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Rural urban interface scenarios in Portugal based on land cover changes

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Motivation

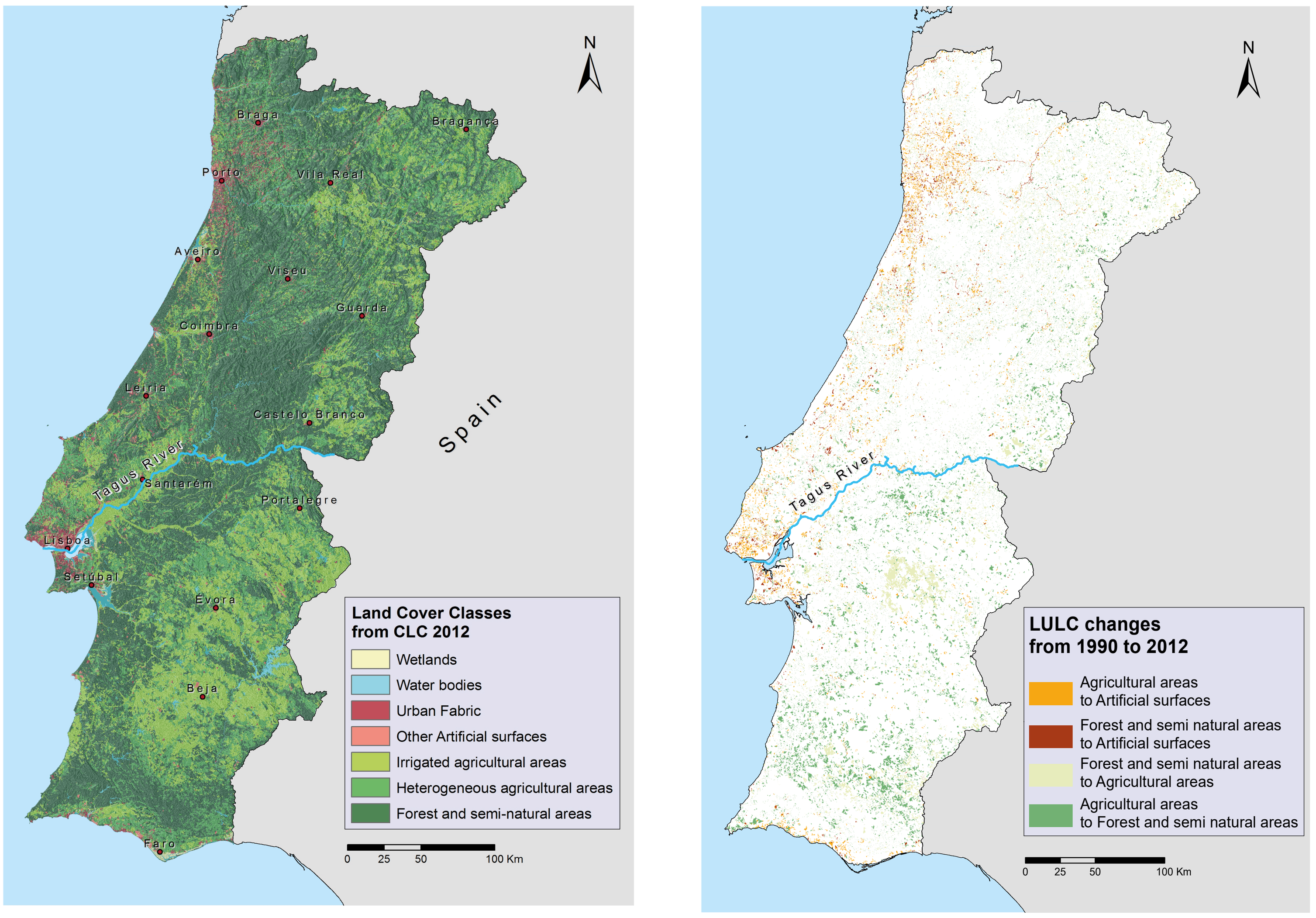
The **Rural Urban Interface (RUI)** define the area where humans and their development intermix with wildland fuels, including forest and rural areas. Here human-caused wildfires are more likely to occur and represent a main hazard for people, houses and infrastructures.

Land use/land cover changes (LULCC) highly affect the spatio-temporal evolution of the RUI.

RUI mapping is generally based on measurements the distance among specific land covers (i.e. urban area and forest/rural vegetation), but this methodology suffers from the definition of fixed parameters. To avoid this arbitrariness, a new procedure based on **Multilayer Perceptron (MLP)** and **Fuzzy Set Theory** is introduced in this study.

The methodology is applied to the case study of Portugal.

Study area



Data Source: Corine Land Cover (CLC) inventory (Copernicus Programme, http://land.copernicus.eu)

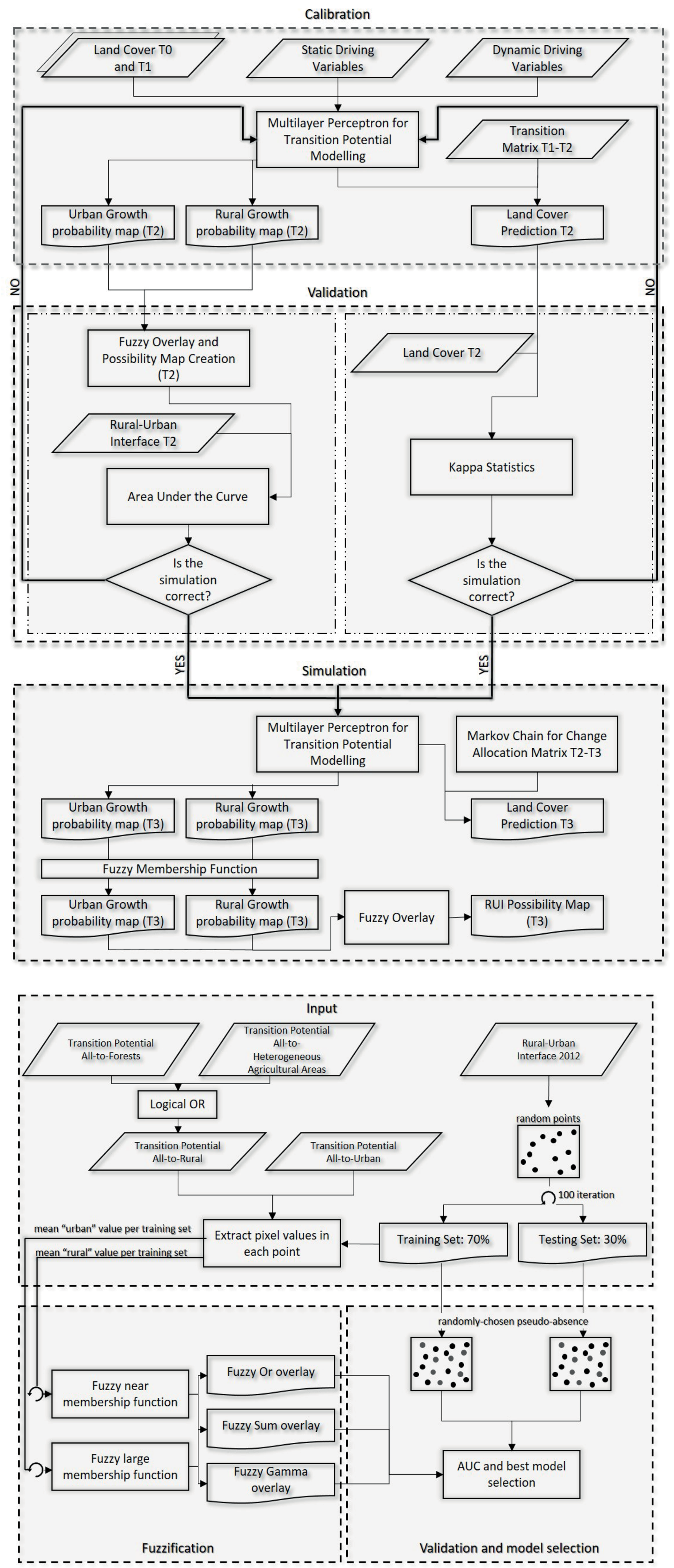
Mainland Portugal has a surface of 89,000 km² with an altitude range from sea level to about 2,000 m and a temperate climate.

The country is splitted by Tagus River into the northern half, where forest is predominant, and the southern half, where prevail agricultural lands and scrub vegetation. Main urban areas are mostly located close to the coast.

The northern half (with 25,322 fires registered in the period 1990-2013) is much more affected by **wildfires** than the southern (with olny 1,951 event in the same period).

LULC information came from the CORINE Land Cover inventory (CLC). Driving variables were also used to calibrate the simulation model (e.g. DEM, census data, road network, soil properties).

General flowchart of the methodology



Three land cover maps, corresponding to $T_0 = CLC_{1990}$, $T_1 = CLC_{2000}$ and $T_2 = CLC_{2012}$, were used to calibrate and validate the model.

CLC_{1990} and CLC_{2000} acted as input to prenict a land cover maps at the time T_2, adopting **MLP** neural network algorithm for the **transition potential modelling**.

The resulting map was than compared with the real CLC_{2012}. Once the model validated, via **Kappa statistics**, the same MLP hyper-parameters were applied to simulate the land use map at the time T_3, by means of the CLC_{2000} and CLC_{2102}. At this stage, **Markov Chain** procedure was applied to allocate the transition.

Finally, the **future scenario** allowing to predict the land cover for the year 2030 (i.e. LULC hard prediction), provided new boundaries for the future RUI map.

Fuzzy set theory was applied to produce maps expressing the probability of each pixel to transit toward rural coverages or urban areas in 2030 (i.e. soft prediction). These maps were then overlapped through joint membership fuzzy functions, resulting in a map expressing the **possibility** of an area to belong to the **RUI in 2030** (i.e. the RUI possibilty map).

To validate the fuzzification procedure, the RUI bounderied were used as benchmark vs the simulated RUI_{2012} and the AUC was computed.

Amato, F., **Tonini, M.**, Murgante, B., Kanevski, M.; *Fuzzy definition of Rural Urban Interface: An application based on land use change scenarios in Portugal*; Environmental Modelling & Software, Volume 104 (2018), pp. 171-187.
https://doi.org/10.1016/j.envsoft.2018.03.016

Results: soft and hard prediction

The proposed methodology resulted into two **land cover scenarios for 2030**, allowing to predict the future RUI:

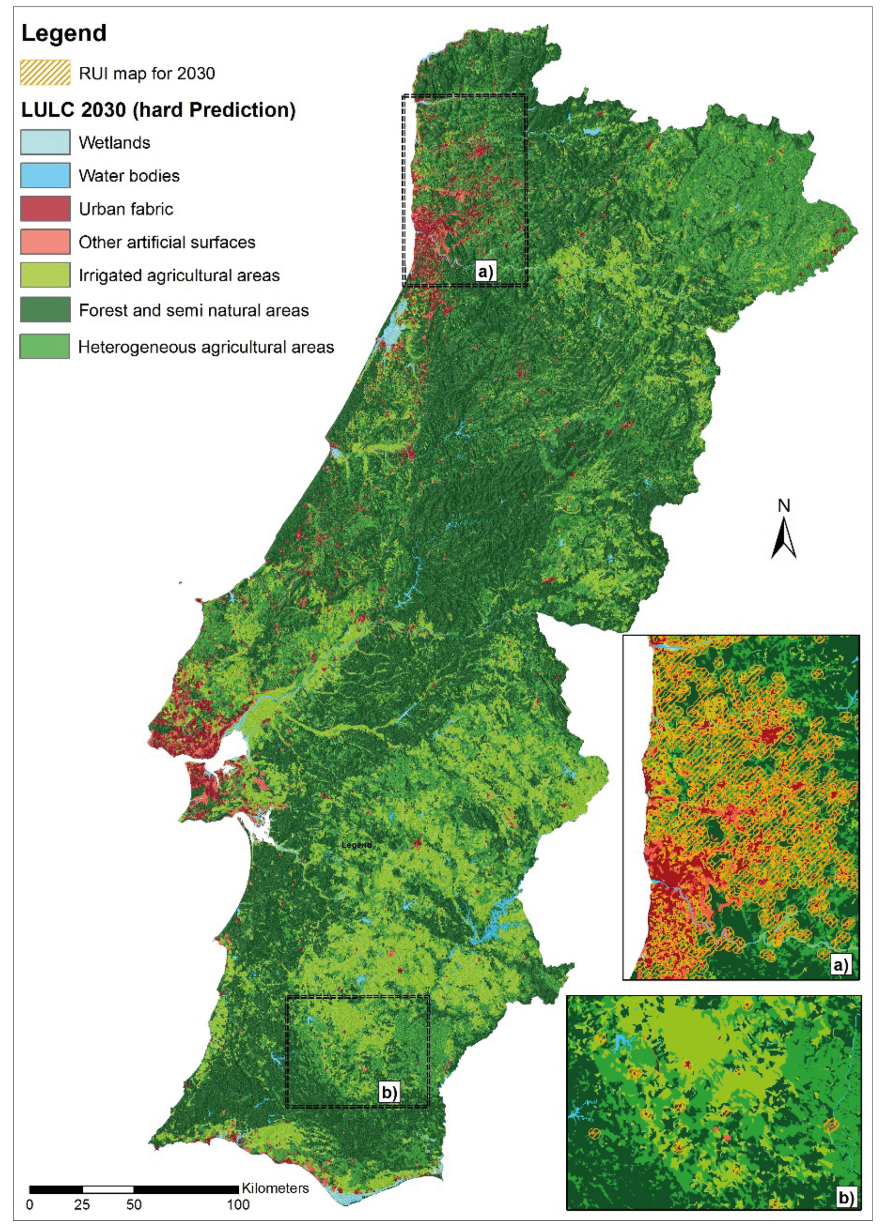
- **Hard Prediction** → future RUI boundaries
- **Soft Prediction** → possibility fuzzy RUI map

The difference between the two is that the soft prediction yields the entire set of simulated transitions, while the hard prediction yields only one specific transition, selected through a multi-objective land competition model.

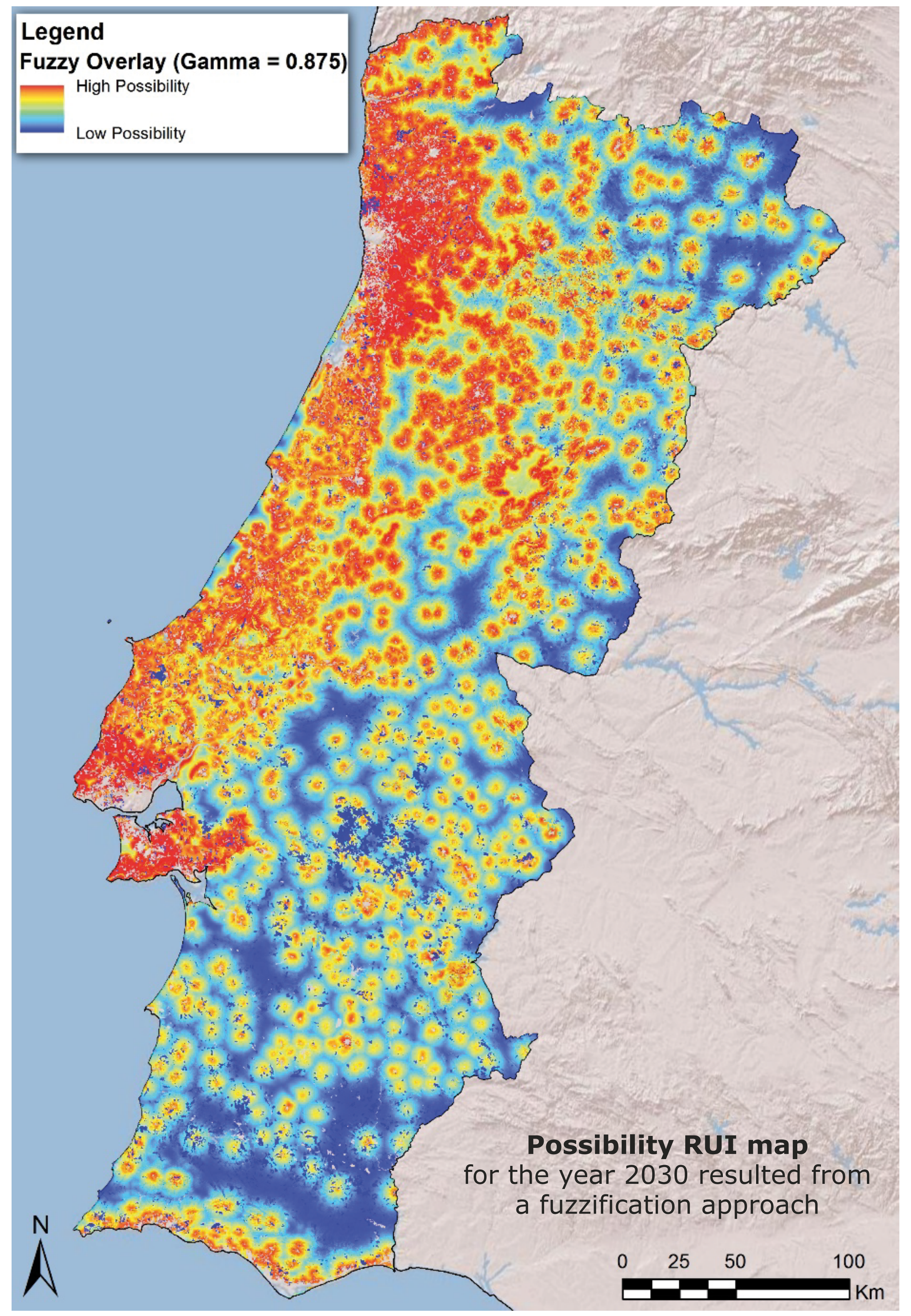
The areas where RUI has the higher possibility to extend in 2030 were find in the fringes of urban areas, **driven by the peri-urban growing**. Specifically, in the area enclosed by Braga, Porto, Aveiro and Vila Real in the North-West, with a spatial contiguity along the coast up to the city of Lisbon. In the South, highly predisposed area is along the Faro Region, probably due to the expansion of urbanism in this costal-touristic place. Eastern-Northern interior mountainous lands present scattered hotspots for RUI, caused by the **abandonment of agricultural lands** and the consequent forest spreading.

The resulting **possibility fuzzy RUI map** represents the tendency towards the overlapping areas between relevant classes (i.e. rural and urban) identified on the prospective CLC_{2030}.

This **innovative methodology**, although quite complex, is extremely robust, account for uncertainty and has the advantage of not relying on expert knowledge inputs.



LULC hard prediction for the year 2030
Zoomed areas represent the RUI boundaries (considering a buffer width of 1000 m) in a highly densely populates places around Porto (a) and in scattered rural-residential areas (b).



Possibility RUI map
for the year 2030 resulted from a fuzzification approach