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# A SUSTAINABILITY PERFORMANCE-BASED ASSESSMENT TOOL FOR ECODESIGN OF ROADS AND RAILWAYS

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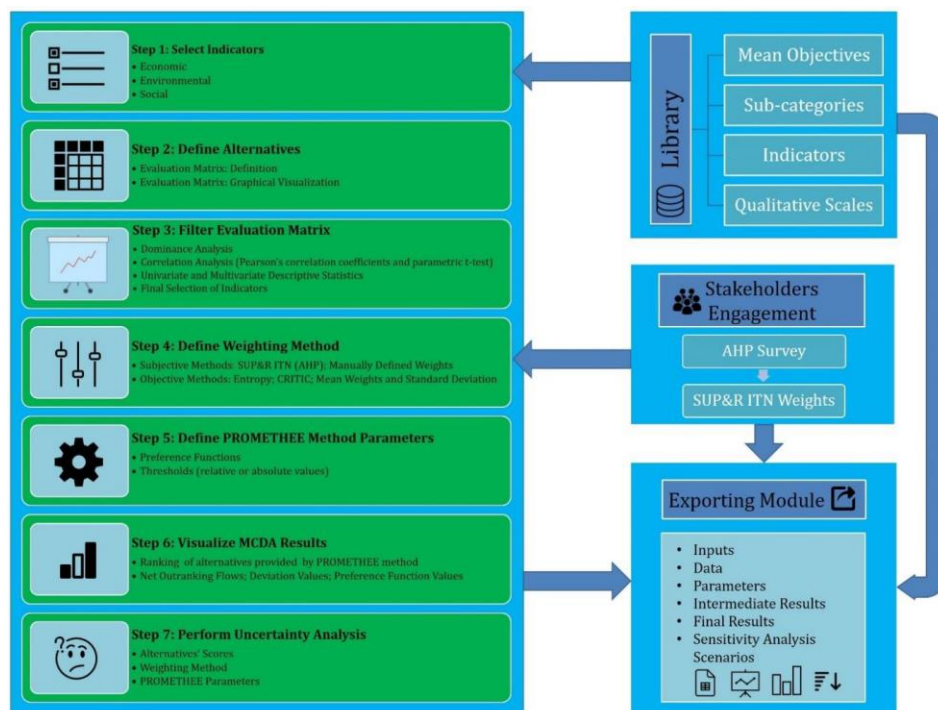
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**INTRODUCTION:** Addressing the sustainability of transport infrastructures requires exploring the environmental, social, and economic impacts of technological options while balancing the often conflicting priorities of different stakeholders, at an early design phase of the infrastructure delivery process. That is a typical multi-criteria decision-making (MCDM) problem, in which the decision-makers need to measure the sustainability through a set of meaningful, representative and quantifiable criteria, balance the relative importance of those criteria and determine the sustainability sequence of multiple alternative technologies for fostering transportation sustainability.

In order to help the decisions makers to efficiently address this challenging task, a decision support toll (DST) was developed in the scope of the FP7 Marie Curie training-through-research programme Sustainable Pavements & Railways Initial Training Network ([www.superitn.eu](http://www.superitn.eu)). It consists of a computational platform that implements a conceptual framework developed to quantify sustainability. It comes with a set of sustainability indicators tailored to both road and railway systems as well as several objective and subjective weighting methods. Amongst those belonging to the last category, the DST includes a set of default weights derived from an Analytical Hierarchy Process (AHP)-based survey that engaged stakeholders from different sectors and from several European countries. At last, the Preference Ranking Organization Methodology of Enrichment Evaluation II (PROMETHEE-II) MCDM method is employed for prioritizing alternative road pavement and railway tracks solutions at the design stage.



**OVERVIEW OF THE TOOL:** SUPR&R ITN DST is based on the multi-criteria decision making (MCDM) approach. PROMETHEE II – Preference Ranking Organization Methodology of Enrichment Evaluation [3]. This was implemented, enabling a quicker ranking and thereby identification of the most sustainable pavement and railways track construction and management solution. It was developed using C#, on Visual Studio 2015. The database engine used is the SQL Server 2014 Management Studio, where all the user's and default data are stored. The SUPR&R ITN DST framework is displayed in Figure 1.

- The first step consists of selecting the set of indicators that will rationally prioritize alternatives. The DST comes with a set of default indicators defined according to a methodology developed under the framework of the SUPR ITN

project [4], with the final aim of maximizing their significance to the three Wellbeing dimensions. Nonetheless, the user is enabled to add and consider other indicators.

- In the second step the evaluation matrix is formulated. It corresponds to assess the performance of each alternative with regard to each indicator. This information is inserted by the user and might be both qualitative and quantitative, depending on the type of indicator.
- In the third step the matrix undergoes a filtering process. First, a dominance analysis is performed, meaning that the various alternatives are compared for each indicator individually. It allows to identify if a given alternative is better than the others for all the considered indicators. If so, that alternative might be excluded from the analysis depending on the user's intention. Next, a correlation analysis is undertaken by calculating the Pearson's correlation coefficients to determine if there is a correlation between the selected indicators. The DST displays in matrixes the Pearson's correlation coefficients values as well as the results of their statistical significance. This procedure is done by calculating the t-statistic value of each correlation coefficient at the level of significance of  $\alpha=0.05$  and the respective p-value. Additionally, multivariate descriptive statistics (i.e., covariance matrix) and univariate descriptive statistics (i.e., mean, standard deviation, variance, maximum value, minimum value and range value) are also made available to the user in matrixes.
- In the step 4 the user has to decide about the relative importance (weights) of the different indicators. For that purpose, two different weighting approaches were considered, namely objective and subjective approaches, and for each one several methods were made available. The set of objective methods comprise the Entropy, the Criteria Importance through Inter-Criteria Correlation (CRITIC), the Mean Weights and the Standard Deviation methods, whereas the set of subjective methods include the AHP-based SUP&R ITN weights and the Manually Definition method. The AHP weights were obtained from a survey conducted within the scope of the SUP&R ITN research project. It engaged stakeholders of different sectors and from several European countries.
- In the step 5 the user is asked to define the PROMETHEE-II parameters, what means selecting preference functions (PF) and respective parameters (preference, indifference and eventually Gaussian thresholds). PROMETHEE-II methodology uses PF, which is a function of the difference between two alternatives for any indicator. Six types of PF based on the notions of indicators can be selected. Regarding the definition of the parameters, two alternative approaches were made available: an absolute value-based and a relative value-based approach. The relative value-based approach was considered with the objective of helping the users who do not have sufficient knowledge about the decision-making methodology. According to this approach, the parameters values are calculated as a user defined percentage of the difference between the highest and lowest evaluation for each indicator.
- In the step 6 the multi-criteria decision analysis results are displayed. They consist of the ranking of alternatives as well as several other PROMETHEE intermediate and final outputs (e.g., preference indexes, incoming, outgoing, and net flows).
- In the step 7 the user is given the possibility of conducting an uncertainty analysis to investigate the influence of modified input data and methodological choices on the calculated results and stability of the solution found as the most sustainable. The set of input data and methodologies allowed to be changed comprise the evaluation matrix, the weighting method and the PROMETHEE PF and parameters.

**CONCLUSIONS:** The SUP&R ITN DST is a freely available tool and can be used at professional level, by professionals interested in advancing sustainability in transportation, as well as for educational purposes, to provide knowledge and educate on the use sustainability concepts and on what are the important issues to consider during the sustainable transportation decision-making process. The methodology is flexible enough to be adapted to any system

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## REFERENCES

- [1] Bryce J., Brodie S., Parry, T. and Lo Presti D., 'Systematic assessment of road pavement sustainability through a review of rating tools', *Resources Conservation and Recycling*. **120** (2017), 108-118.
- [2] Bueno, P., Vassalo, J. and Cheung, K., 'Sustainability assessment of transport infrastructure projects: a review of existing tools and methods', *Transport Reviews*. **35**(5) (2015), 622-649.
- [3] Brans, J. and Mareschal, B., 'PROMETHEE methods', in 'Multiple criteria analysis – State of the art surveys', International series in operations research and management sciences, edited by J. Figueira, S. Greco, M. Ehrgott, (Springer, New York, 2005), vol. 78, 163-95.
- [4] Bressi, S., Santos, J., Cerezo, V., Di Mino, G., and Lo Presti, D., 'Indicators selection for the sustainability assessment of road pavements and rail infrastructures', *Resources, Conservation & Recycling*. (2017) (submitted for publication).