A Combination of PROMETHEE and Goal Programming Methods for the Evaluation of Water Airport Connections

Charalampos Nikolaos Roukounis, School of Rural and Surveying Engineering, National Technical University of Athens, Athens, Greece
Georgios Aretoulis, Department of Civil Engineering, Aristotle University of Thessaloniki, University Campus, Thessaloniki, Greece
Theofanis Karambas, Department of Civil Engineering, Aristotle University of Thessaloniki, University Campus, Thessaloniki, Greece

ABSTRACT

Greece is a country with a unique morphology. Having an extensive coastline and thousands of islands, the rise of the touristic industry is significant. The recent economic crisis as well as the increased infrastructure construction costs on the islands, created the urge to develop alternative and innovative transport systems. The seaplane, a modern, eco-friendly mode, allows effortless and quick connection between ports and airports from all over the country and distant coastal areas and islands. Seaplanes can be used by both residents and visitors or/and carry shipments. The research presented herein focuses on the development of a methodological framework for the evaluation of different areas for water aerodrome allocation, initially among different islands. Multicriteria decision analysis (MCDA) was selected among the large spectrum of existing evaluation methods, because it was considered to be the most suitable approach as it gives the opportunity to use diverse criteria, both quantitative and qualitative. Significant criteria include the distance between the origin waterdrome location and protected natural areas, wave and wind data of each area, the operational cost of seaplanes and the number of passenger arrivals and departures. Weights are accorded to the criteria based on experts’ opinion and applying goal programming approach. The evaluation of the alternatives takes place with the aid of the PROMETHEE method. The suggested approach is then implemented through a case study; the investigation of the potential connection of Thessaloniki, the second-largest city in Greece and a transportation hub for the southeastern Europe and the Balkans, with the Cyclades islands, in South Aegean Region.

KEYWORDS
Goal Programming, Multicriteria Decision Analysis (MCDA), Seaplanes, Transport Planning

INTRODUCTION

Greece is a country with many insular districts, the socio-economic characteristics of which distinguish them from the mainland. Islands face development problems, especially concerning accessibility issues, and the distance between them and the mainland (Spilanis et al., 2010). Improved transportation is heavily associated with economic growth, making less developed regions favorable for investments...
and able to take advantage of their strengths (Katarelos et al., 2011, Rodrigue & Notteboom, 2017). The assessment of modern transportation projects (in terms of policies and constructions) require methodological approaches that are able to take into consideration conflicting objectives and harmonically combine both quantitative and qualitative criteria (Macharis et al., 2011). Due to that fact, Multicriteria Decision Analysis (MCDA) methods have achieved wide acceptance (Thomopoulos et al., 2009), comprising an extensive number of different methods and techniques.

The establishment of a seaplane network can be the key to improve the current transportation system in Greek Islands. Seaplanes have multiple advantages including limited infrastructure requirements, shorter travel times, lower operation and investment cost (Iliopoulou et al., 2015), as well as the ability to connect distant islands that lack connection with major Greek cities such as Athens and Thessaloniki. The implementation of a seaplanes network would assist financially the low-populated islands. In this context, the aim of this paper is to develop an innovative tool addressed to decision makers and stakeholders (e.g. port authorities and other public agencies) in order to design an effective water airport network between major cities in the mainland and islands. The potential connection of Thessaloniki, the largest city of northern Greece, with nine (9) major islands in Cyclades is used as a case study. Different areas of waterdrome connections are evaluated and ranked using the PROMETHEE MCDAs method. The paper is structured as follows: the literature review is presented in Section 2, followed by theoretical underpinning on the subject. Survey design is presented in Section 4 and the main findings of the analysis are displayed and discussed in Section 5. The paper concludes in Section 6, with a critical overall analysis of the results and directions for future research.

**LITERATURE REVIEW**

The relevant literature on the evaluation of alternative destinations for a seaplane network is very limited, apart from some fragmentary efforts mainly concerning the optimal design of a transport network (e.g. Iliopoulou et al., 2015, Pagonakis, 2016), without taking into account other socio-economic factors. This paper aims to fill this gap in the literature, by using multi-criteria decision making techniques.

Helping people make informed and, hopefully, better decision is the prime concern of decision making (Keeney, 1992). With multi-criteria decision analysis (MCDA), it is possible to overcome many of the weaknesses of traditional evaluation methods as it allows factors that cannot easily be quantified or expressed in monetary terms, but nevertheless play a decisive role in shaping the policy, such as the environmental, spatial and social impacts of a project, social justice, etc., to be taken into consideration (Roukouni, 2016). Moreover, MCDA evaluates the alternatives by combining both quantitative and qualitative criteria (Vincke, 1992). A significant number of methods have been developed, including Multi Attribute Utility Theory (MAUT) (von Neumann & Morgenstern, 1947), Elimination and Choice Expressing REality (ELECTRE) (Roy, 1968), Analytical Hierarchical Process (AHP) (Saaty, 1977), Preference Ranking Organisation METHod for the Enrichment of Evaluations (PROMETHEE), (Brans et al., 1986), Verbal Decision Analysis (Larichev and Moshkovich, 1997). The evaluation of new transportation projects presupposes the use of methods that can take into account conflicting objectives and combine tangible and intangible criteria (Macharis et al., 2011). The use of MCDA in the research area of transport has steadily risen markedly in recent years (Macharis & Bernardini, 2015).

Many different methods have been developed, based on the outranking concept, and many are applications in transportation projects’ evaluation, particularly in Europe. They are also used in decision making with distinct alternatives (Roy & Vanderpooten, 1996). This set of methods makes comparisons between each pair of alternative scenarios. Their basic principle is that between two choices, A and B, option A outranks B if there is enough evidence, according to the views of the decision makers, that A is at least as good as B, and there is no evidence to
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