Implementation of fuzzy logic in GIS model of terrain trafficability for vehicles

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Introduction

Military terrain analysis is crucial part of the intelligence preparation of the battlefield process because its results can contribute critical information to assist the intelligence preparation, decisions, and operations of the preferred military activities (US Army, 1994)

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Introduction

- „The term “terrain trafficability” is commonly used to denote the terrain component of the environment which affects ground vehicle mobility” (Birkel, 2003)
- „Trafficability is a multidimensional concept which considers vehicle performance in relation to terrain stability, obstacle and slope negotiation, water crossing, and ride quality” (Wong, 1993)
- „The ability of the Terrain to support and provide traction for vehicle operation is called *trafficability”* (Shoop, 1993)

Research area - contact area of Đakovo loess plateau and Dilj hills

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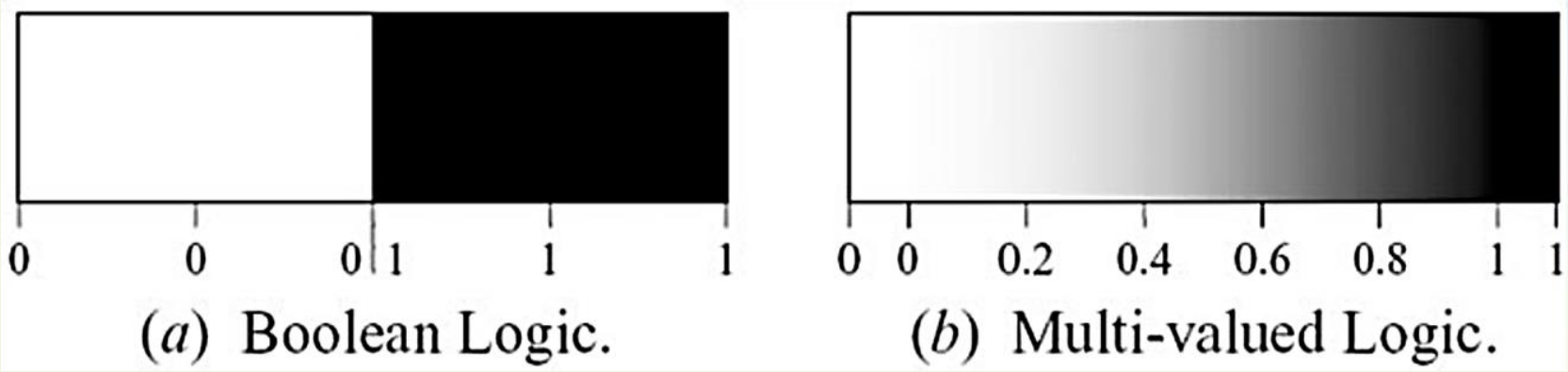
Fuzzy logic concept

- Fuzzy logic is a set of mathematical principles based on degrees of membership (Zadeh, 1965)



- Unlike two-valued Boolean logic, fuzzy logic is multi-valued
- Fuzzy logic uses the continuum of logical values between 0 (completely false) and 1 (completely true).

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Fuzzy logic – implementation

- Fuzzy logic is based on set theory; you define possibilities, not probabilities
- Fuzzy logic defines how likely the phenomenon is a member of a set (or class)
- Fuzzification converts the original values of the phenomenon to the possibility that they belong to a defined set (ArcGIS 10.4)

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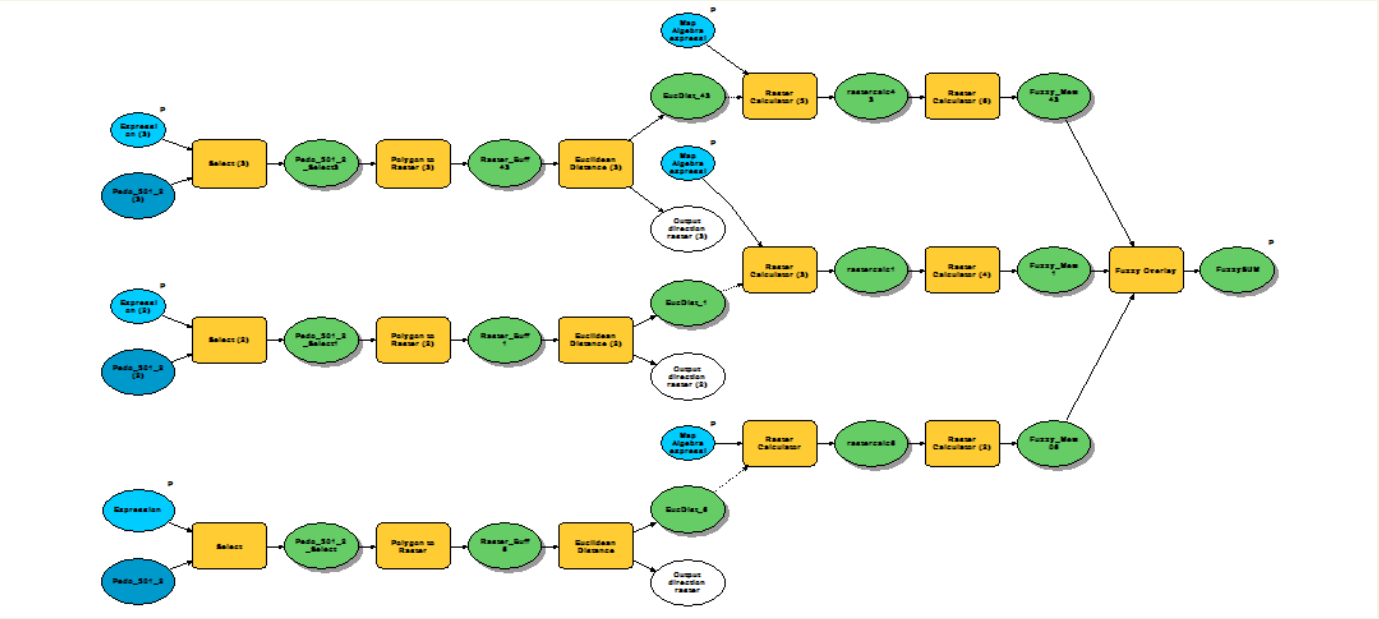
Software

- ESRI – ArcGIS environment
  - Model builder (visual programing language)
    - Main tools: Fuzzy Membership
      Fuzzy Overlay



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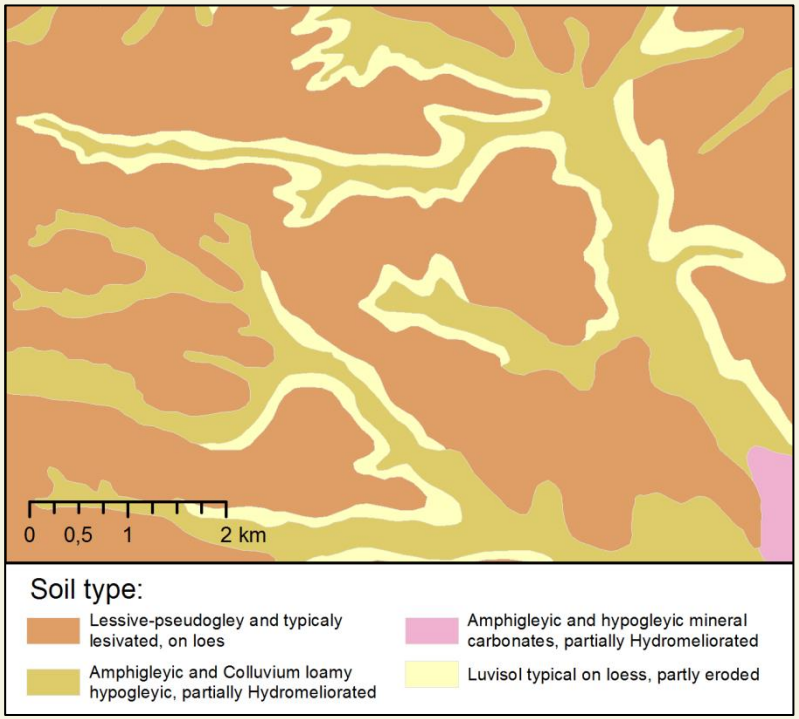
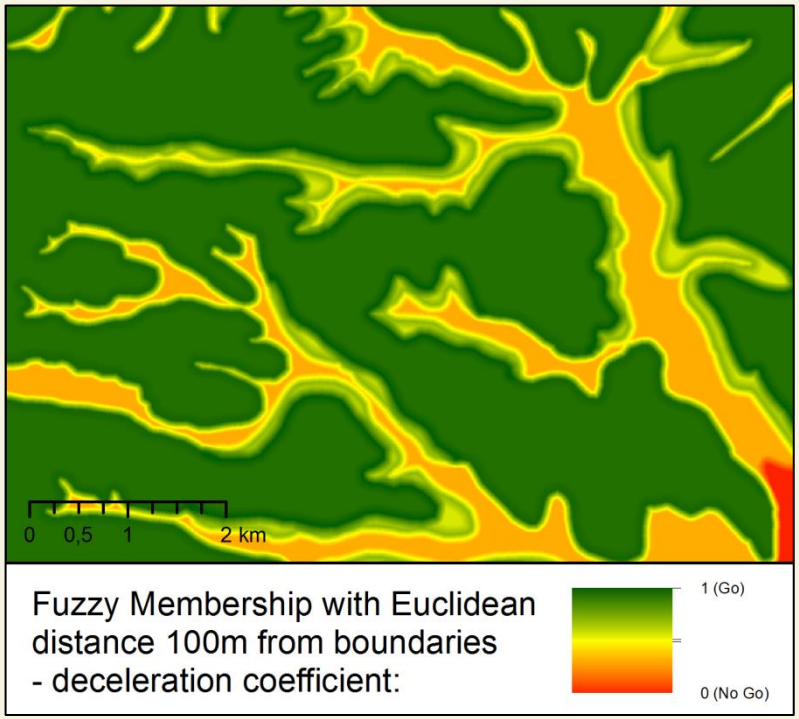
Data preparation:

Soil – class boundaries





- Fuzzy logic is not analysis of the uncertainty in data, but instead explores the imprecision in class boundaries

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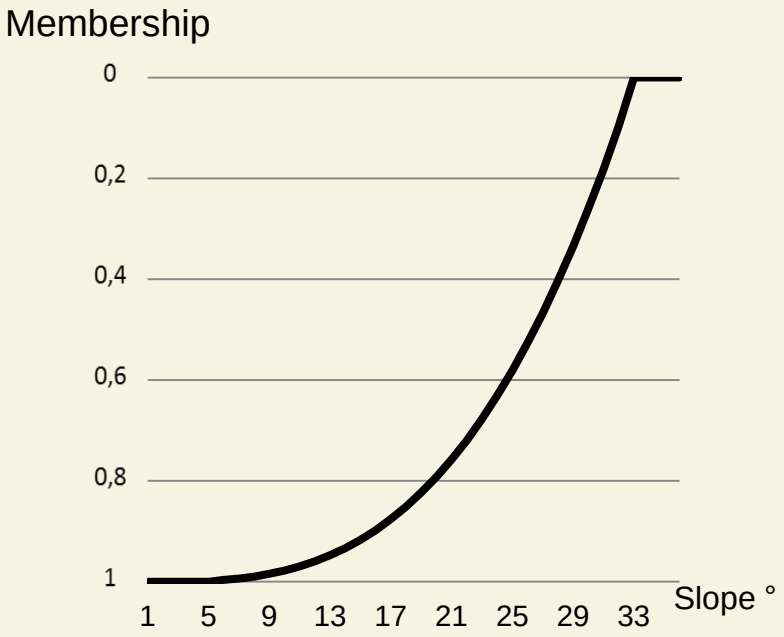
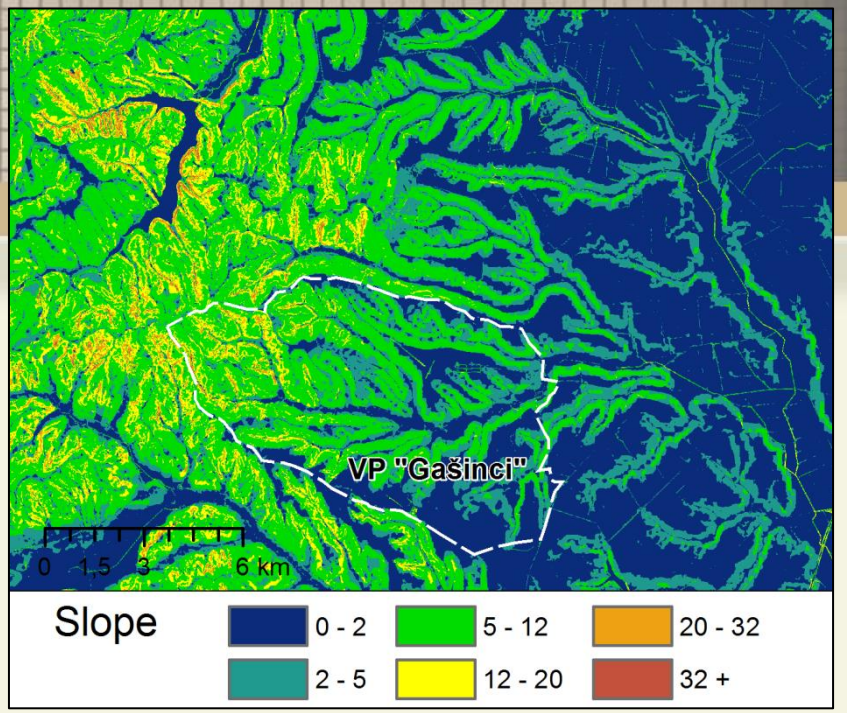
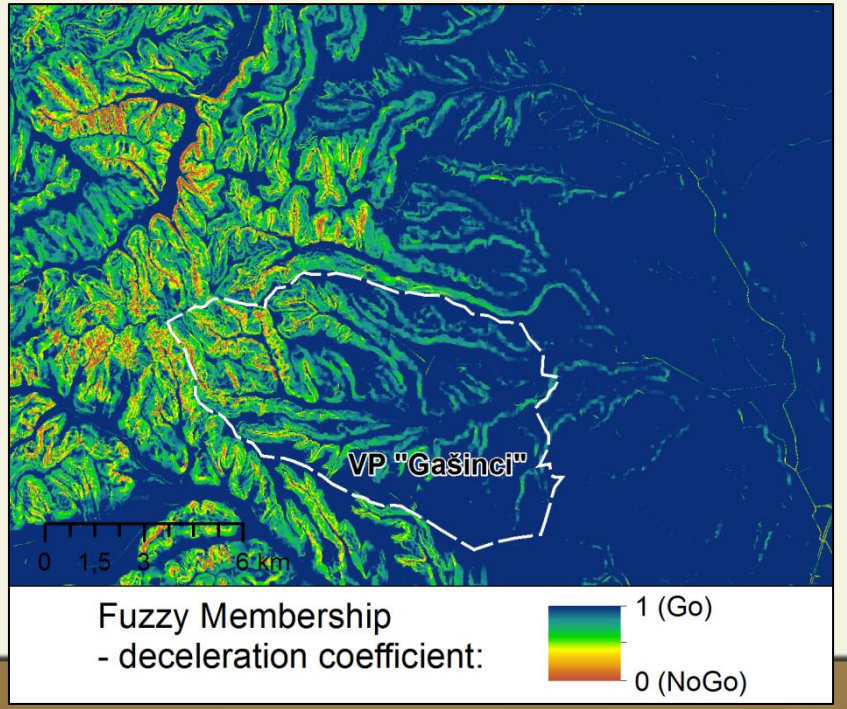
Fuzzy membership

- Fuzzification converts the original values of the phenomenon to the possibility that they belong to a defined set.







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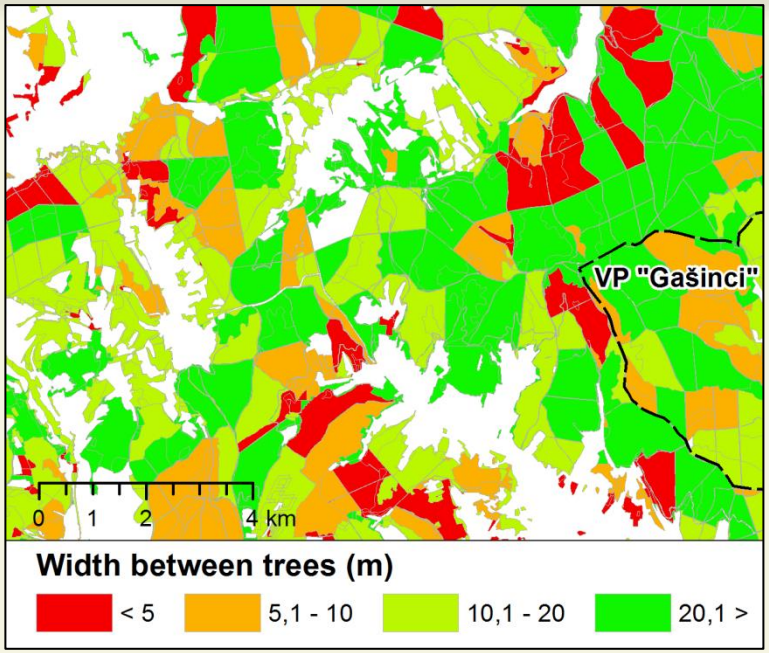
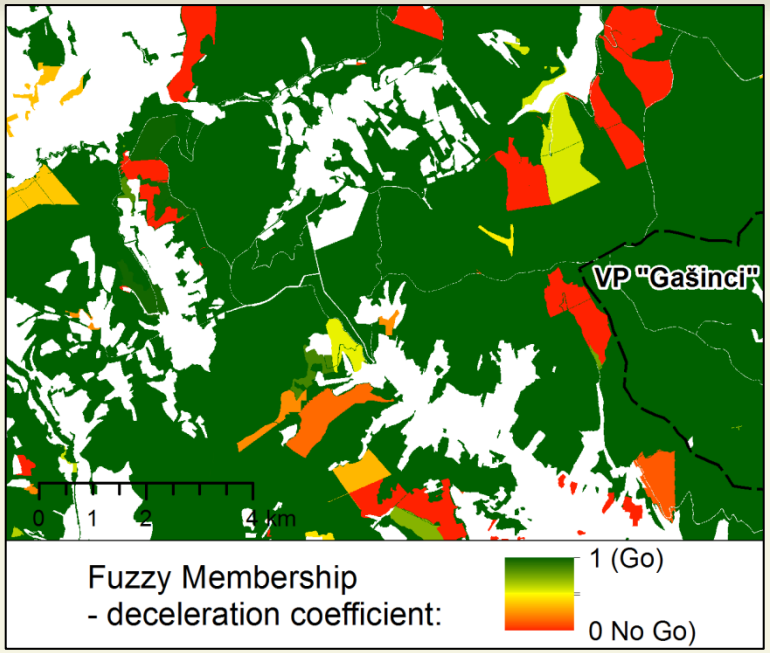
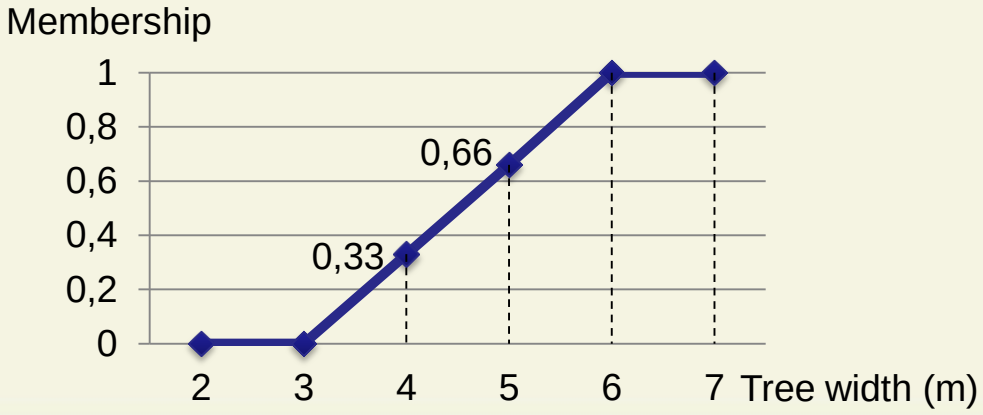
Fuzzy membership







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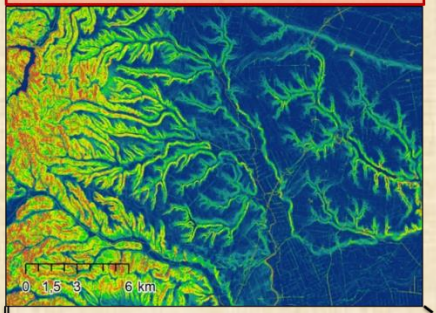
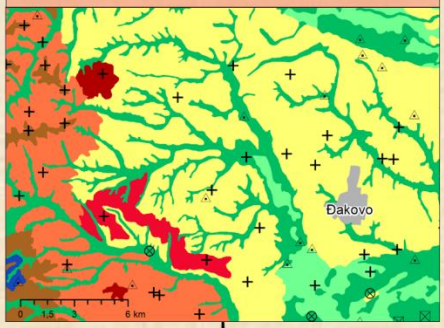
TERRAIN (Factors 1-7) **VEHICLE**

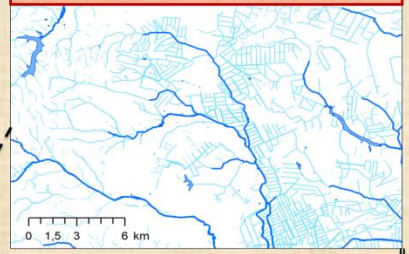
Slope Factor (F 1)
Macro relief forms
Decelaration = 0 – 1



Soil data



Hidrography factor (F 4)
Decelaration = 0

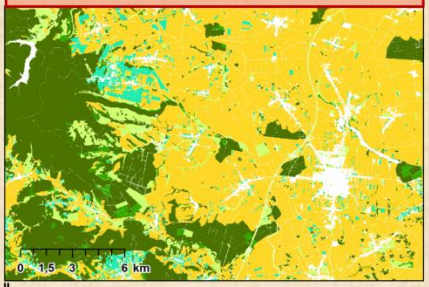


Weather conditions
Scenario:

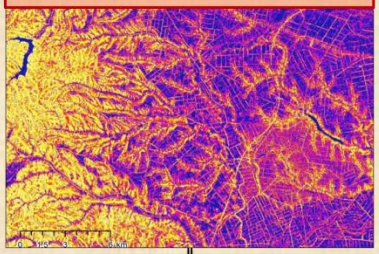
Terrain roughness factor (F 2)
Micro relief forms
Decelaration = 0 – 1

Form	Evaluation parameter
Embankment	hight, width, slope
Canal, ditch, gully	depth, width, slope

Vegetation factor (F 5)
Decelaration = 0 – 1



Soil factor (F 3)
Mechanical properties of soil
Decelaration = 0 – 1



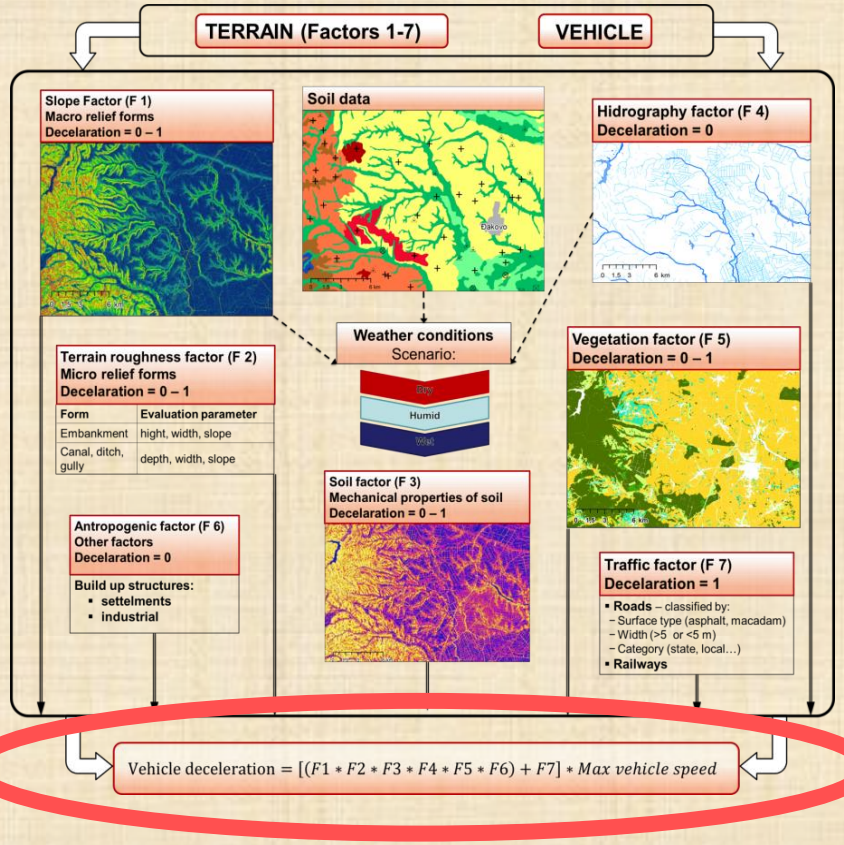
Antropogenic factor (F 6)
Other factors
Decelaration = 0

Build up structures:
- **settelments**
- **industrial**

Traffic factor (F 7)
Decelaration = 1

- **Roads** – classified by:
  - Surface type (asphalt, macadam)
  - Width (>5 or <5 m)
  - Category (state, local…)
- **Railways**

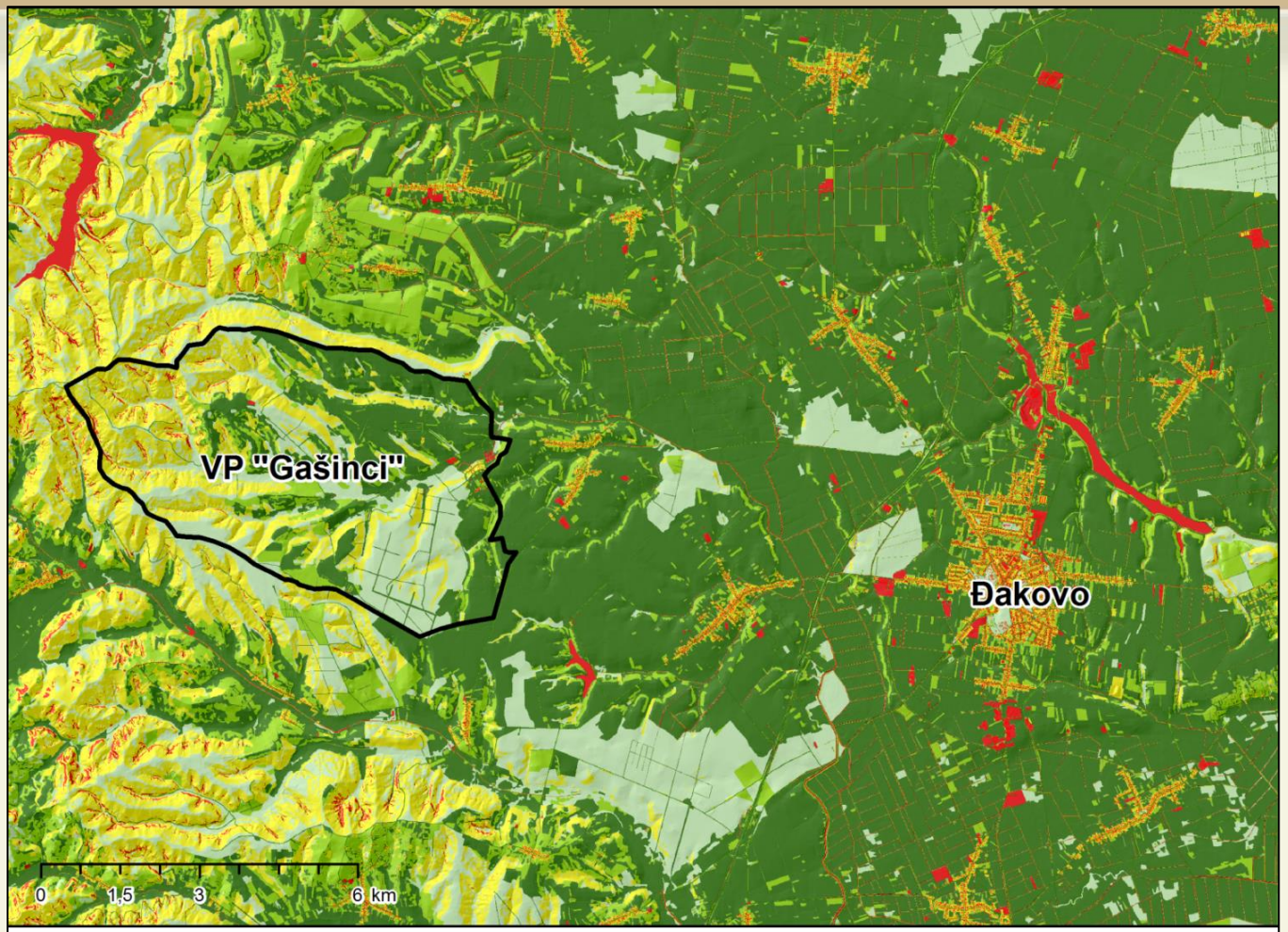
$$\text{Vehicle deceleration} = [(F1 * F2 * F3 * F4 * F5 * F6) + F7] * Max\ vehicle\ speed$$



Fuzzy Overlay Function: Product & Sum

$$\text{Vehicle deceleration} = [(F1 * F2 * F3 * F4 * F5 * F6) + F7] * Max\ vehicle\ speed$$

Preliminary results – cross country mobility map



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Conclusion

- Fuzzy logic and sets theory proved to be very good and flexible method for:
  - Analyses
  - Data structuring
  - Results presentation
  - Help for decision making

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Any Questions?

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