



PYSOLO – Stakeholder Event



Mapping forest and agricultural biomass and assessment for solar-powered biorefineries in the Mediterranean region

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Zaragoza, Spain

Methodology to quantify biomass types and identify optimal biorefinery locations through different criteria

Forest Biomass

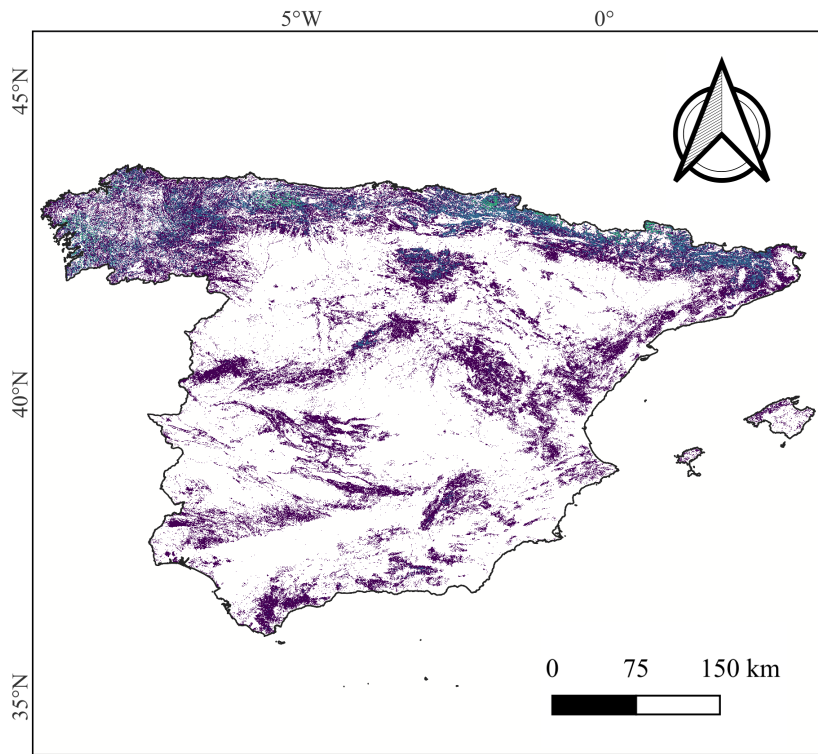
- Quantify **forest aboveground biomass (AGB)** in areas with **high potential direct normal irradiation (DNI)** across Spain, Italy, and Greece.
- **Classify** forest AGB into **three main species groups**: pines, oaks, and other species.
- **Identify optimal locations** for the storage and processing of forest AGB.

Residual Agricultural Biomass

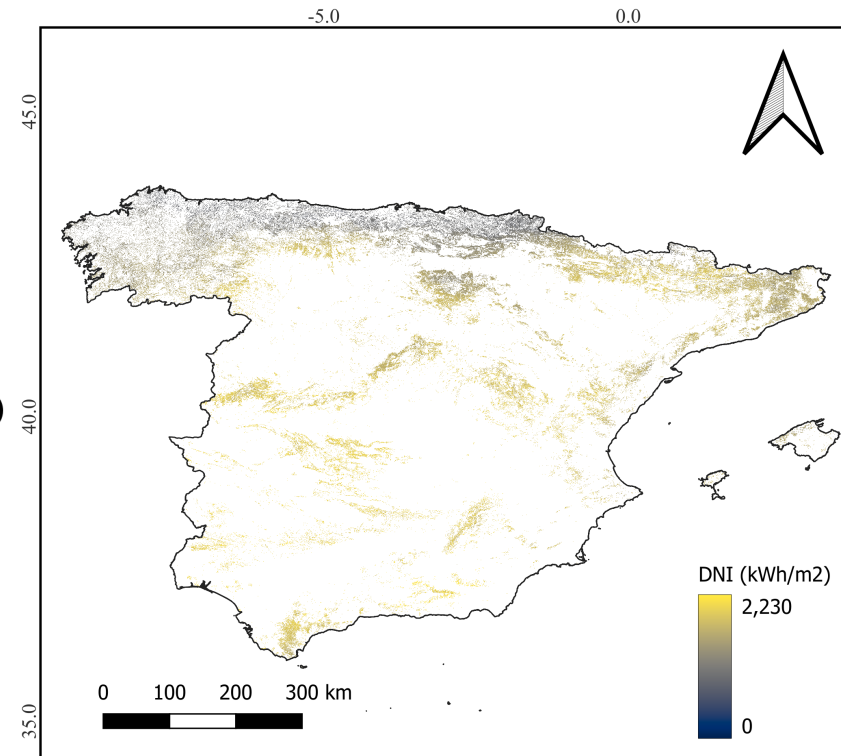
- Identify the **two main** crop types in the Mediterranean region: **vineyards and olive groves**.
- Determine **crop yield** by province and region and quantify residual biomass from **grape pomace** and **olive mill waste**.
- Identify **optimal locations** to deposit both residual agricultural biomass.

Forest Biomass

The forest AGB is **mainly distributed** in areas with relatively **low DNI** values. Therefore, DNI was integrated in a later stage. First, it was essential to account for **spatial restrictions**, followed by a **multi-criteria analysis** to calculate the **suitability index (SI)** values.



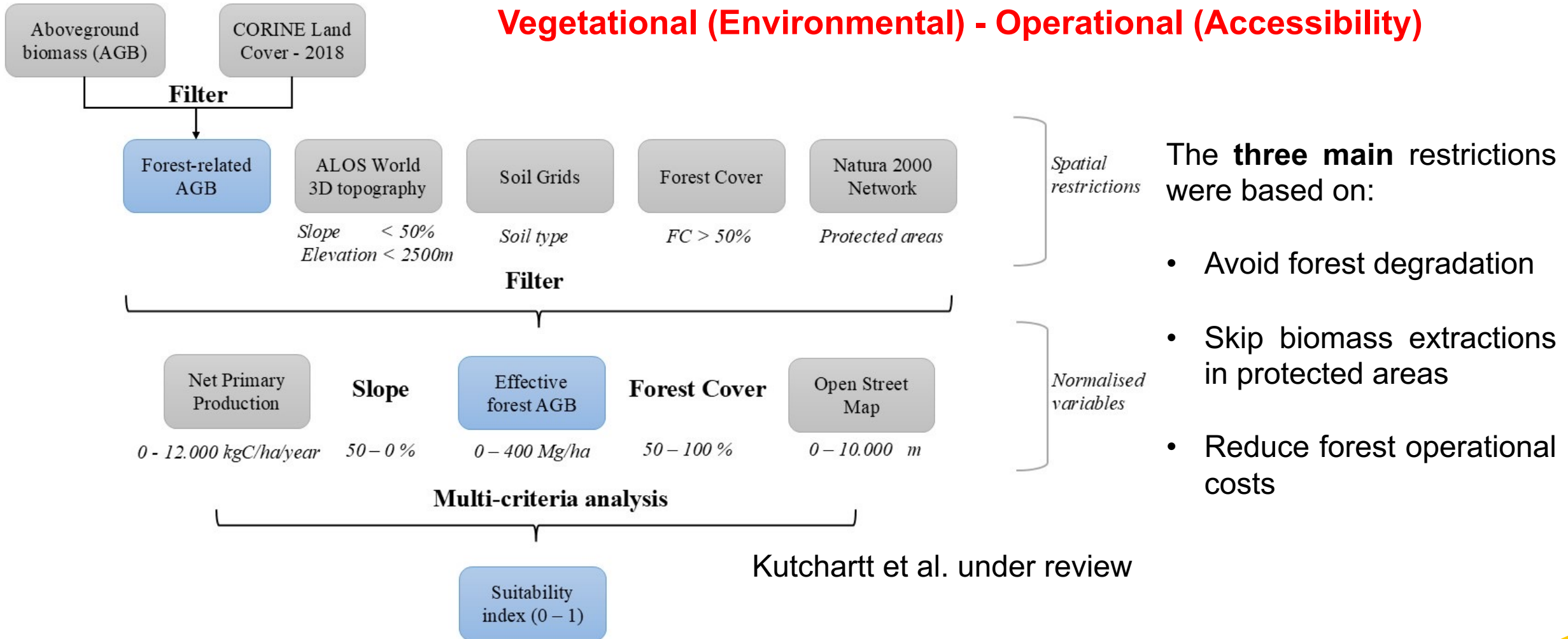
Pirotti et al. 2023



ESMAP, 2019

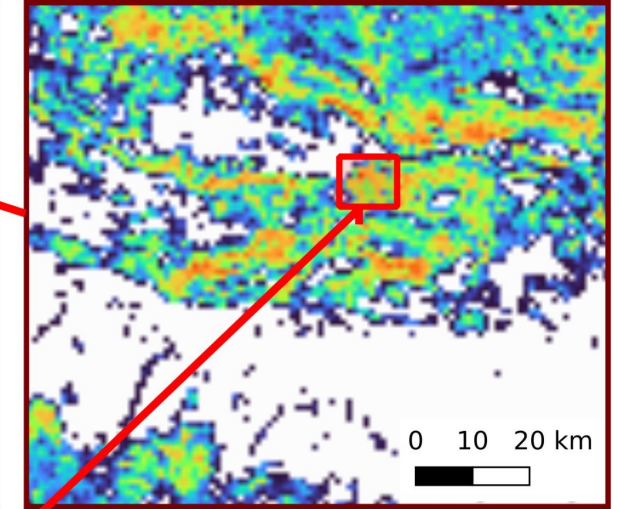
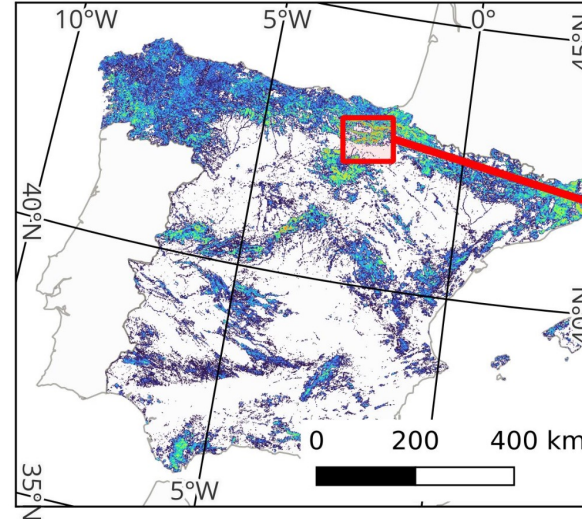
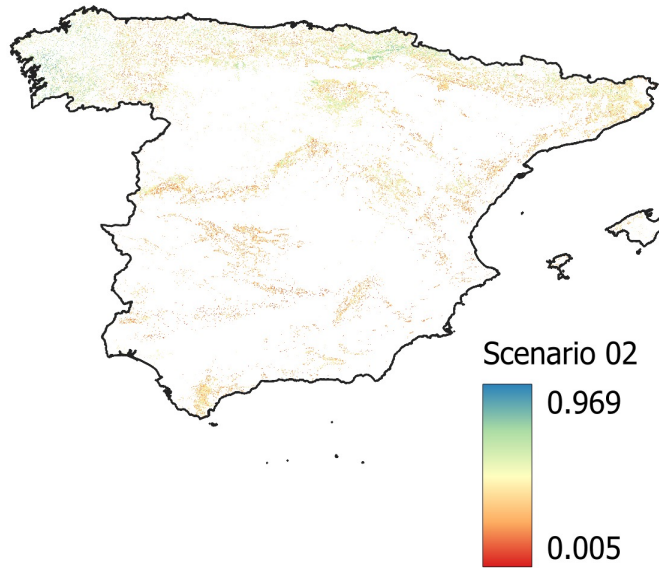
DNI (kWh·m ⁻²)	Level
>2500	6 - Very high
2000 – 2500	5 – High
1700 – 2000	4 - Medium-heigh
1300 – 1700	3 – Medium
1000 – 1300	2 - Medium-low
<1000	1 – Low

What restrictions were identified to establish a solar-powered biorefinery plant?

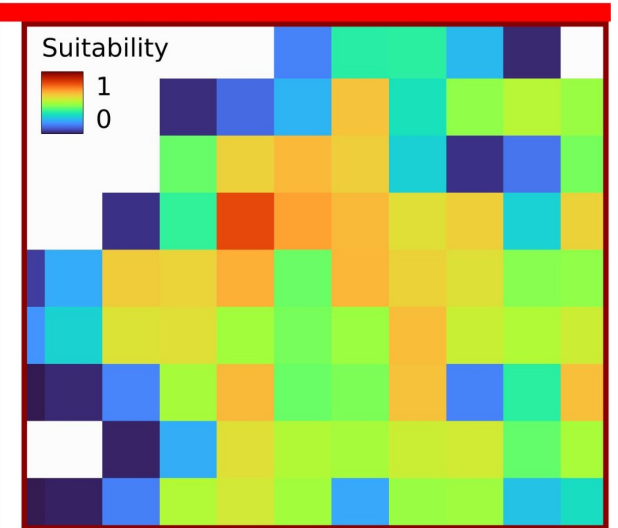
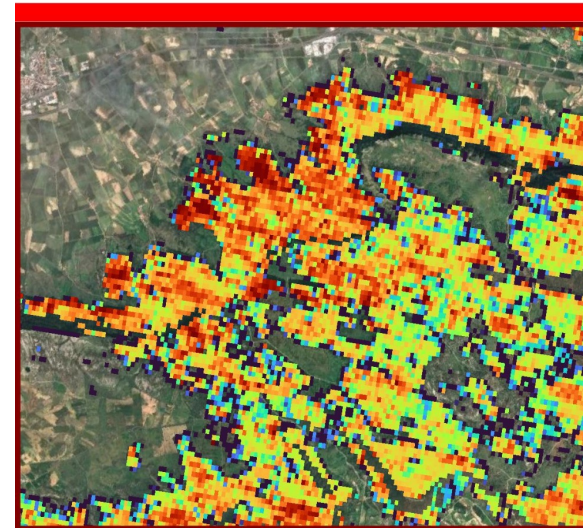
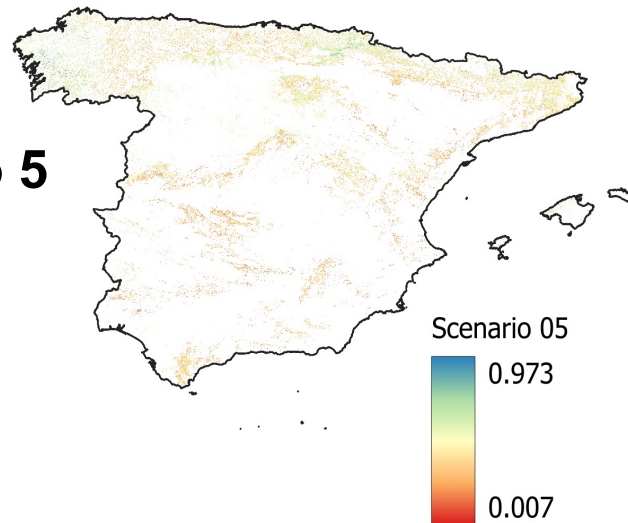


Results from the MCA based on normalized values [0 – 1]

Scenario 2



Scenario 5



To determine the optimal localization, we used the simulate annealing algorithm

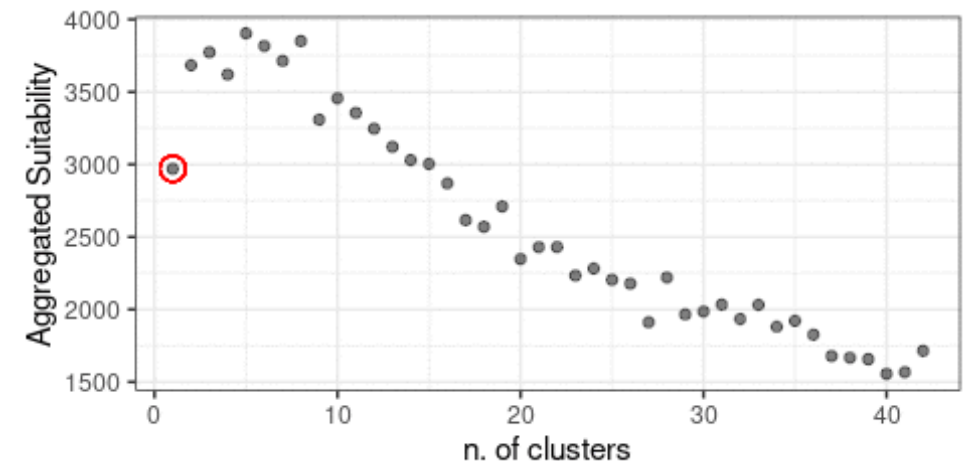
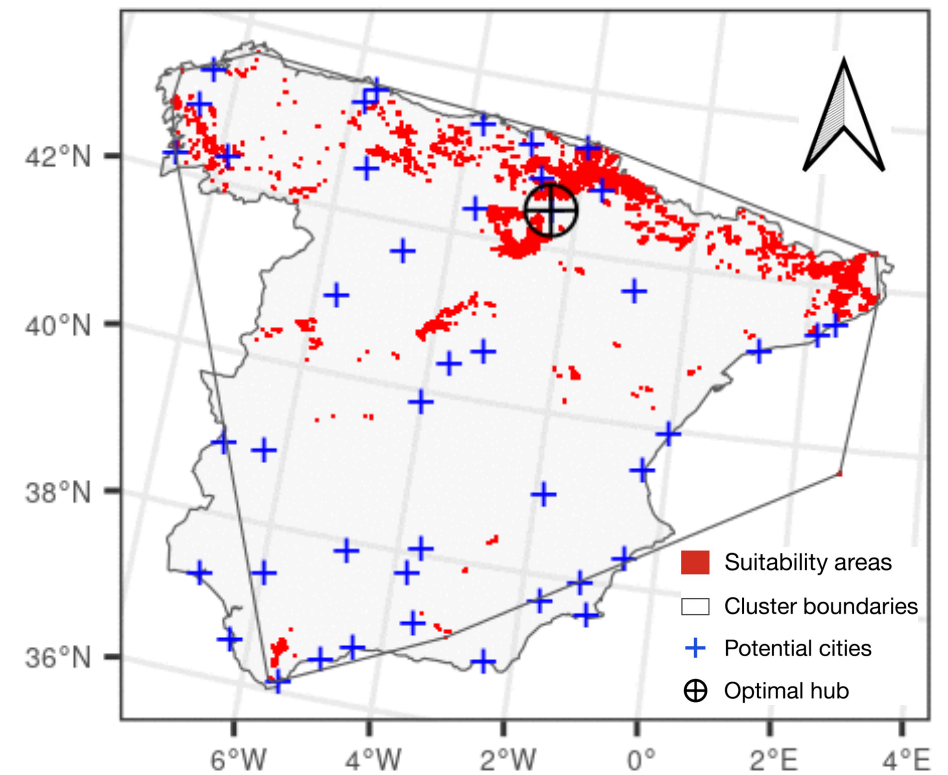
$$V_{k,i} = \left[\sum_{n=1}^N \left(\frac{S_n - \text{Dist}_{n \rightarrow i}}{S_n + \text{Dist}_{n \rightarrow i}} \right) \right] * nDNI_i$$

The cost-function was based on:

- Suitability areas (MCA)
- Road network (OpenStreetMap)
- Direct normal irradiation (DNI – WB)

City	Potential Biomass (10 ⁶ Mg)	Effective Biomass (10 ⁶ Mg)	Proximal Biomass (10 ⁶ Mg)	Without Natura 2000 (10 ⁶ Mg)
Algeciras	18.8	11.7 (62.1%)	1.08 (5.8%)	0.01 (0.1%)
Leon	85.2	41.1 (48.2%)	2.33 (2.7%)	1.66 (1.9%)
Logroño	99.7	69.6 (69.8%)	24.3 (24.4%)	11.4 (11.5%)
Madrid	13.9	10.2 (73.8%)	3.07 (22.1%)	0.16 (1.2%)
Mataro	60.7	37.3 (61.5%)	8.02 (13.2%)	4.29 (7.1%)
Ourense	131	59.7 (45.6%)	3.52 (2.7)	3.30 (2.5%)

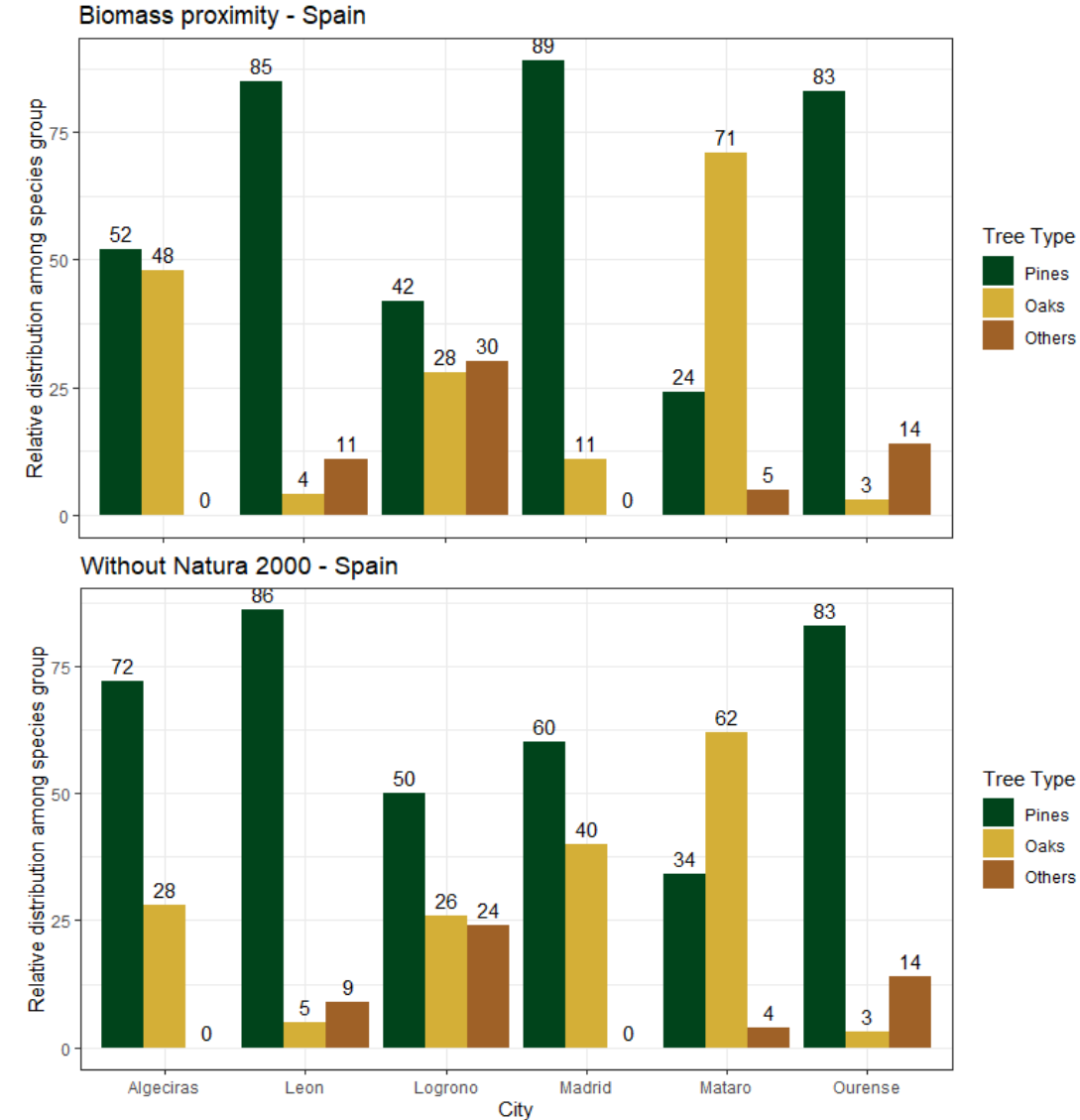
Kutchartt et al. under review



Biomass proximity (Mg) by tree species - Spain

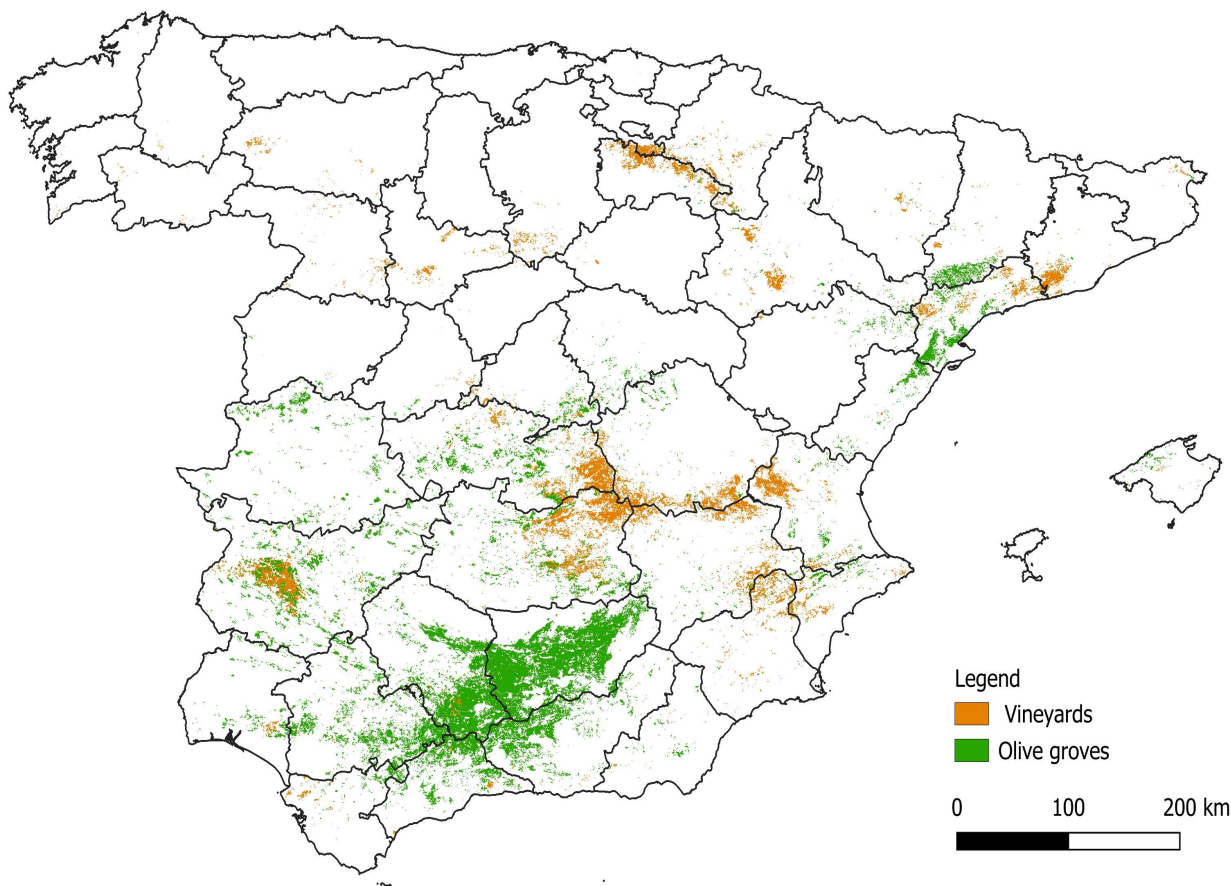
Biomass proximity considered only the biomass (Mg) within a **100 km radius** of the **optimal hub** and was very important to mask the areas that overlap **Natura 2000** protected areas.

	Proximal Biomass			Without Natura 2000		
City	Pines	Oaks	Others	Pines	Oaks	Others
Algeciras	561.6	518.4	0	7.6	2.9	0
Leon	1,980.5	93.2	256.3	1,427.6	83.0	149.4
Logrono	10,206.0	6,804.0	7,290.0	5,700.0	2,964.0	2,736.0
Madrid	2,732.3	337.7	0	97.2	64.8	0
Mataro	1,924.8	5,694.2	401.0	1,458.6	2,659.8	171.6
Ourense	2,921.6	105.6	492.8	2,739.0	99.0	462.0



Residual Agricultural Biomass

Residual agricultural biomass was quantified using the CORINE Land Cover map and crop yield data (kg/ha) at the provincial and regional scales.



Region	Rainfed (kg/ha)	Irrigated (kg/ha)	Total rainfed (Mg)	Total irrigated (Mg)
Castilla–La Mancha	3,939	14,079	1,727,749	6,176,061
Extremadura	3,955	10,865	298,782	820,801
Castile and Leon	3,862	6,782	282,070	495,340
Valencian Community	4,968	7,802	321,559	504,952
Catalonia	6,435	9,658	370,180	555,586
La Rioja	5,790	7,970	275,924	379,812
Aragon	2,666	6,773	93,020	236,319
Region of Murcia	2,720	6,490	80,610	192,338
Andalusia	4,956	6,782	130,773	178,949
Galicia	6,928	-	149,284	-
Navarra	5,355	6,552	100,223	122,625
Basque Country	5,890	8,572	83,603	121,672
Madrid	1,397	3,340	12,635	30,209

In wine production, **about 21%** of the grapes become **pomace**. However, the table on the right only estimates potential residues from wine production, assuming all **vineyards** identified in the CORINE land cover produce wine.

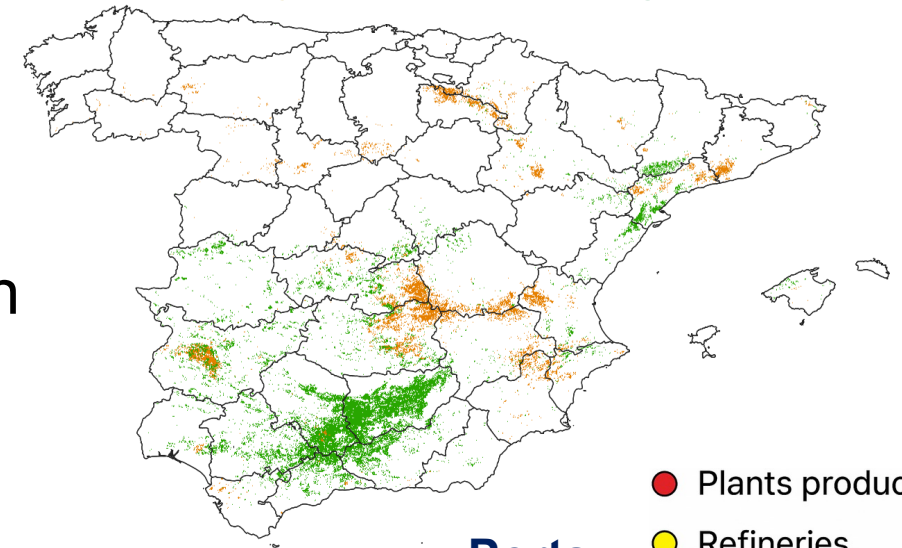


Region	Res. Rain. (Mg)	Res. Irr. (Mg)
Castilla–La Mancha	362,827	1,296,973
Extremadura	62,744	172,368
Castile and Leon	59,235	104,021
Valencian Community	67,527	106,040
Catalonia	77,738	116,673
La Rioja	57,944	79,761
Aragon	19,534	49,627
Region of Murcia	16,928	40,391
Andalusia	27,462	37,579
Galicia	31,350	-
Navarra	21,047	25,751
Basque Country	17,557	25,551
Madrid	2,653	6,344

Procedure to identify the optimal location for residual agricultural biomass were based on six main criteria:

- Landuse / Vegetational index (NDVI)
- Road network
- Direct normal irradiation
- Plants of olive oil and winery production
- Biorefineries
- Ports

Vineyards and **olive groves**

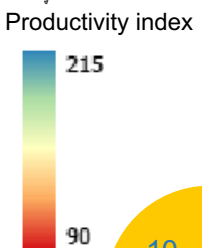
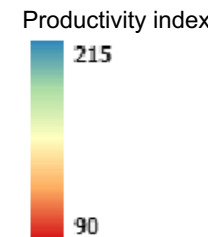
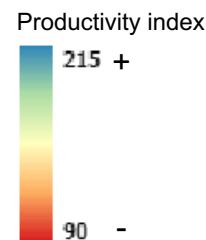
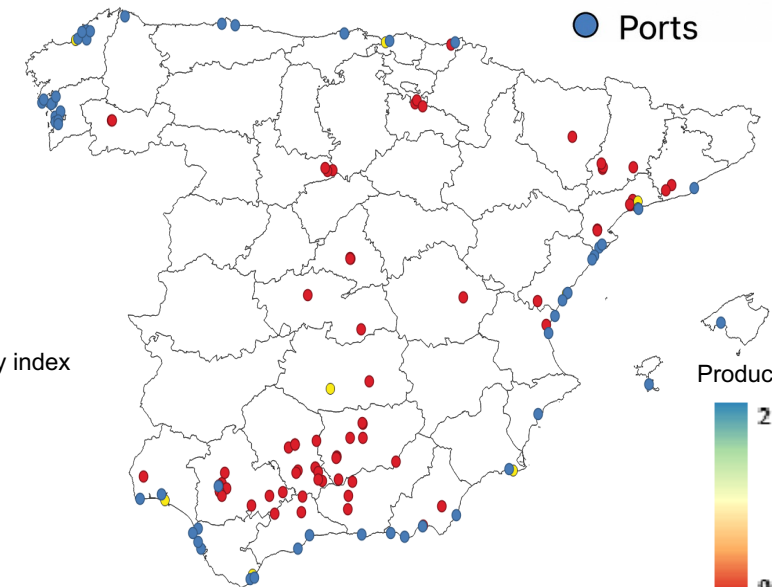
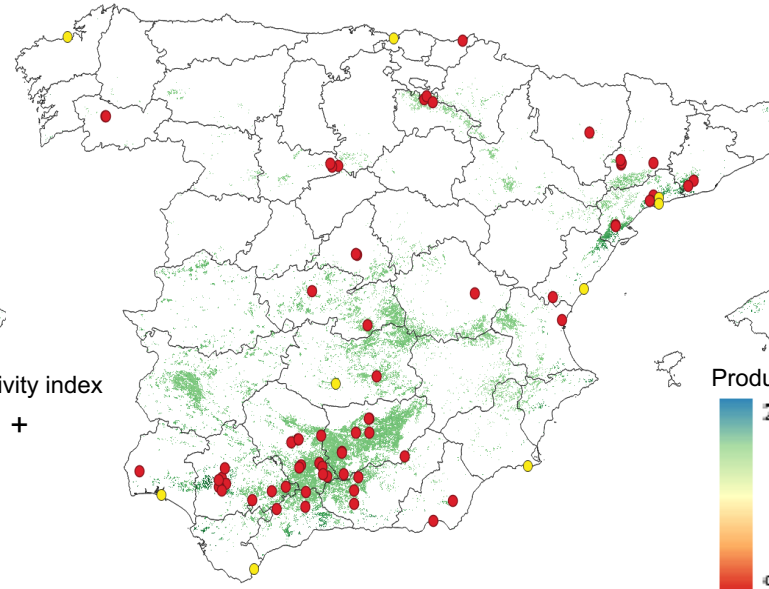
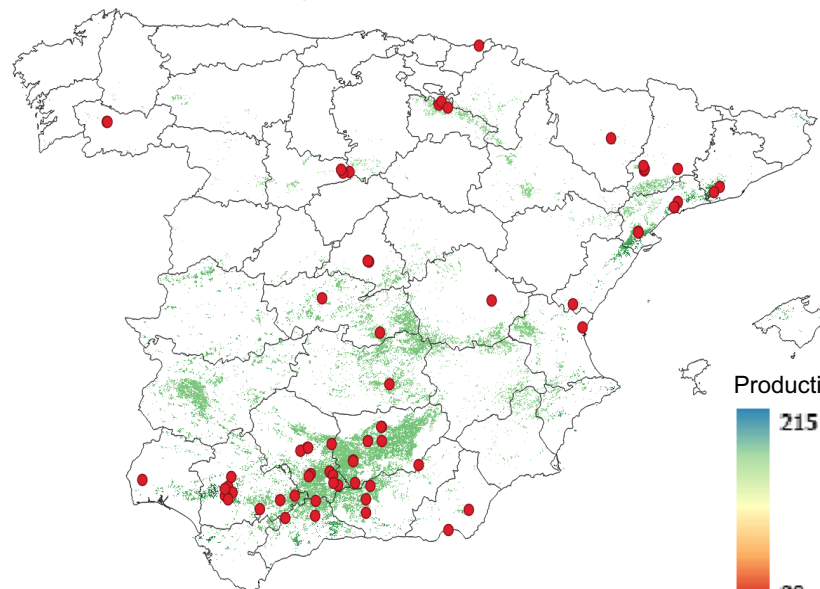


Winery and Olivar companies

Refineries

Ports

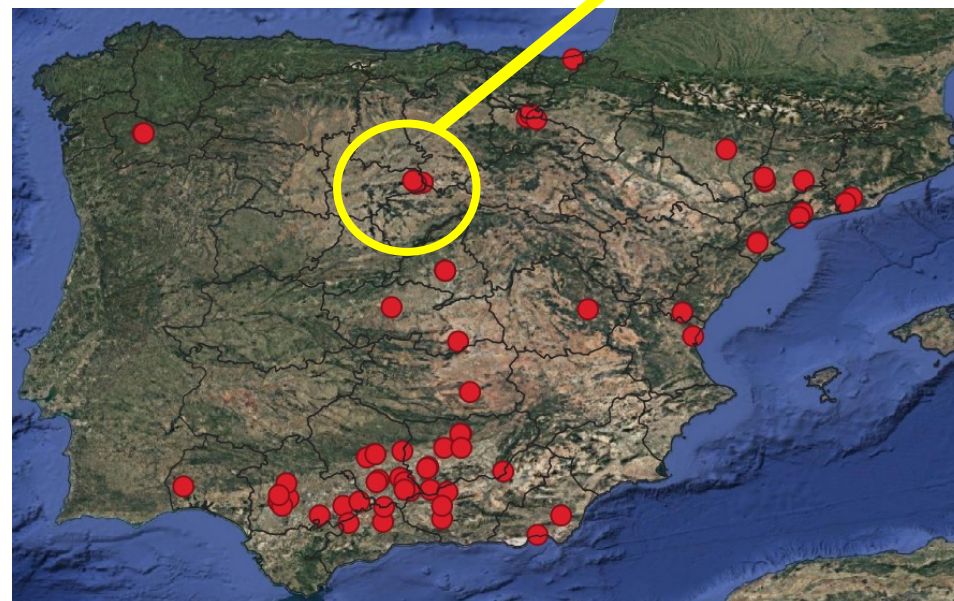
- Plants production
- Refineries
- Ports



Geodatabases regarding winery and olive oil producers and biorefineries were created through different portals



Through **satellite images** the **Olive oil** and **Winery** producing plants were **verified**



Here, it is important to **avoid** points in **urban areas**

Selection of the potential city to establish the solar-powered biorefinery using residual agricultural biomass

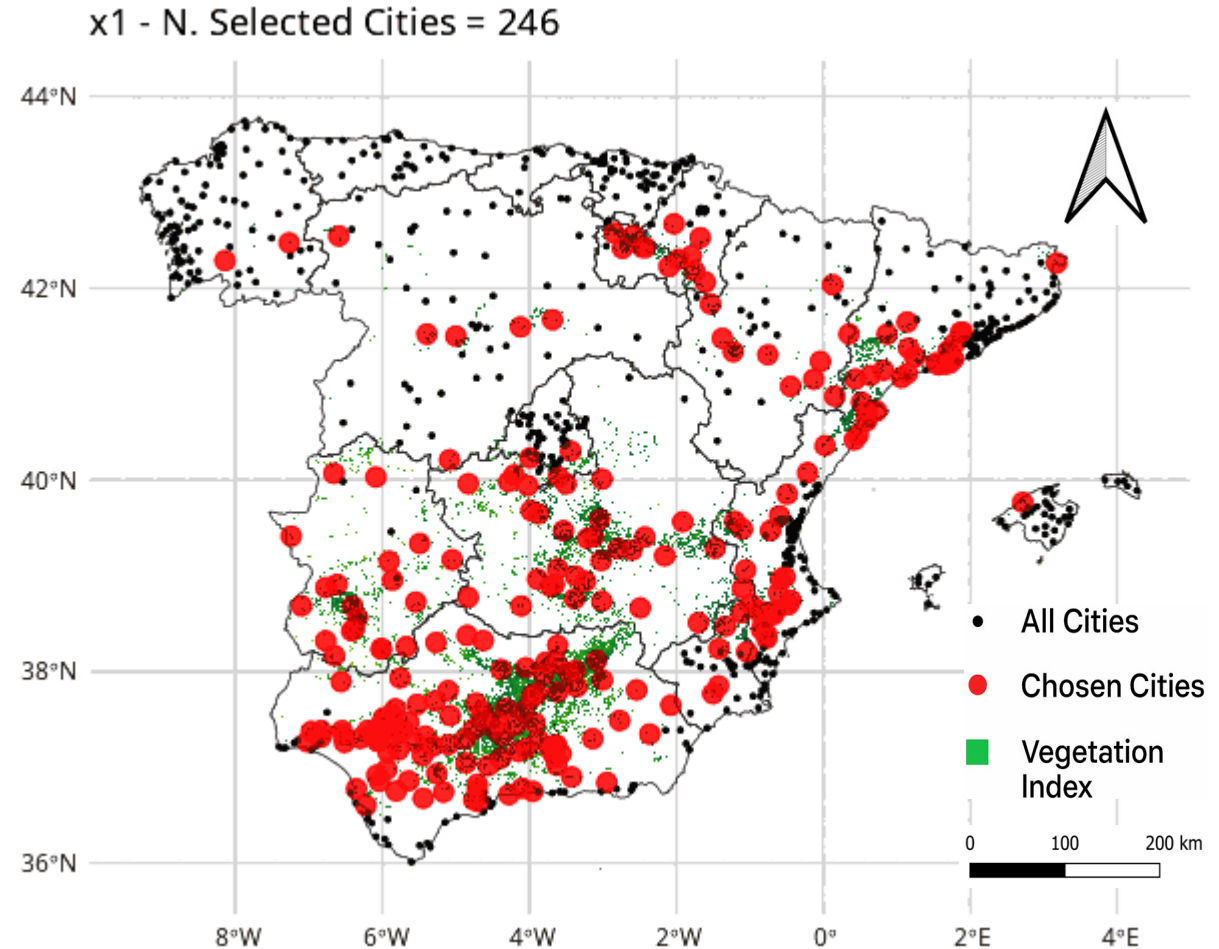
The result of most optimal location was found in the **Province of Sevilla**.

Therefore, in order to **allocate** a solar-powered biorefinery plant and use the residual agricultural biomass, the **nearest distance** was determined to a) road infrastructure, b) olive oil and winery companies, c) refineries, and d) ports.

$$C(n, k) = \binom{n}{k} = \frac{n!}{k!(n-k)!}$$

k = total number of cities available

n = number of cities actually chosen to build the plants

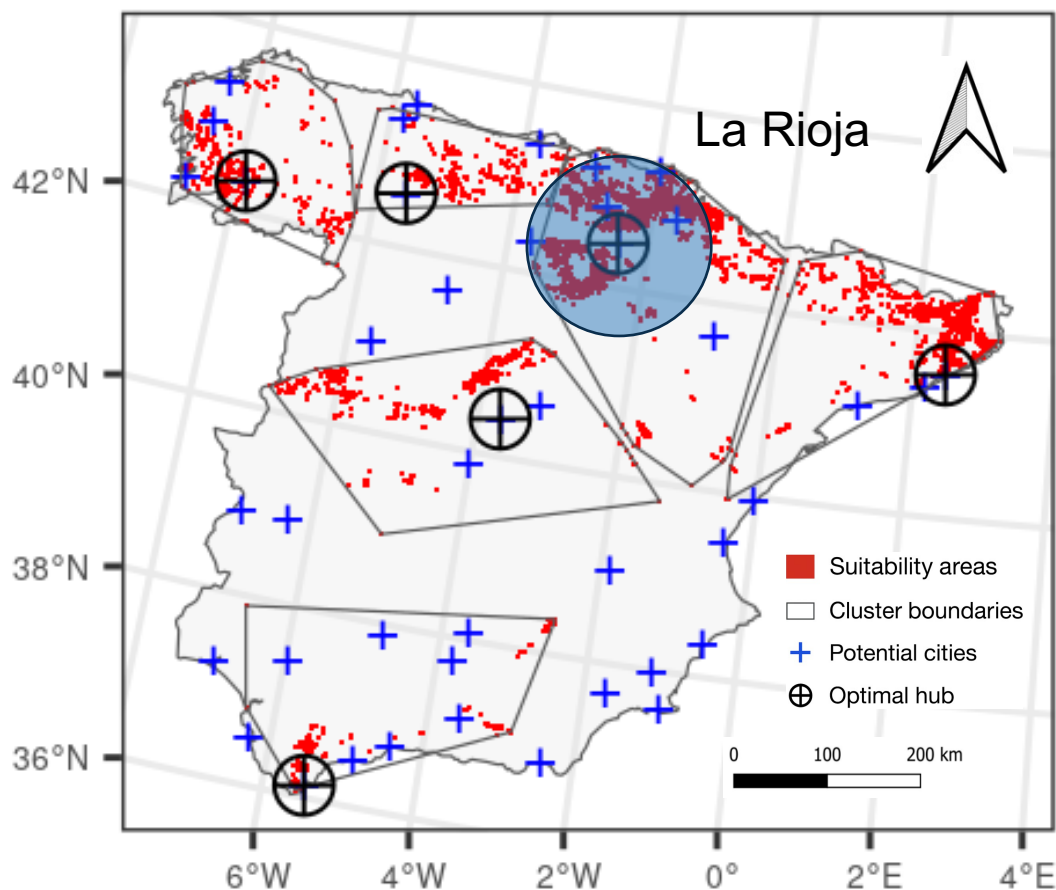


Kutchartt et al. under preparation

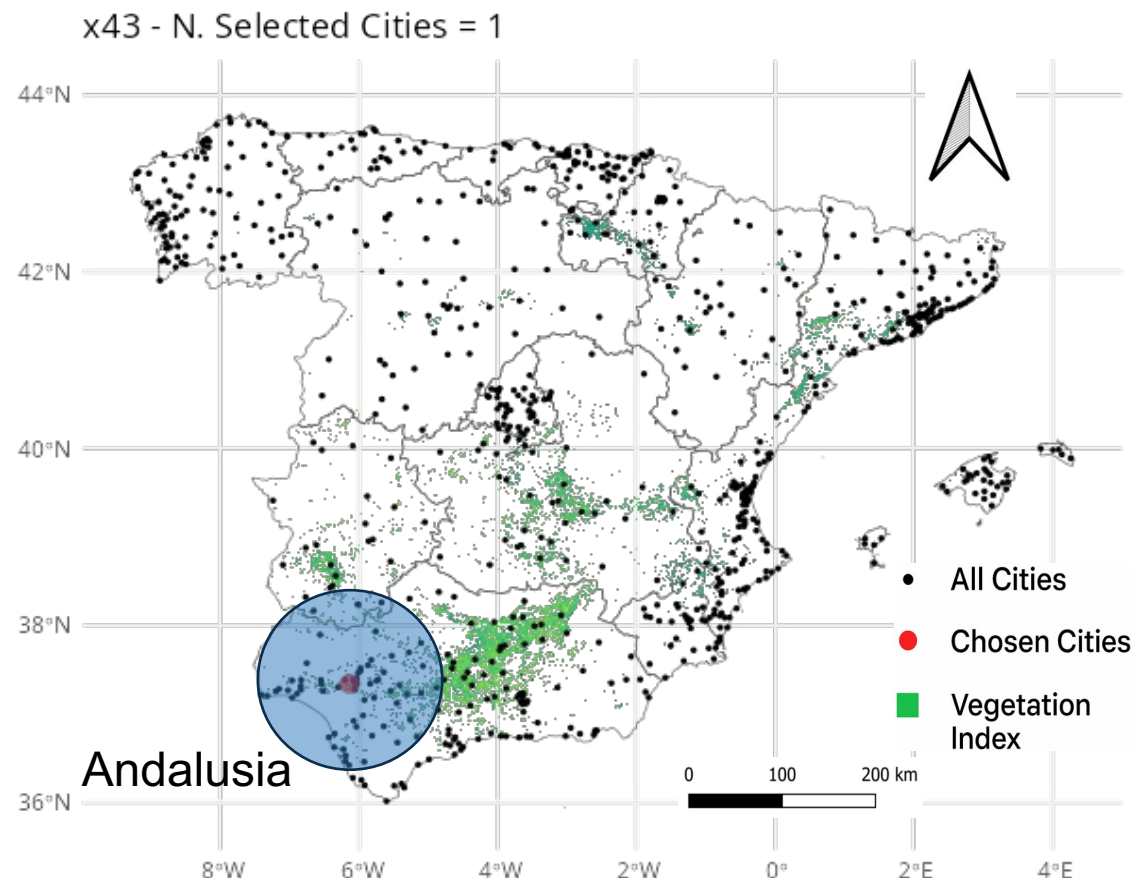
Final remarks

The allocation of forest and residual agricultural biomass was determined separately, with **La Rioja** and **Andalusia** identified as the most suitable regions.

Forest Biomass



Residual Agricultural Biomass





Thank you!

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