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The Use of Multi-Criteria Assessment Techniques in Defining Sustainable Transport Systems for Different Sized Cities Ankara and Rize Example

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Abstract: Transportation is an important component in the sustainability. Making the right decision on transportation investments plays an important role in saving the resources. Transportation master plans that focus on transportation investments require a decision-making process on resources. In this study, the analytical hierarchy process, which is a multi-criteria evaluation technique, is used. It is being investigated which component of sustainability is effective in transportation systems of different sized cities.

Keywords: sustainable transport; decision making; transport planning

Introduction

The city is defined as "a settlement unit in continuous social development that meets the basic needs of the society and is composed of small neighbourhood units, which are more concentrated in terms of population with fewer people nowadays engaged in agricultural works"(Aydoğdu, 2013).

Demographically in Turkey 100.000-750.000 populated cities are medium sized. The cities with a population above this value are defined as big sized (Üzmez, 2012).

Large-scale cities;

- Grows uncontrollably and quickly.
- The continuity of mobility can't be ensured.

BEYOND ALL LIMITS 2018: International Congress on Sustainability in Architecture,
Planning, and Design, 17-19 October 2018, Ankara, Turkey

- The time and money spent on transportation is excessive.
- 40-50% of the journeys are home-business trips (Burgess and Jenks, 2002).

Ankara is an example of large-scale cities in terms of its attributes. The rate of home-business trips in the city is 50-60%.

It seems that the built-up periphery of Ankara has reached a radius of 50 km. (UTTAC, 2014)

Medium – Sized Cities

- Urban economic functions are presented in a mixed way.
- Has a sustainable urban future potential with its intact structures.
- Home-business day trips are moderate (Tosun, 2013).

Rize city, which is examined in the scope of the study, can be given as examples of medium sized cities in terms of its attributes. The rate of home-business trips in Rize is 28%. There is a negative effect on the development of the transportation network of the topography which is in a rugged structure throughout the city. Urbanization speed is slow due to inadequate transportation network structure (UTTAC, 2016).

Sustainable transport systems are shaped by the choice between multiple scenarios in the process of planning. At the beginning of the conditions necessary for a healthy selection of the type of transportation, it is necessary to make a comparison between the scenarios. There are different problems in different sized cities. As a solution to the problems, more than one suitable alternative should be produced according to the attributes of cities and these alternatives should be evaluated with social, economic and environmental criterias. (Orman vd., 2018).

Multi Criteria Decision Method

Multi-criteria evaluation is the method of selecting the best one from multiple alternatives produced for problems. The choice of scenario is important in terms of sustainability of future transport systems, in keeping with economic, social and environmental criteria.

One of the methods used among multi-criteria evaluation methods is the analytical hierarchy method (AHP). AHP is a frequently used method that results in a multidimensional structure. In transportation plans, expert opinions are taken and important criteria are determined for the city. Alternative scenarios according to the calculated criteria weights are evaluated with AHP and the most appropriate scenario is determined (Orman vd.. 2018).

Findings and Discussion on Ankara Transport Master Plan and Rize Transport Master Plan

Ankara Transportation Master Plan and Rize Transportation Master Plan were made by Urban Transportation Technology Accessibility Implementation and Research Center (UTTAC). It is evaluated by multi-criteria evaluation method from the scenarios developed within the scope of the plans. (See Table 1)

Table 1. Criteria Used In Transportation Master Plan

Main Criteria	Sub Criteria	Definition
Economic	Journey Cost	The cost of a journey created by a passenger
	Investment Cost	The cost of investment for transportation types
	Journey Time	Km per average Journey time of a passenger
	Air Pollution	Emission value created by transportation types
Environmental	Noise Pollution	Decibel value created by transportation types
	Energy Consumption	Type of transport energy consumption (Kcal/passenger)

Each city has its own different dynamics. Ankara and Rize are cities of different sizes and different attributes in terms of which is stated in the study. Different results are observed for the transportation plan for Ankara and Rize, where the same method is used for the two transportation master plans. If these results are to be examined;

5 main objectives have been set for the Ankara transportation master plan;

- Reduction of motor vehicle traffic in the future
- Improving the public transport infrastructure

- Increasing mobility and accessibility inner city
- Ensure sustainable transport system with efficient use of transport system
- Creating a more livable urban environment.

It is seen that 4 alternative scenarios are produced in line with the targets set for Ankara city. (See Table 2) The weights of the criteria determined for evaluating such scenarios as a result of expert opinions are as in the decision equation (See equation 1). The economic criterion value is 54% while the environmental criterion value is 46%. Briefly, the economic measures for Ankara city more important than environmental measures.

As a result of these calculations, a decision equation is formed;

$$F_k = (0,15 * \text{Journey Cost} + 0,13 * \text{Investment Cost} + 0,25 * \text{Journey Time}) + (0,09 * \text{Air Pollution} + 0,07 * \text{Noise Pollution} + 0,30 * \text{Energy Consumption}) \quad (1)$$

In the equation, the cost of the multi-criteria evaluation of the scenario is calculated using the standardized costs in each scenario. According to this:

Table 2. Total Weight Factor Ratio For The Scenarios

Scenarios	Current	Highway	Rail Road	Mixed
Economic Cost (%)	%40	%38	%36	%37
Environmental Cost (%)	%44	%45	%37	%30
Total Cost (%)	%84	%83	%73	%67
% Percentage Display	%84	%83	%73	%67

It is observed that the mixed development scenario is less costly and preferable than the other scenarios when evaluated by the analytical hierarchy method (UTTAC, 2014).

In Rize, another city of this study, there are four main objectives of the transportation master plan;

- Reducing the effects of the vehicle traffic foreseen by the increase,

- Improvement of public transport infrastructure and transfer of travel requests from individual transport to public transport
- Formation of mobility by keeping accessibility in urban transport
- Making environment and energy efficient use and transportation systems sustainable,
- It is seen that 4 alternative scenarios are produced for the targets determined for Rize city. (See Table 3)

In Rize, the weight of the economic criteria is 46% while the weight of the environmental criteria is 54%.

In summary, environmental measures for Rize city seem to be more dominant than economic measures.

As a result of these calculations, a decision equation is formed;

$$F_k = (0,55 * \text{Journey Cost} + 0,26 * \text{Investment Cost} + 0,17 * \text{Journey Time}) + (0,25 * \text{Air Pollution} + 0,50 * \text{Noise Pollution} + 0,25 * \text{Energy Consumption}) \quad (2)$$

When the equation is written in place of the standardized costs in each scenario:

Table 3. Total Weight Factor Ratio For The Scenarios

Scenarios	Monorail	Tram	Rapid Bus Line	Current
Economic Cost (%)	%31	%32	%20	%36
Environmental Cost (%)	%52	%50	%51	%50
Total Cost (%)	%84	%83	%71	%86
% Percentage Display	%84	%83	%71	%86

It is observed that the rapid bus line scenario is less costly and preferable than the other scenarios when evaluated by the analytical hierarchy method (UTTAC, 2016).

Conclusion

Techniques are used to make choices with decision-making mechanisms that determine more than one criteria in order to solve problems in urban transportation planning. For Ankara,

a big size city, it seems that a mixed scenario targeting an economically sustainable transportation system has been selected to reduce motor vehicle use, to direct traffic demand from private automobiles, increase accessibility within the city, and create a more livable urban environment. For medium sized Rize city, it is seen that the rapid bus line scenario is selected as a system that reduces the environmental effects of the motor vehicle system, promotes mass transportation, does not harm the environment that aims for a more environmentally sustainable transportation system with the efficient use of the economy, and contributes to economic development.

The study uses the analytical hierarchy process method. Within this method, expert opinion is asked and method is applied. As a result of the applications made in Ankara which is a large scale from the 2 cities examined, it is seen that the travel time is the most weighted by the economic criteria. This may be attributed to the high population of Ankara and therefore the demand for travel. The high cost of travel may be attributed to frequent travel by passengers. In Ankara, air pollution is the most important environmental criterion. This weight may be attributed to the number of Ankara's intensive private vehicles and the emission of greenhouse gases generated by these vehicles.

In the medium-sized city of Rize, environmental criteria are more weighted. The city of Rize is plenty with vegetation. As a result of this situation, air pollution may be considered as having a low weight by the experts. Long journeys between neighborhoods in the city may cause the journey time to have a heavier value on economic criterias. The public transportation service in Rize is done at high prices due to its long distance. This may have an impact when the travel cost variable is having an average weighted parameter.

Acknowledgments

The authors would like to extend their thanks the editors, referees and experts for their valuable contributions to the present study. This study was supported by the data of the Project on the Transportation Master Plan of the Ankara Metropolitan Area and Its Surroundings and Transportation Master Plan of Rize

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