Modelling vegetation roughness and its impact on flood propagation: The case of river Piave in Italy

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INTRODUCTION

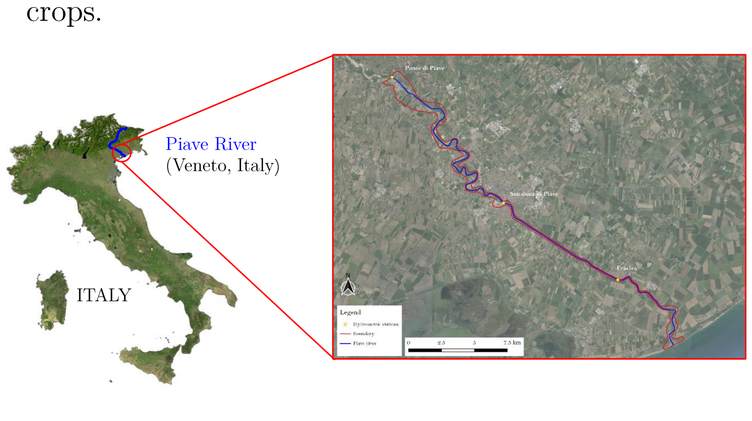
Vegetation is an essential component of riverine ecosystems. It contributes to the formation and development of habitats for fauna and flora, acts as a natural filter for pollutants, and protects against erosions. However, during heavy rainfalls, rivers overflow, and the vegetation sited in floodplains increases the resistance to flow, raising water levels and leading to an increased risk of flooding. Thus, an improved understanding of the role played by riparian vegetation in flow resistance is fundamental for flood analysis and river management activities.

This study aims to analyse the influence of arboreal vegetation on flow depths and water extent during a flood, as well as to explore vegetation management strategies aimed at risk mitigation and environmental protection.

CASE STUDY

STUDY AREA

The Piave river is located in the Veneto region of north-eastern Italy. The length of the main channel is 220 km and the catchment area is close to 4130 km^2.
The analysis was carried out on the final reach of the river from the town of Ponte di Piave to Eraclea. The river length is 31 km and the basin area is 14 km^2. The zone is characterized by a flat terrain covered mainly by arboreal vegetation and crops.



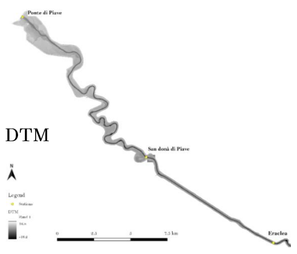
FLOOD EVENT

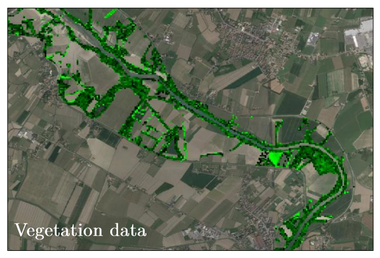
The event occurred between October 29 and 31st, 2018 and was characterized by extreme precipitations and strong winds. The water reached levels up to 11m, causing loss of life and significant damage to forests and infrastructure.

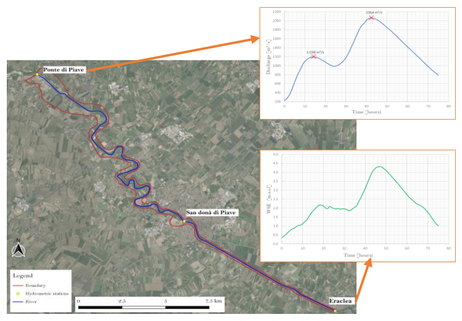
METHODOLOGY

Vegetation roughness and flow depths are evaluated by implementing the hydrodynamic model Telemac 2D. Input data such as DTM, vegetation characteristics, and hydraulic conditions, including hydrographs and water levels, are required to perform the simulations.

INPUT







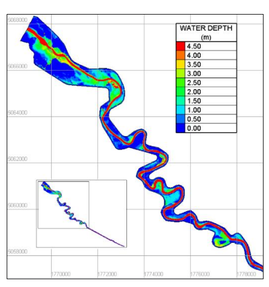
BLUEKENUE

TELEMAC 2D

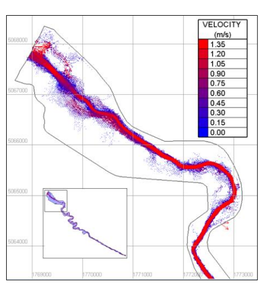
Vegetation Models:
- Lindner, 1982
- Van Velzen et al., 2003
- Baptist et al., 2007
- Huthoff et al., 2007
- Luhar & Nepf, 2013

OUTPUT

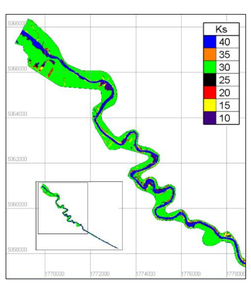
Flow depths



Velocities

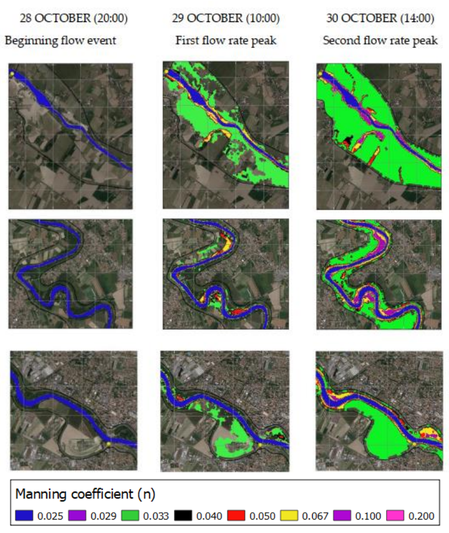


Roughness coefficients

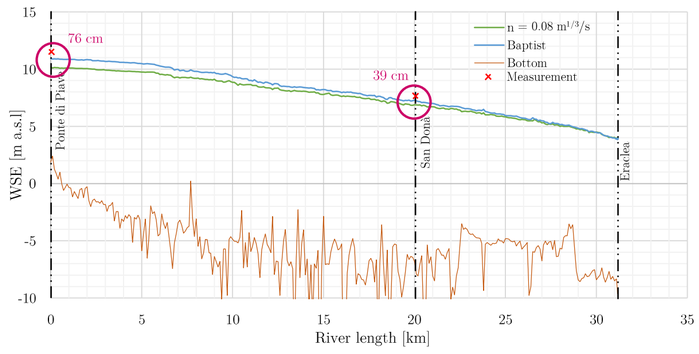


RESULTS

DYNAMIC ROUGHNESS MAPS

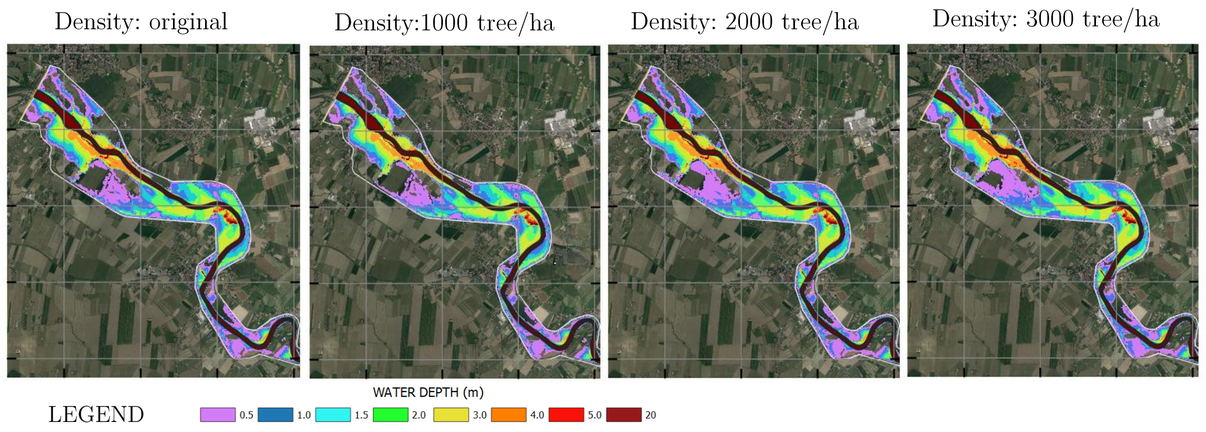


- Vegetation roughness is variable with flow depth and plant characteristics.
- Arboreal vegetation is the main responsible for the increase in water levels.



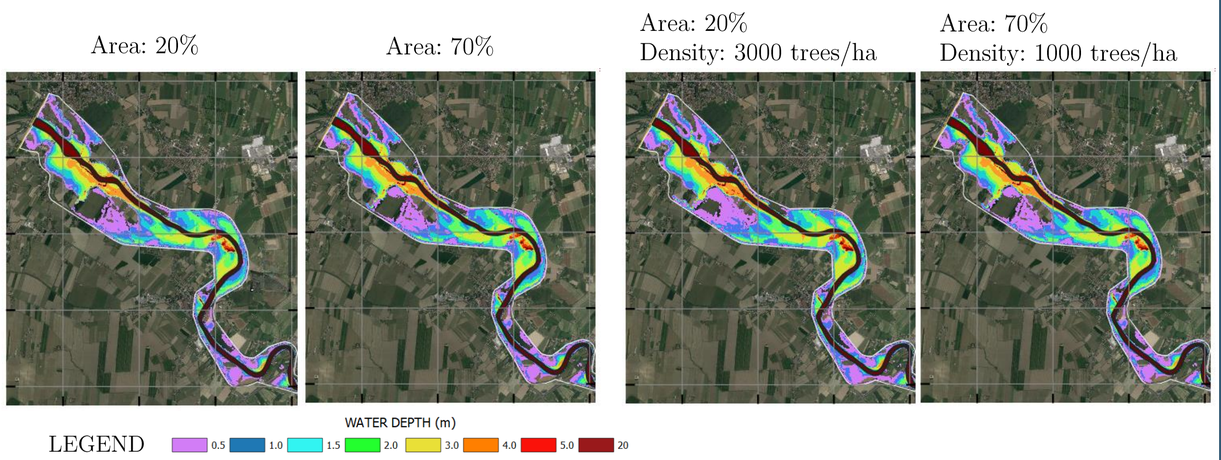
DENSITY EFFECT

CASE 1: Vegetation cover area: 20% (Original) - Density: variable



CASE 2: Vegetation cover area: variable
Density: 1000 trees/ha

CASE 3: Vegetation cover area: variable
Density: variable



- When vegetation density increases, flow depths and flood extension also increase.
- With the same density, a significant increase in the area covered by vegetation represents a slight increase in the flood extension.
- Vegetation concentrated in small areas with high density has a more significant effect on water levels than vegetation distributed in larger areas with low densities.

CONCLUSIONS

- In arboreal vegetation, the flow resistance increases with water level, therefore, during a flood event, roughness coefficients vary over time. Consequently, setting a constant roughness value in the mathematical models could lead to an underestimation of the water levels and the extent of the flood.
- The analysis showed that higher densities in small areas have a major impact on flow depths and extent, indicating that separation between plants is crucial in reducing the effects of vegetation on flooding. As a result, one flood mitigation strategy is to distribute vegetation over a larger area while maintaining the number of plants but reducing the effective density.

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