

Assessment of wind damage risk in forest areas: *application with GIS and Fuzzy-AHP MATLAB GUI tool*

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Introduction

Throughout the century, climate change, CO2 concentration, and disasters have negatively affected the growth of degradation through higher forest loss. During the past decade [2]. Furthermore, the report illustrates that agriculture (crops, livestock, fisheries, aquaculture, and forestry) absorbed 23 percent of all damage and loss caused by natural hazards.

A literature review describes the many tools and practices developed for sustainable resource management or disaster risk reduction. Forests and agricultural lands combat land degradation and desertification by stabilizing soils, reducing water and wind erosion, and maintaining nutrient cycling in soils (United Nations and Climate Change, 2015) (Figure 2). A large variety of software are used within decision-making aids. Geographical Information System (GIS) is intended to support decision-making approaches.

Main Objectives

This study aims to use the combination of GIS and fuzzy-AHP MATLAB GUI to assess the potential wind damage sites. The main objective of this research is to provide a user-friendly decision-making tool for forest managers, accessible for numerous decision-makers and stakeholders.

Materials and Methods

The fuzzy-AHP model was applied to calculate the weight of the corresponding criteria. The steps followed for this method were the same as those used in a previous paper [4], the goal of which was similar. By contrast, the GIS spatial approach was used to map the estimated risk of wind damage in a part of Czech forest areas.

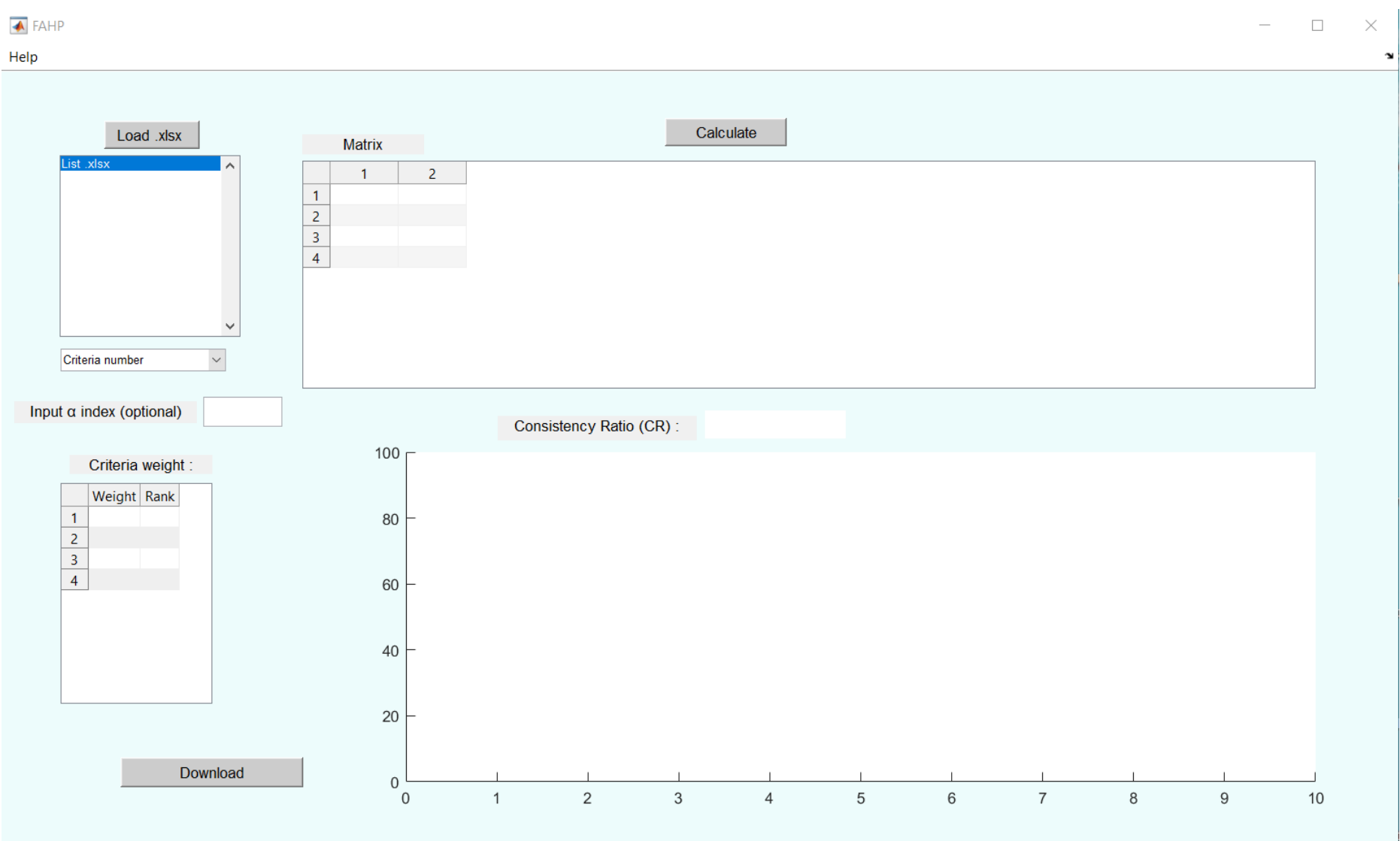


Figure 1: Fuzzy-AHP MATLAB GUI application for desktop

Five criteria were used to assess wind damage risk (Figure 2): wind speed, wind direction, stand age, share proportion of Norway spruce and forest vegetation type. The criteria selection was based on feedback from several researchers with experience in forests around the world.

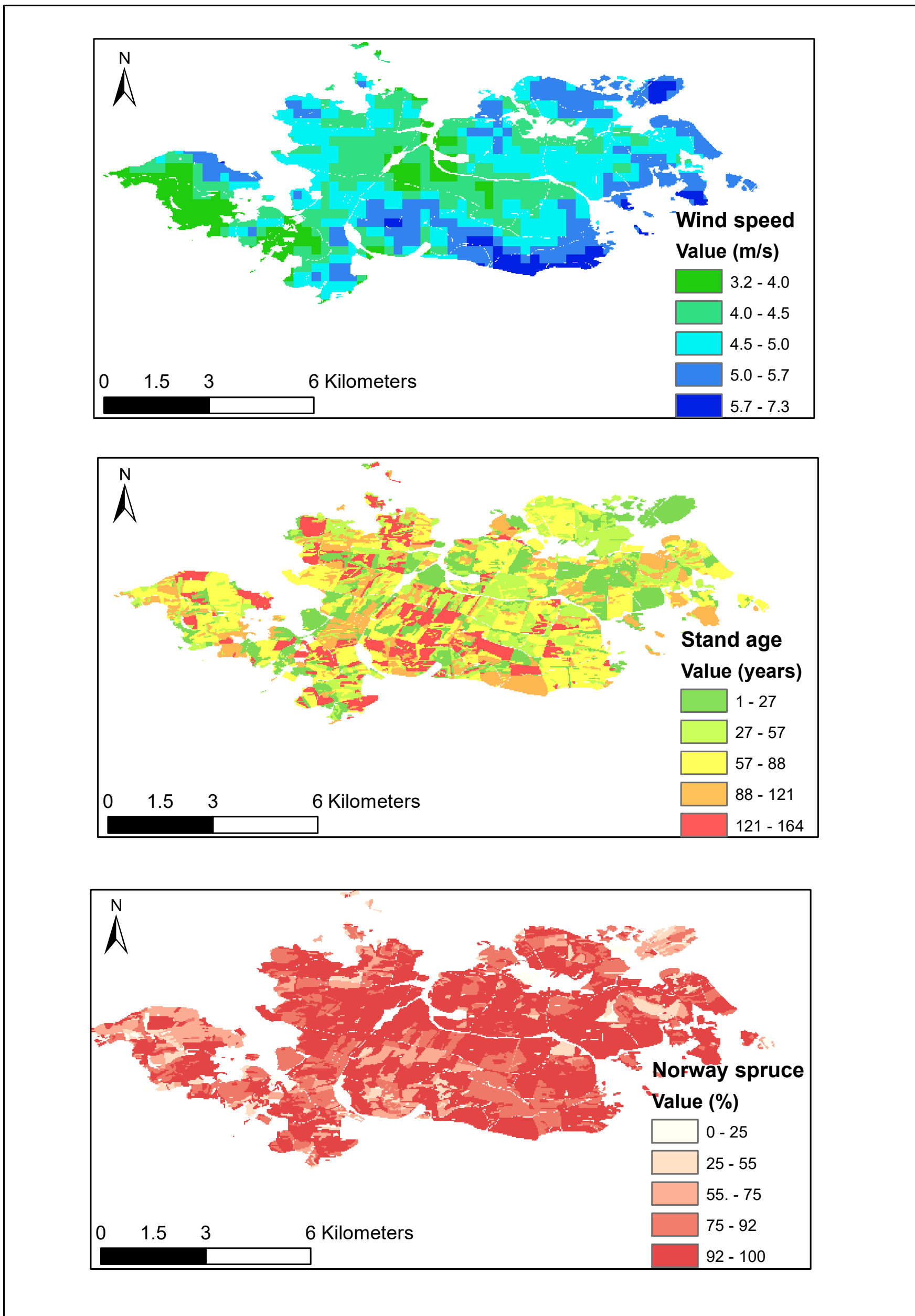


Figure 2: Criteria example considered for forest case study

Fuzzy-AHP theory

Fuzzy-AHP was developed by two mathematicians [7] and [5]. The method help to optimize resource allocations based on several criteria

in decision-making technique. The approach generate also potential solutions for land development planning. Let consider m and n criteria and experts respectively. The pairwise comparison matrix is built using online AHP application survey (<https://bpmsg.com/ahp-online-calculator/>) by [3].

a_{ij}^k is the comparison by expert k of the two criteria i and j , where i is more important than j . Therefore $a_{ji}^k = 1/a_{ij}^k$.

[1] approach was used to derive the fuzzy matrix. Where n corresponds to expert opinions, and $\tilde{A}$ is the fuzzy matrix (See matrix 1).

$$\tilde{A} = \tilde{a}_{ij} = \begin{bmatrix} 1, 1, 1 & l_{12}, m_{12}, u_{12} & \cdots & l_{1m}, m_{1m}, u_{1m} \\ l_{21}, m_{21}, u_{21} & 1, 1, 1 & \cdots & l_{2m}, m_{2m}, u_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ l_{m1}, m_{m1}, u_{m1} & l_{m2}, m_{m2}, u_{m2} & \cdots & 1, 1, 1 \end{bmatrix} \quad (1)$$

Where $l_{ij}, m_{ij}, u_{ij} \in [1/9, 9]$ as mentioned above are respectively minimum, mean geometrical and maximum for $k = 1, \dots, n$ of a_{ij}^k :

$$l_{ij} = \min a_{ij}^k$$
$$m_{ij} = \sqrt[n]{\prod_{k=1}^n a_{ij}^k}$$
$$u_{ij} = \max a_{ij}^k$$

for all $i, j = 1, \dots, n$.

The further steps of defuzzifying pairwise comparison matrix are defined in works of [6]. The screen of fuzzy-AHP MATLAB GUI application is shown in Figure 1.

Results

Based on the methodology in section algorithm and adding expert opinions in fuzzy-AHP matlab GUI application, the graph presents the criteria priority risk ranking.

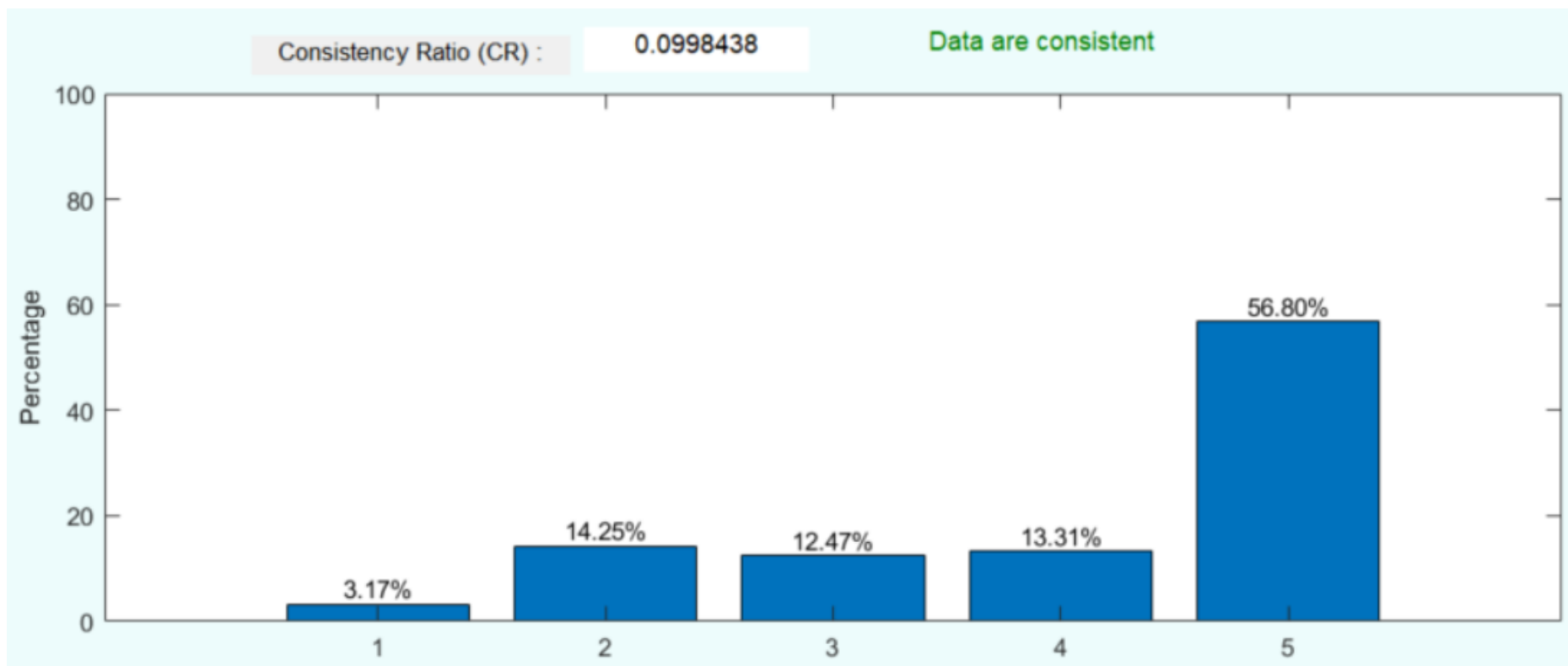


Figure 3: Priority criteria results; Where X-axis corresponds to the number of selected criteria: Share of Norway spruce, habitat, stand age, wind direction and wind speed, respectively

According to analysis, the wind speed criterion is rated as the most risky since it increases the main perturbation to forest damages, following by forest vegetation type, wind direction, stand age and share proportion of Norway spruce. Also, the application screen (See Figure 3) highlights the consistency ratio value with 0.09. Indeed, CR was ≤ 0.10 and considered acceptable. The next step is to overlay criteria raster layers to obtain the risk of wind damage map.

Conclusions

The provided methodology in this study could help the planners and engineers to investigate the conservation and preservation of forest areas with the lowest cost of financial expenses. This research indicates the powerful combination of fuzzy-AHP MATLAB GUI with GIS, which can handle ordinal, numerical, and descriptive information on the optimal selected alternative locations.

References

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