Risk-based Corridor Asset Management: Applying Multi-Attribute Utility Theory to Manage Multiple Assets

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Abstract

Simultaneous consideration of various types of assets and investment objectives for the purpose of allocating resources more efficiently can improve the system-wide performance of the transportation system. Currently, various studies have been conducted on the development of management systems such as pavements, signs, mobility, safety, or preservation. However, studies that specifically investigate the synergistic effects of these systems on transportation system performance are not as many. This paper develops a multi-attribute utility model that identifies high-risk corridors within a transportation system for prioritization, based on multiple objectives and various assets. Three objectives are used in evaluating the performance of the system: minimizing the number of incidents, maximizing mobility, and improving preservation of assets. The methodology is generally applicable to system-level management of transportation systems. The model is applied to a selected corridor in the state of Georgia. The results illustrate that the developed model can aid transportation agencies in identifying high-risk corridors that degrade the performance of their transportation system. This model can be used in identifying high-risk corridors during program development.

Gap Analysis

. Decision making has focused on silo-form asset management
. Lack of efforts in integrated decision making
. Lack of use of risk management in program decision making
. Lack of corridor-level analytical tools to aid decision making

Study Objectives

• To review risk principles in asset management
. To review asset management and multi-objective optimization concepts
• To develop a multi-objective decision-support tool for corridor analysis
• To demonstrate an application of the model

Concepts of Risk

Definition: Risk can be defined in many different ways depending on data availability, the analyst experience, or industry.

Traditional:

Risk= Probability of failure X Consequence of failure

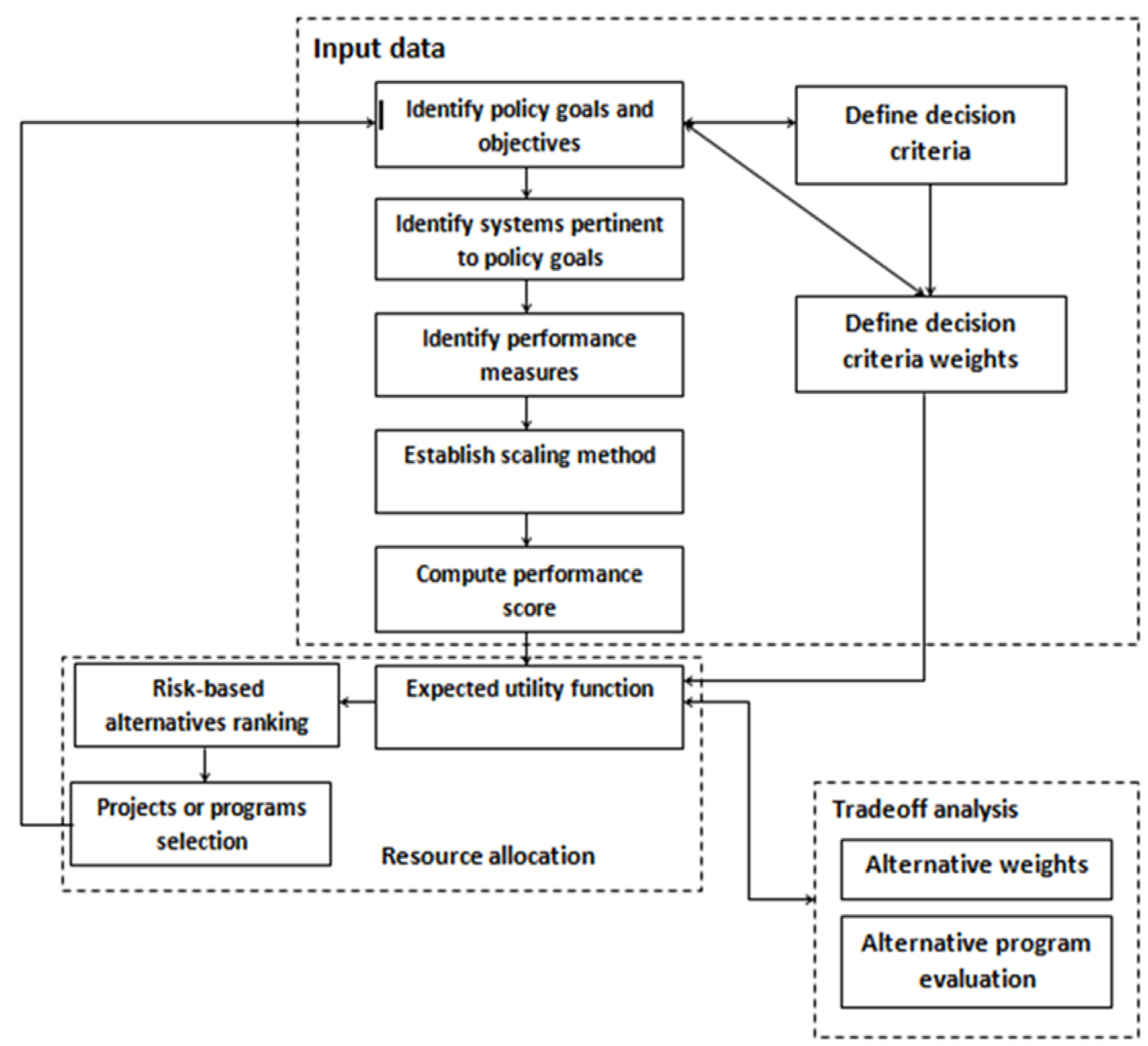
Theoretical:

Risk= the measure of uncertainty surrounding an outcome

Examples of MCDM Techniques

• Multi-Objective Linear Programming
• Preemptive Optimization
• Weighted Sum
. Multiplicative Utility Function Method
• Goal Programming

Proposed Framework



Model Formulation

Based on goal-programming solution seeking strategy

$$EUS_{A_i} = \min\left(\sum_{j=1}^{n} v_x w_j\, a_i\right) \quad i = 1,2,\ldots\ldots,m$$

Where w_j = weight of program area j

a_i = percentage deviation of goal from target for asset/program i

v_x = Traffic Volume factor for segment x = 1,2,3,…….k

EUS= Expected Utility Score of link i

n and m are the number of goal targets and alternatives, respectively.

Estimating Segment EUS

. Based on the availability of historic data
. Based on the principles of goal-programming method
. Analysis segments are defined using mile post, major intersections, or landmarks
. Characteristics of analysis segments are used as attributes to compute the EUS for a given segment
. Pavement rating is used to indicate preservation
. Average peak-speed is used to capture congestion
. Safety is captured by the number of incidents recorded over the segment
. The measure of EUS determines the risk potential of the segment
. The higher the EUS, the higher the uncertainty; therefore, high risk

Evaluation Example

Strategic goals/program areas under consideration:

. Making safety investment and improvements where the traveling public is most at risk—Safety
. Taking care of what we have in the most efficient way possible—Preservation
. Planning and constructing the best set of mobility-focused projects we can on schedule—Mobility

Segment (GA 3)	Milepost From	Milepost To	AADT	Expected Average Peak-Speed	Actual Average Peak-Speed	COPACES Rating	Number of Fatalities
S1	11.6	14.4	15000	45	35	63	0
S2	14.4	17.83	15000	50	35	56	0
S3	0.8	5.9	47000	55	35	100	1

Segment ID	Deficiency			Weight			Segment Expected Utility
	Safety	Mobility	Preservation	Safety	Mobility	Preservation	
S1	0	0.2222	1	0.4	0.3	0.3	0.17
S2	0	0.1000	1	0.4	0.3	0.3	0.18
S3	1	0.3636	0	0.4	0.3	0.3	0.38

Conclusion

. Risk can be defined in a variety of ways
. The definition or approach adopted depends on the availability of data and experience of the analysts
. MCDM is one methodology in assessing risk
. The use of this framework can yield optimal performance of the overall transportation system by making use of limited resources

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