Developing a Simplified Maintenance & Rehabilitation Activity Prioritization Tool for Afghanistan Roads

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Introduction

- Afghanistan lack proper road maintenance, which resulted investment loss past 10 years.
- Donor & government focused on development of roads without considering maintenance issues.
- Due to civil war, staff decreased and road lengths increased.
- The M&R authorities face lack of budget and need to do the important projects first.
- Road maintenance prioritization is on ah-hoc basis without technical evaluation.
- Technology based prioritization support tool is crucial need of the government.

Objective

- Study the current situation of road maintenance system in Afghanistan
- Evaluate the suitability of existing road maintenance system in the world.
- Develop a road maintenance activities prioritization tool, considering the existing resources in Afghanistan.

Road Maintenance Current Situation

- Categorized based on staff expertise and systems
- Russian colonial government, 90s Russian system impact
  - Routine maintenance
  - Periodical maintenance
  - Emergency maintenance
  - Seasonal maintenance
    - Spring
    - Summer
    - Fall
    - Winter
- World's famous software Micro Paver and HDM-4
- Main issue is financing, data requirements and complexity
- Afghanistan do calculations manually only use Ms. Excel (time consuming)
- New tool suitable to Afghanistan situation

TOPSIS Model

- The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is a multicriteria decision analysis method, developed by Hwang & Yoon (1981, 1987).
- TOPSIS concept is that the alternatives should have the shortest geometric distance from PIS and longest from NIS.
- In this method, it compare a set of alternatives by identifying weights for each criterion.
- The TOPSIS method evaluates the following decision matrix which contains *m* alternatives associated with *n* attributes (or criteria):

A_i = the *i*th alternative considered

C_j = the *j*th criterion considered

x_{ij} = the numerical outcome of the *i*th alternative with respect to the *j*th criterion

$$D = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_i \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{ccccccc} C_1 & C_2 & & C_j & & C_n \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1j} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2j} & \cdots & x_{2n} \\ \vdots & \vdots & & \vdots & & \vdots \\ x_{i1} & x_{i2} & \cdots & x_{ij} & \cdots & x_{in} \\ \vdots & \vdots & & \vdots & & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mj} & \cdots & x_{mn} \end{bmatrix} \end{array}$$

TOPSIS Solving Steps

1) Construct the normalized decision matrix

$$r_{ij} = \frac{X_{ij}}{\sum_{i=1}^{m} X_{ij}^2}$$

2) Construct the weighted norma1ized decision matrix

$$W = (w_1, w_2, \ldots, w_j, \ldots, w_n)$$

$$\sum_{j=1}^{n} W_j = 1$$

$$V = \begin{bmatrix} v_{11} & v_{12} \cdots v_{1j} \cdots v_{1n} \\ \vdots & \vdots \quad \vdots \quad \vdots \\ v_{i1} & v_{i2} \cdots v_{ij} \cdots v_{in} \\ \vdots & \vdots \quad \vdots \quad \vdots \\ v_{m1} & v_{m2} \cdots v_{mj} \cdots v_{mn} \end{bmatrix} = \begin{bmatrix} w_1 r_{11} & w_2 r_{12} \cdots w_j r_{1j} \cdots w_n r_{1n} \\ \vdots & \vdots \quad \vdots \quad \vdots \\ w_1 r_{i1} & w_2 r_{i2} \cdots w_j r_{ij} \cdots w_n r_{in} \\ \vdots & \vdots \quad \vdots \quad \vdots \\ w_1 r_{m1} & w_2 r_{m2} \cdots w_j r_{mj} \cdots w_n r_{mn} \end{bmatrix}$$

TOPSIS Solving Steps

3) Determine ideal and negative-ideal solutions

$$A^+ = (V_1^+, V_2^+, \dots, V_n^+) = \left\{\left(\max_i V_{ij}\right), i = 1, 2, \dots, m, \quad j = 1, 2, \dots, n\right\}$$

$$A^- = (V_1^-, V_2^-, \dots, V_n^-) = \left\{\left(\min_i V_{ij}\right), i = 1, 2, \dots, m, \quad j = 1, 2, \dots, n\right\}$$

4) Calculate the separation from ideal and negative-ideal solutions

$$S_i^+ = \sqrt{\sum_{j=1}^{n} \left(V_{ij} - V_j^+\right)^2}, \quad i = 1, 2, \dots, m$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} \left(V_{ij} - V_j^-\right)^2}, \quad i = 1, 2, \dots, m$$

TOPSIS Solving Steps

5) Calculate the relative closeness to the ideal solution

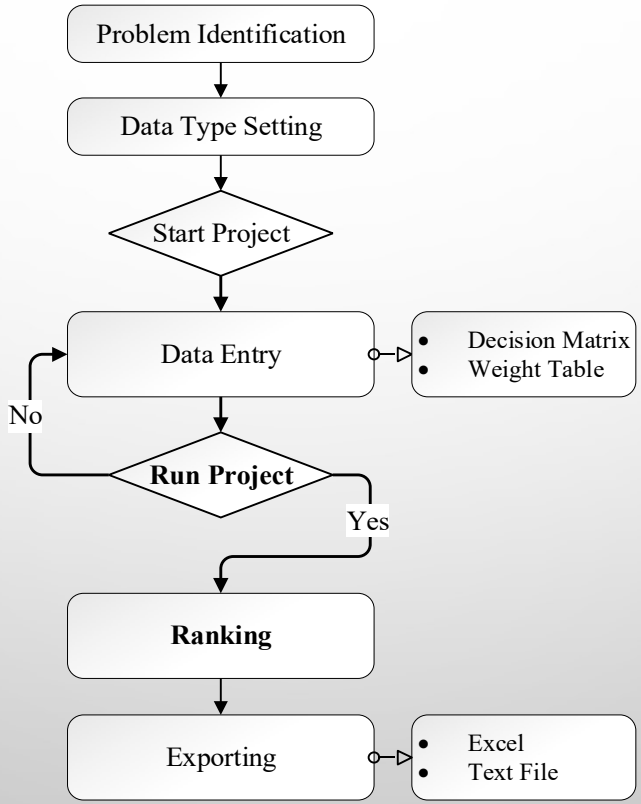
$$C_{i+} = \frac{s_i^-}{(s_i^+ + s_i^-)}$$

6) Rank the preference order

Tool Development

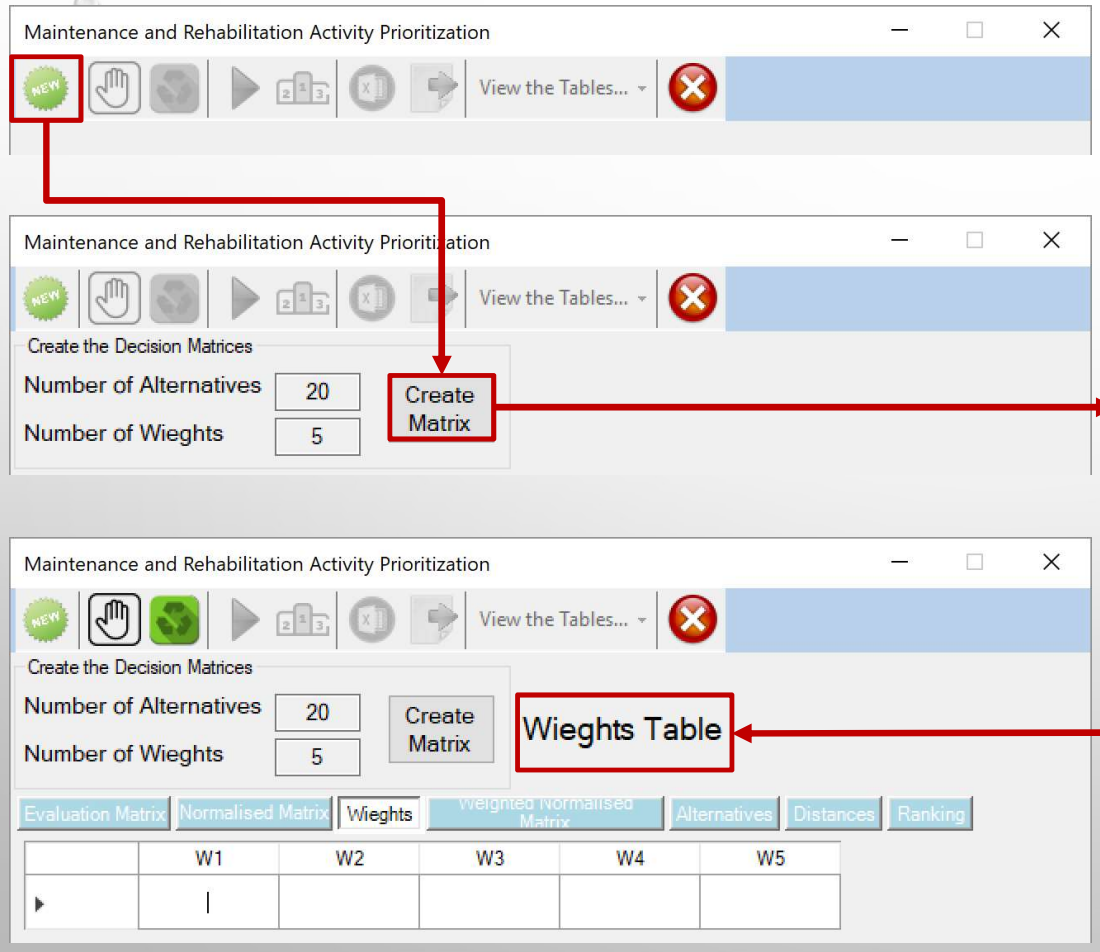
- Software used, Visual Studio 2015
- Method used, TOPSIS
- Name, Maintenance and Rehabilitation Activity Prioritization (MRAP)

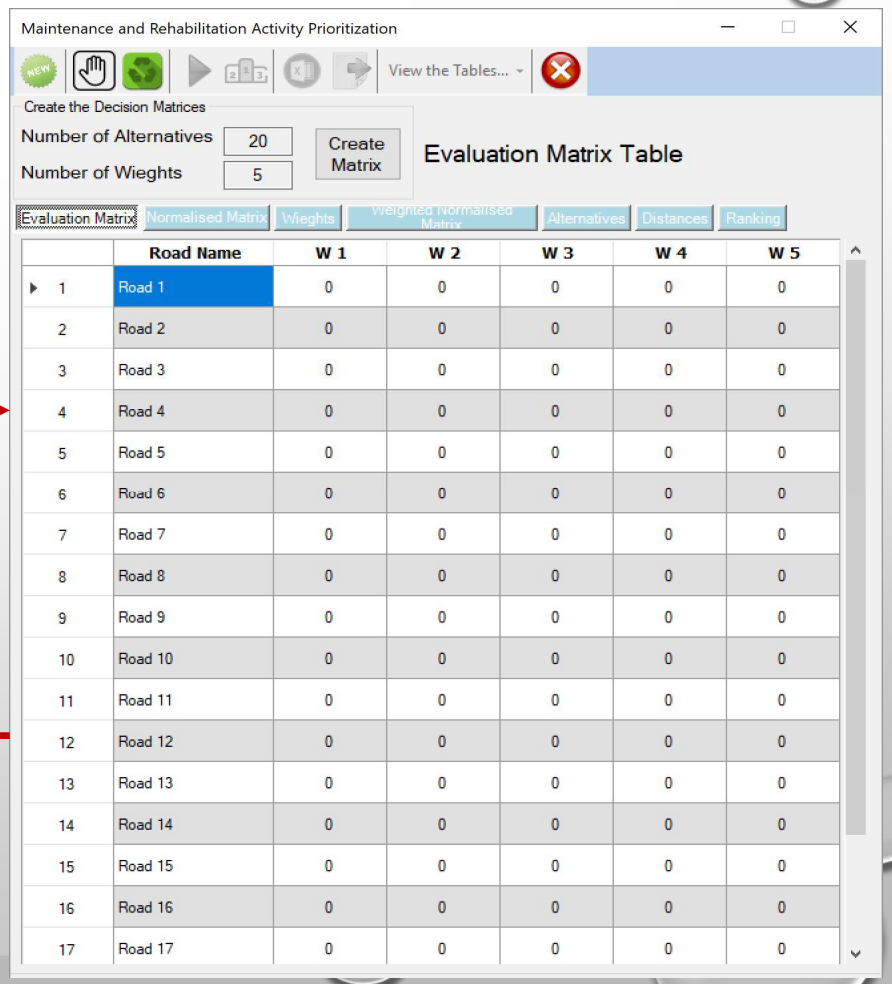
Calculation Steps Flowchart



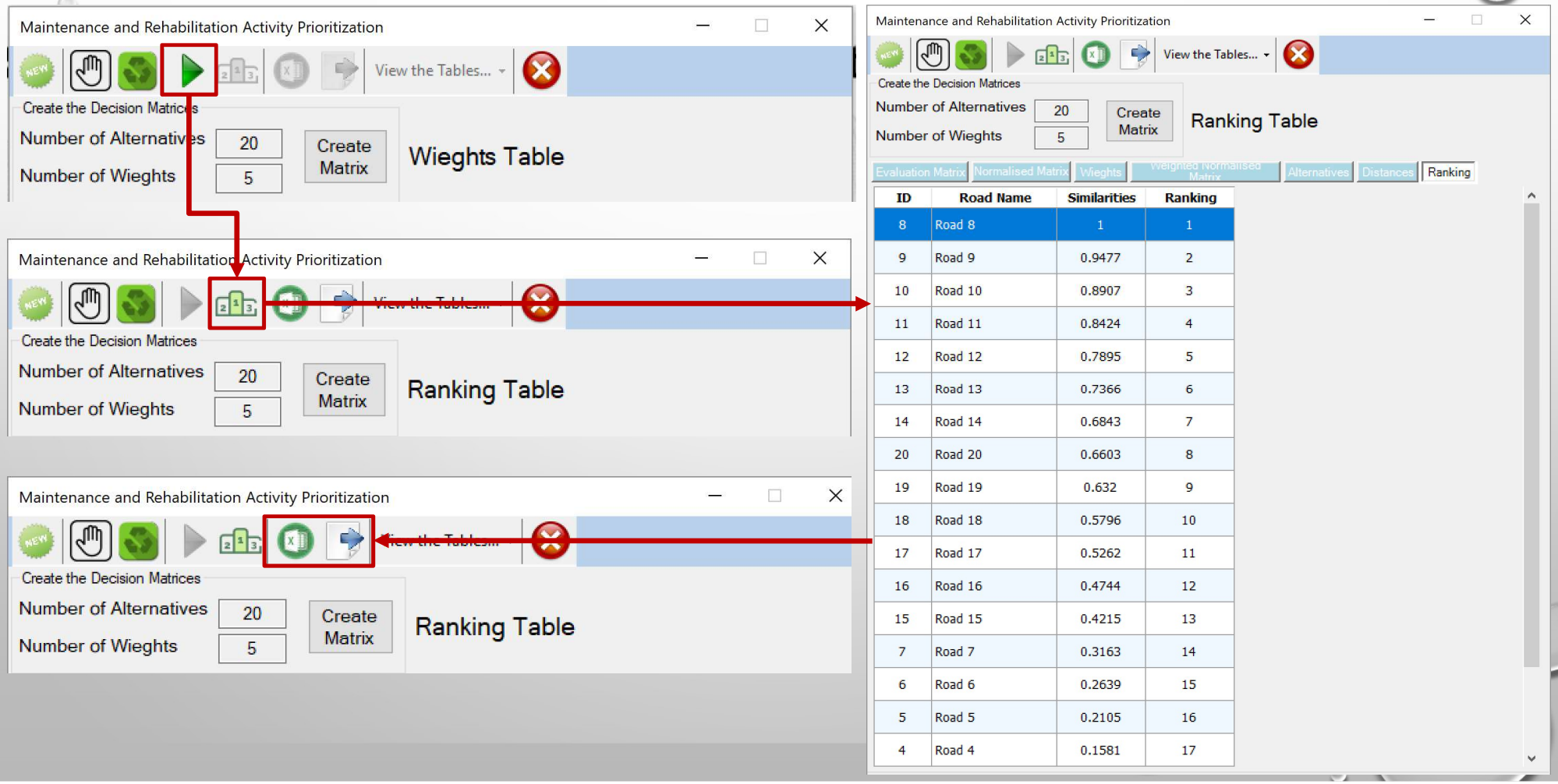
MRAP Tool Main Window

Calculation Steps Illustration





Calculation Steps Illustration



ID	Road Name	Similarities	Ranking
8	Road 8	1	1
9	Road 9	0.9477	2
10	Road 10	0.8907	3
11	Road 11	0.8424	4
12	Road 12	0.7895	5
13	Road 13	0.7366	6
14	Road 14	0.6843	7
20	Road 20	0.6603	8
19	Road 19	0.632	9
18	Road 18	0.5796	10
17	Road 17	0.5262	11
16	Road 16	0.4744	12
15	Road 15	0.4215	13
7	Road 7	0.3163	14
6	Road 6	0.2639	15
5	Road 5	0.2105	16
4	Road 4	0.1581	17

Calculation Steps Illustration

- Sample text file format & sample map

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6	Road 6	0.2639	15
5	Road 5	0.2105	16
4	Road 4	0.1581	17
3	Road 3	0.1058	18

Conclusions

- In this study, the Tool were developed in Visual Studio in order to simplified the computation process.
- The main objective of the developed tool is to prioritize the maintenance and rehabilitation activity.
- For using this tool there should be at least 2+ alternatives with minimum 2+ criteria/weights.
- In the further works, comparing it with other similar tools in terms of advantages and disadvantages, pricing, and requirements of responsible organization.


thank
you . . .