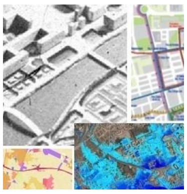

SUPTM 2026

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Title: **Land Use Change and Runoff Modelling in Emilia-Romagna: Assessing Hydraulic Risk for Spatial Planning**

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Figure 1: Map of Emilia-Romagna region.

The Emilia-Romagna region is located in northern part of Italy (Figure 1) and it's highly exposed to flooding. The region has a total area of 22,500 km² and has a complex morphological structure, including the Tuscan-Emilian Apennines, the Po Valley and the eastern Adriatic coast; In detail, agricultural land covers 53% of the region. As of 2020, the urbanized area covers 2,757.72 km^2, with an urbanization density of 12.25%. In 2024, the region had the highest land consumption in Italy, at 1,013 hectares. The region has a complex hydrography, with a dense network of natural and artificial waterways.

The region has a large amount of territorial data available on the regional Geoportal, in particular historical series of land cover maps, covering the period from 1954 to 2018, with a resolution of 10 metres and a minimum mappable unit of 1,600 m².

This availability has made it possible to construct a continuous evolutionary picture of territorial transformations, with particular reference to the processes of urbanization, infrastructure development and changes in agricultural land. The land use maps are characterized by a high level of thematic detail, up to level 4 of the Corine Land Cover (CLC) legend. The land use classes of the different datasets have been grouped into the first-level macro-classes of the Corine Land Cover Legend (artificial surfaces, agricultural areas, forests and semi-natural areas, wetlands, water bodies), to make the results more readable and, above all, useful for quantifying land use transitions from one time section to another (Figure 2, Figure 3).

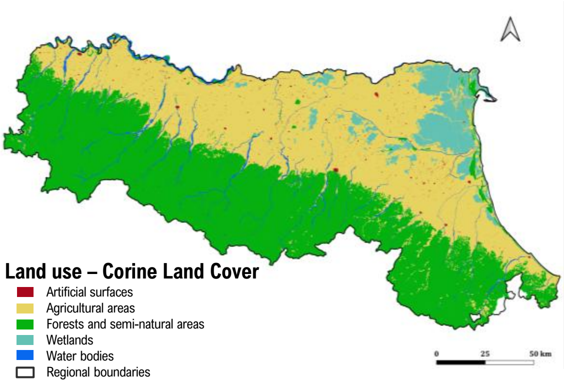

Figure 2: 1954 land use in Emilia-Romagna region.

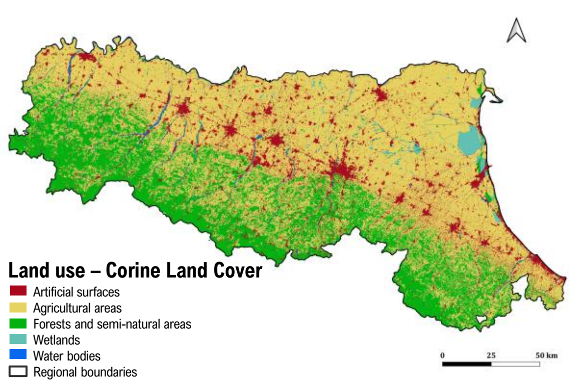

Figure 3: 2018 land use in Emilia-Romagna region.

Comparing land use the analysis adopts a spatial planning approach based on ecosystem services, suitable for contexts characterized by widespread urbanization and increasingly frequent and intense extreme events. The open source InVEST model, Urban Flood Risk Mitigation (UFRM), can spatially explicitly assess the contribution of different land covers to hydrological regulation, surface runoff retention capacity and flood risk mitigation.

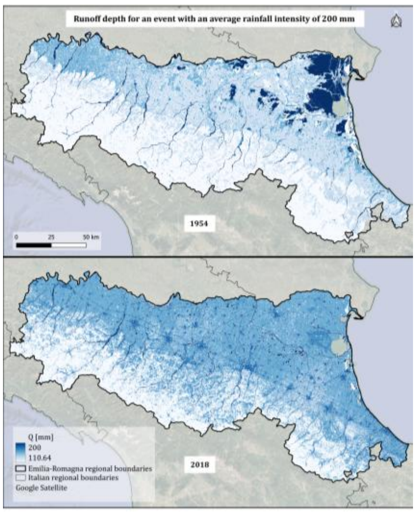

Figure 4: Runoff depth [mm]

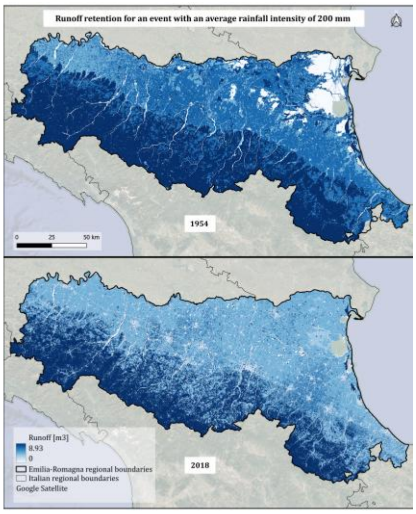

Figure 5: Runoff retention [m3]

A rainfall event with an average intensity of 200 mm, representative of a severe but plausible extreme event, was simulated using the UFRM model for two land-use scenarios (1954 and 2018). The runoff depth maps (Figure 4) show a clear spatial intensification of surface runoff in the 2018 scenario, particularly across the urbanized lowlands and coastal areas, while the 1954 configuration exhibits more heterogeneous patterns and higher runoff retention, especially in agricultural and semi-natural areas. The runoff retention maps (Figure 5) further highlight a marked reduction in the capacity of the landscape to retain rainfall in 2018, with extensive areas shifting towards lower retention values, consistent with long-term processes of urban expansion and soil sealing. These spatial patterns are reflected in the quantitative analysis of major cities (Figure 6 and 7), where Q values systematically increase between 1954 and 2018, with increments ranging from approximately +9% to +21%, indicating a more intense hydrological response to the same rainfall forcing.

The two indicators capture complementary aspects of urban hydrological behavior: runoff depth (Q) reflects the intensification of local surface response, while the runoff indicator highlights broader changes in flow dynamics and spatial redistribution. Overall, the combined analysis of maps and city-scale indicators demonstrates how land-use change has led to a more concentrated and less buffered hydrological response, increasing exposure to urban flood risk under extreme rainfall events.

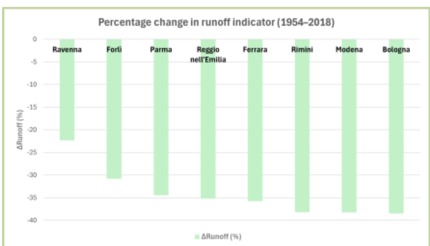

Figure 7: Runoff % in major cities

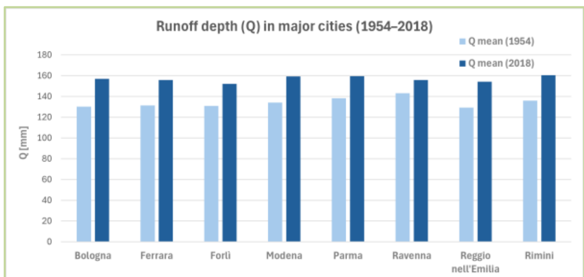

Figure 6: Runoff depth in major cities

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