the criteria, as well as discuss the validity and usability of the criteria created. Furthermore, the suitability of multi-criteria analysis in the context of regional transport planning is discussed, in addition to the consistency requirements between the criteria and the multi-criteria model. The criteria have been created in an ongoing Finnish study that aims at supporting regional transport planning, concerning the impacts that changes in the transport system may have on the welfare of the communities and individuals. Furthermore, the suitability of certain Multi-Criteria Decision Aid (MCDA) methods in creating consensus in the planning process is tested.

Key words: Transport system, welfare impact, assessment, criteria, multi-criteria decision aid (MCDA)

1) Introduction

In this paper we introduce a set of criteria for assessment of welfare impacts of a major transport plan or policy. The regional transport system plans present the wide framework for local transport planning in Finland, and are the means of applying the national high-level objectives regionally. Transport system plans are usually created interactively with the regional land use planning. Prediction and appraisal of the potential impacts of the alternatives under discussion form an important part of the planning process.

The above-mentioned criteria have been created in an ongoing Finnish study that aims at supporting regional transport planning, concerning the impacts that changes in the transport system may have on the welfare of the communities and individuals. An important issue is the link between the formation of the objectives and the actual evaluation of impacts, as well as the underlying values and views that influence the selection of planning methods and practises. This study is continuation of research examining the concept of welfare impact and methods of assessing those (Rusila 2004, Rusila, Pekkarinen and Britschgi 2003).

However, it is not possible to consider these different aspects of welfare separately and independently of each other. When it comes to questions about sustainable development, it is often crucial to be able to decide about actions that are simultaneously *ecologically sustainable, socially acceptable* and *technically and economically realistic and feasible*. This means that the conceptions of welfare need to be brought together under the same framework of analysis in order to reconciliate the diverse needs of the different aspects.

The social scientific approaches to welfare can roughly be divided to *needs-based* or *resource-based* perspectives of welfare and well-being The crucial difference between these points of view is whether the state of welfare is assessed *subjectively* (needs-based) as people's own impression of their well-being or *objectively* (resource-based), which means analysing the resources that enable the satisfaction of various human needs. From the needs-based aspect, welfare is considered as a state that already exists, and from resource-based aspect, welfare is a state that is possible to reach. All in all, welfare and human well-being can be seen as an entity that consists of different interconnected and interdependent needs, possibilities and resources.

Mobility and taking part in different activities are important parts of people's everyday life, and transport system creates prerequisites for comfortable and fluent organization of these activities. Thus transport system generates welfare by helping people to satisfy the needs

connected to mobility and activity. On the other hand, traffic and travel also generate harmful and unhealthy side effects, and this makes it necessary to assess also the negative welfare impacts of transport system.

We need to recognise the connections between transport system and human welfare (or creating welfare) to be able to assess the various impacts connected with these interactions. It is necessary to consider how the changes in e.g. traffic volume, choice of means of transport, share of different modes of travel, other mobility choices, travel costs, traffic emissions etc. change the human welfare and its conditions. It is also important to consider how these conditions and impacts are allocated between different demographic groups, for example children, women versus men, old people, disabled or handicapped, people living in urban versus rural areas, car-owners versus people without cars etc.

In this research, welfare is considered consisting of several fields that can be defined as follows: living conditions, health, safety, attractive living environment, opportunities for mobility and activity (also economic opportunities) and equality. The welfare impacts in this study are defined as a change in welfare conditions caused by a change in environment. The welfare impacts within regional planning of transport systems are examined as changes in welfare conditions of people, communities, society and nature. The operational environment of society forms another dimension for the analysis, and it consists of e.g. commerce and business opportunities, economical structure, urban structure and built environment. (Maslow 1943, Kajanoja 1999, Marski 1995, Heltimo 2003, Doyal and Gough 1991, Allardt 1976 Litman 2001).

This study aims at providing clear, easy-to-use criteria for assessment of preconditions for welfare that result from changes in the transport system. These criteria will be used as practical tools by planners and decision makers of transport systems.

2) Methodology

The criteria were created through a gradual process. At first, a preliminary list was written as expert work and given to the steering group of the project for discussion. The steering group comprises representatives from the Finnish Ministry of Transport and Communications, the Ministry of Environment, Finnish National Road and Rail Administrations, Helsinki Metropolitan Area Council, Finnish Ministry of Social Affairs and Health, National Research Centre for Welfare and Health, and Finnish Federation of Municipalities. After the workshop with the steering group, the draft list of criteria was revised.

The revised list was used in 18 individual interviews with the steering group members and selected experts. In these interviews, the significance of the criteria was examined by pairwise comparisons. Each interview included a sample of criteria from two to three areas of concern. The interviewees were asked to indicate the relative significance of to criteria at a time, using a scale from -9 to 9. The data from the interviews was analysed with Analytic Hierarchy Process (AHP) (see for example Saaty and Vargas 1994). As a result of these interviews, relative priorities for each of the criteria were calculated, separately for each interview. The priorities of individual interviewees were aggregated by calculating geometric means for all the criteria (for group decision making with AHP, see for example Bryson and Joseph 2000 or Barzilai and Lootsma 1997). After the analysis of inconsistency, and three new interviews with which we tried to remove the inconsistency from all the judgments, it was agreed that some inconsistency could be allowed, as the results of the AHP process were used only as a starting point of a discussion, not as final results of the analysis.

The priorities generated with AHP were used as guidelines for selection of the criteria. In this process, the most relevant criteria were selected for the suggested list of criteria (see Table 1-7), some new criteria were formulated and the least significant ones were completely left out of the list. This selection was based on the relative priorities, and standard deviation of the individual judgments. Finally, this new version of the list was presented to the steering group for comments and discussion and accepted as the list of criteria that will be tested in practise.

The list of criteria is currently being tested in practise, using data from a development project of an inter-urban railway connection between Finnish cities Seinäjoki and Oulu. In addition to this, the relevance of the criteria is being tested through a questionnaire survey in Oulu region and Helsinki Metropolitan area.

The initial plan was to use the MCDM method MACBETH (see e.g. Bana e Costa 2001, Bana e Costa et al. 2004). However, as the time and resources constraints were tight at this stage of the project, a simplified procedure, using Analytic Hierarchy Process (AHP) was selected. However, the MACBETH will be the main method in the future phases of the project, where a tool for decision-making will be created.

3) Results

Total of 66 evaluation criteria were suggested (see Tables 1-7), classified into seven subject areas and twenty sub-groups (Figure 1). Consequently, 47 criteria were rejected at this stage of selection process. However, the suggested set of criteria will be modified as the criteria are

being tested in connection with the assessment of welfare impacts of the Seinäjoki-Oulu railway connection.

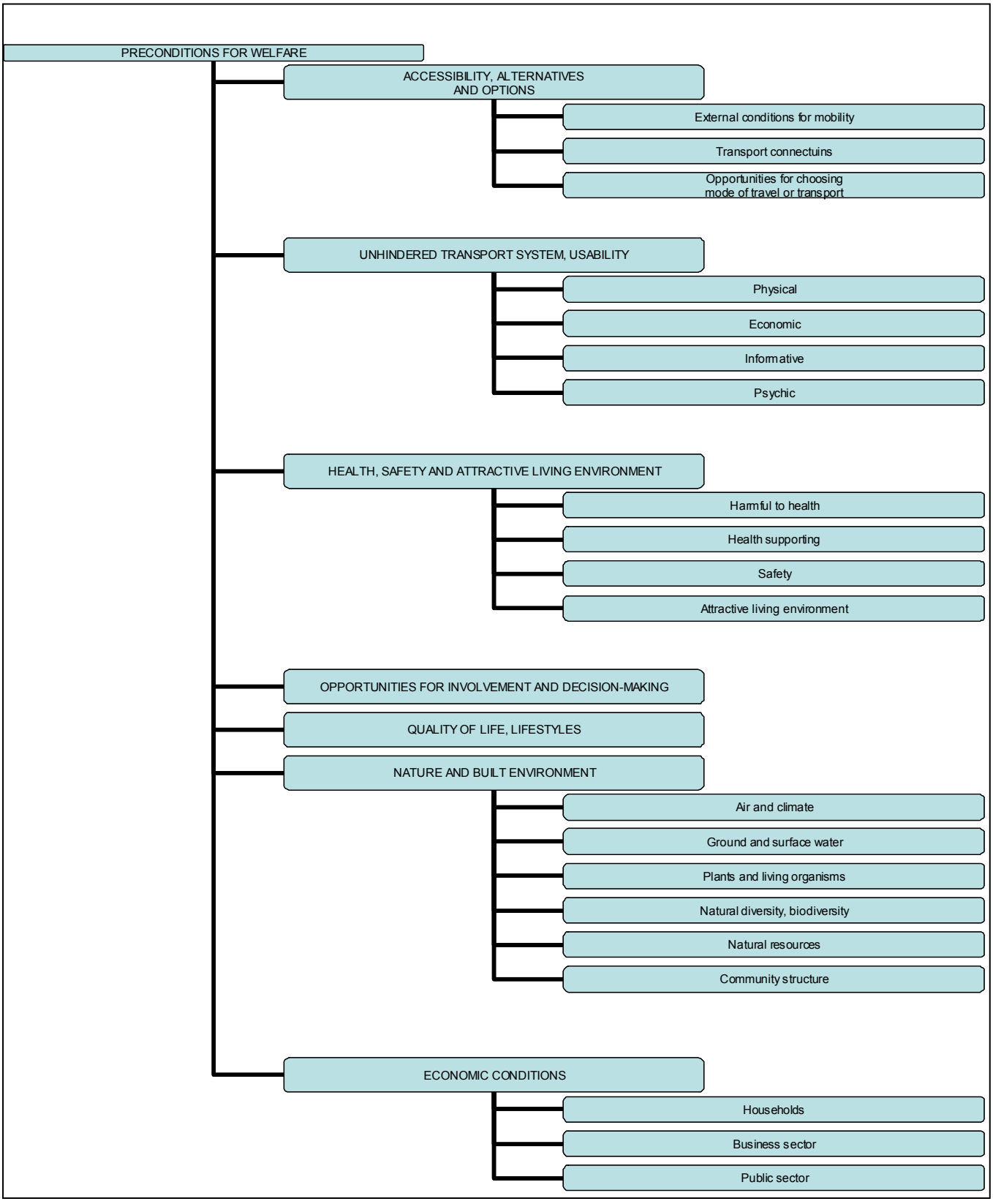

Figure 1. The criteria were classified according to seven main objectives.

Most probably, the number of criteria needs to be reduced considerably. Also, some new criteria may emerge in the testing process. In addition to testing the validity and extensibility of the criteria, the testing phase will provide information about suitable indicators that can be used to measure the criteria. Our tentative idea is that there will be several alternative indicators for each criterion. The best indicator can then be chosen based on the requirements of the assessment and quality of data. These indicators will be both qualitative and quantitative.

For all the criteria we present the mean scores as geometric means of the individual priorities. The individual priorities were generated with AHP for each of the interviews separately. These scores summed up to one within each of the seven main groups.

The first group of criteria describing changes in Accessibility, Alternatives and Options consists of four sub-groups describing the functionality and conditions of overall transport system and mobility opportunities.

The first sub-group External conditions of mobility consists factors of the external structure of society, e.g. location as well as amount and quality of different activities indicating the need and pre-conditions of travel. The most important (mean score 0,27 in Table 1) seems to be at which amount the community structure is supporting public, pedestrian and bicycle transport .

The second sub-group Transport Connections includes options to use different transport modes and services to reach activities, indicating how well different mobility and logistics needs can be fulfilled. From seven indicators the connections to work places, schools and children's day car as well as to basic public and private services were found the most important with the mean scores around 0,20. Transport connections to leisure and other outdoor actitivities and possibility to build intermodal travel chain got very low importance around 0,5.

The third sub-group Opportunities for choosing mode of travel (transport) reflects the freedom of travel choice considering different modes. The interviews is resulting in the highest mean score (importance) for connections of bicycle and pedestrian transport. The criteria describing connections at different times and freight transport were created after the AHP analysis. These new criteria were combined from three more detailed ones. The reason to this was that the detailed criteria were insignificant, but it was agreed that these issues had to be included in the criteria on a more general level.

The fourth sub-group Functionality, fluency and convenience of connections indicates how predictable and accurate in general travelling is, and how predictable are travel times as well as the rate of success of each individual trip or transport task that is the most important criteria (0,38) by interviews.

Table 1. The criteria for assessment of changes in accessibility, alternatives and options for mobility. The numbers in parentheses indicate the comparative priorities generated with AHP.

ACCESSIBILITY, ALTERNATIVES AND OPTIONS

External conditions for mobility	
Potential criteria	**Rejected criteria**
Regional and urban structure *(0,15)*	Land use efficiency *(0,04)*
Amount and quality of activities (services, housing, employment, leisure activities) *(0,14)*	Opportunities for industry and commerce location (e.g. site supply) *(0,05)*
Location of activities (services, housing, employment, leisure activities) *(0,16)*	Car dependency within communities *(0,04)*
Population size and structure (0,08)	
Community structure that supports public, pedestrian and bicycle transport *(0,27)*	

Transport connections	
Potential criteria	**Rejected criteria**
Connections to basic public and private services (shopping facilities, health services, post offices etc.) *(0,17)*	Business connections *(0,04)*
Connections to other shops and personal business *(0,11)*	
Connections to workplaces, schools, children's day care etc. *(0,20)*	
Connections to leisure, recreation and outdoor activities *(0,05)*	
Possibilities to combine modes of transport *(0,04)*	
Connections at different times of day, week and year *(a new criterion, derived from three more detailed ones after the AHP analysis)*	
Freight transport connections *(a new criterion, derived from three more detailed ones after the AHP analysis)*	

Opportunities for choosing mode of travel or transport	
Potential criteria	**Rejected criteria**
Connections of bicycle and pedestrian transport *(0,31)*	Air transport connections *(0,04)*
Motor traffic connections *(0,07)*	Waterway connections *(0,06)*
Freight transport connections (ground, water, air) *(0,11)*	
Connections and supply of local public transport *(a new criterion, derived from more detailed ones after the AHP analysis)*	
Connections of long-distance transport (bus, rail, flight, water) *(a new criterion, derived from more detailed ones after the AHP analysis)*	

Functionality, fluency and convenience of connections	
Potential criteria	**Rejected criteria**
Predicability and accuracy *(0,11)*	Fluency of connections *(0,05)*
Predictability of travel times *(0,15)*	Condition of connections *(0,04)*
Functionality and fluency of trip and transport chains *(0,16)*	Predictability of traffic circumstances *(0,07)*
Certainty of successful trip or transport *(0,38)*	

In the second sub-group the unrestrictedness or usability of the transport system is measured by four aspects; physical opportunity or easiness to travel, the costs of transport, information and subjective health or subjective feeling of capability to travel.

For this sub-criterion it is difficult to find any powerful indicator over all the others. It is possible that there are too many indicators reflecting the same aspects of freedom to use transport system.

Table 2. The criteria for assessment of changes in unrestrictedness and usability of transport system. The numbers in parentheses indicate the comparative priorities generated with AHP.

UNHINDERED TRANSPORT SYSTEM, USABILITY OF TRANSPORT SYSTEM

Physical	
Potential criteria	**Rejected criteria**
Unhindered means of transport *(0,04)*	Unhindered construction *(0,05)*
Unhindered transport infrastructure *(0,04)*	Quality of construction *(0,04)*
Obstacles caused by transport infrastructure *(0,04)*	

Economic	
Potential criteria	**Rejected criteria**
Travel costs (price of the trip, parking costs, etc.) *(0,05)*	-
Transport costs *(0,06)*	-
Purchase and operation costs of means of transport *(0,05)*	-

Informative	
Potential criteria	**Rejected criteria**
Availability and quality of information and guidance *(New criterion, combined from three more detailed ones after the AHP analysis)*	Availability *(0,02)*
	Intelligibility *(0,02)*
	Real time information and guidance *(0,03)*
	Reliability *(0,04)*

Psychic	
Potential criteria	**Rejected criteria**
Perceived health *(0,13)*	Experienced safety *(0,14)*
	Experienced security *(0,11)*

Table 3. The criteria for assessment of changes in health, safety and attractive living environment. The numbers in parentheses indicate the comparative priorities generated with AHP.

HEALTH, SAFETY AND ATTRACTIVE LIVING ENVIRONMENT

Harmful to health	
Potential criteria	**Rejected criteria**
Traffic noise *(0,09)*	Risk of contamination of soil *(0,02)*
Traffic emissions *(0,04)*	Quality and cleanliness of food products *(0,03)*
Case specific criteria (e.g. vibration, smell, other unhealthy)	
Risk of contamination of surface and ground water *(0,05)*	

Health supporting	
Potential criteria	**Rejected criteria**
Possibilities for walking and cycling (everyday exercise and movement, recreation) *(0,07)*	-
Perceived health impacts *(0,05)*	-

Safety	
Potential criteria	**Rejected criteria**
Risk of accident or injury *(0,04)*	-
Experienced safety *(traffic safety and general feeling of safety) (*0,10)	-

Attractive living environment	
Potential criteria	**Rejected criteria**
Land use characteristics (density, fragmentation) (0,08)	Aesthetic quality of residential environment (0,03)
Satisfaction of residential environment (0,09)	Landscape, urban landscape (0,03)
Vitality of villages and population centres (0,08)	
Regional identity (0,04)	

Involvement in planning and opportunity to participate in decision-making of transport system are significant sub-criteria of sustainability. Two potential criteria were selected; opportunity to participate in planning and opportunity to participate in decision-making, which were seen equally important. Basically, three indicators were included into the interviews but one, opportunities for involvement and decision-making for ‘quiet’ or ‘weak’ groups was subtracted.

Table 4. The criteria for assessment of changes in opportunities for involvement and decision-making. The numbers in parentheses indicate the comparative priorities generated with AHP.

OPPORTUNITIES FOR INVOLVEMENT AND DECISION-MAKING	
Potential criteria	**Rejected criteria**
Opportunities for participation in transport system planning (0,25)	Planning of transport system or residential environment
Opportunities for participation in transport system decision-making (0,26)	Involvement in decision-making
	Opportunities for involvement and decision-making for 'quiet' or 'weak' groups (0,22)

The fifth sub-group Quality of life and lifestyles consists of five criteria reflecting the aspects of individual satisfaction of living conditions. As an individual criterion, the individual satisfaction of living conditions was expresses as the most important indicator by interviewees (0,36). Other significant criteria were changes in attitudes and values, and social interaction between community members and within networks.

Table 5. The criteria for assessment of changes in the quality of life and lifestyles. The numbers in parentheses indicate the comparative priorities generated with AHP.

QUALITY OF LIFE, LIFESTYLES	
Potential criteria	**Rejected criteria**
Attitudes, values *(0,18)*	Interaction *(0,07)*
Relations between community members *(0,07)*	Healthy way of living *(0,03)*
Satisfaction of living conditions *(0,36)*	Traffic behaviour *(0,03)*
Every day ways of living and mobility *(0,05)*	
Social interaction and networks *(0,14)*	

The sub-group of Nature and Built Environment includes criteria generally used in practice for evaluating the impacts of transport projects and policies. The indicators for some criteria may be difficult to quantify or even describe for minor scale projects, e.g. greenhouse effect. Within this sub-group the use of a large number of indicators forced all mean scores low, and this makes it somewhat difficult to assess the relative significance of the criteria. The highest score was given for natural vigour .

Table 6. The criteria for assessment of changes in nature and built environment. The numbers in parentheses indicate the comparative priorities generated with AHP.

NATURE AND BUILT ENVIRONMENT	
Air and climate	
Potential criteria	**Rejected criteria**
Greenhouse effect *(0,07)*	Ozone depletion *(0,04)*
	Acidification *(0,04)*

Ground and surface water	
Potential criteria	**Rejected criteria**
Risk of contamination of groundwater/quality of groundwater *(0,10)*	Risk of contamination of surface water/quality of surface water *(0,04)*

Plants and living organisms	
Potential criteria	**Rejected criteria**
Quantity and quality of wild regions *(0,06)*	Territories and living conditions of plants *(0,05)*
	Territories and living conditions of animals/ecological corridors *(0,04)*
	Interaction between animals and plants *(0,04)*

Natural diversity, biodiversity	
Potential criteria	**Rejected criteria**
Quantity of animal and plant species *(0,06)*	-
Position of endangered species *(0,03)*	-
Natural vigour *(0,14)*	-

Natural resources	
Potential criteria	**Rejected criteria**
Exploitation of natural resources (especially non-renewable natural resources) *(0,05)*	Energy consumption of traffic *(0,02)*

Community structure	
Potential criteria	**Rejected criteria**
-	Fragmentation, density *(0,03)*
-	Buildings, landscape, urban landscape, cultural heritage *(Rejected unanimously by the steering group before AHP analysis)*

The sub-group Economic conditions reflects more the general premises of welfare than any direct monetary consequences of the transport projects. However, these criteria can be used when assessing how economically realistic and feasible transport system is. In this evaluation, the indirect impacts of changes in transport system on the indicators measuring the economic well-being of citizens, enterprises and public organisations need to be taken into account. The interviewees kept all criteria related to individuals (household sector) more important than those to business and public sector. Within indicators reflecting the individual economic welfare, income and wealth as well as have a higher score than other indicators. After the AHP analysis, new and more representative criteria were generated to describe the economic conditions of the public sector.

Table 7. The criteria for assessment of changes in economic conditions. The numbers in parentheses indicate the comparative priorities generated with AHP.

ECONOMIC CONDITIONS

Households	
Potential criteria	**Rejected criteria**
Land price *(0,07)*	-
Value of real estates *(0,09)*	-
Renting expences *(0,11)*	-
Building costs *(0,07)*	-
Level and structure of wealth/property *(0,18)*	-
Income level and structure *(0,19)*	-

Business sector	
Potential criteria	**Rejected criteria**
Profitability *(0,07)*	Market area *(0,02)*
Competition *(0,04)*	Logistics costs *(0,02)*

Public sector **(***Most of these criteria were generated only after the AHP analysis, as the interview and AHP process showed that there is need to include public sector economic criteria in the list, but the initially suggested ones turned out as insignificant)*	
Potential criteria	**Rejected criteria**
Public transport expenditures *(New)*	Other investment needs *(New)*
Capital value of transport system *(New)*	General economic growth (output, tax incomes) *(New)*
Operational preconditions for new business *(New)*	Labour supply *(New)*
Locational advantages of region, community or city (concering housing, industries, trade, tourism) *(New)*	Tax revenues *(New)*
	Productivity in other sectors in economy *(New)*
	Land price *(0,02)*
	Value of real estates *(0,02)*
	Renting expences *(0,01)*
	Building costs *(0,02)*

4) Discussion and conclusions

The current list of criteria forms a good starting point for the assessment tool that will be created within the project by the end of 2006. However, the validity and usefulness of these criteria need yet to be verified before compilation of an extensive list of evaluation criteria. Also, feasible indicators for the above-mentioned criteria need to be specified.

Our approach was successful in revealing the opinions of the interviewed experts and decision-makers about the relative importance of the large number of welfare criteria which may be relevant in the evaluation of the impacts of the changes in the transport system. The active involvement of the project steering group was significant at every stage of the process. This involvement both provided ideas and extensive expertise on the contents of the list of criteria, and ensured user-oriented approach as well as consideration of the end-users needs in creation of the assessment tool.

AHP proved to be useful method for the selection of the potential criteria. However, the method was used only as consultative tool to collect and process the opinions of the interviewees. A major point of success was that the opinions of the decision-makers and

experts were collected through a co-operative and conversational multi-step process that included meetings, workgroup discussions and personal interviews.

The list of evaluation criteria contains yet some overlapping criteria. In addition, some of the criteria are difficult to be evaluated or even verbally described. The current list of criteria is too long and quite complicated. The next step will be to test and clarify the list, and try to find the most relevant criteria for each main component of welfare. Our intention is that the list could be used also in assessing welfare impacts of plans where the resources for evaluation are limited. Therefore, our challenge is to modify the list in a way to include the very relevant criteria, and to define indicators that can be measured with reasonable resources.

After the testing phase of the criteria, MCDA (Multi-Criteria Decision Aid) tool for assessment of welfare impacts will be created. This tool is to be created with MCDA method MACBETH. The essential idea is to recognize the link between the values that have an effect on the planning objectives, and to build a transparent procedure that involves both decision-makers and interest groups in the evaluation process. The fundamental ideas in creating the tool are Value-Focused thinking (Keeney 1992) and decision-making with multiple objectives (Keeney and Raiffa 1993). Both qualitative and quantitative data can be used with the assessment tool. The planning environment presents several requirements on the assessment tool. For example, there are several decision-makers and interest groups involved, often with conflicting views, and the data available varies in its quality and usability. Therefore, the criteria need to be thoroughly tested and modified before entering into the phase of creating the assessment tool. One major concern is how to include possibly overlapping information, and to choose the most practical and informative level of aggregation. When the future MCDA assessment tool has been tested with real-life data, it is possible that the criteria that have been introduced in this paper, need to be once more revised and amended, at the very end of our study.

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