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GIS-BASED MODEL TO IDENTIFY MARGINAL SOILS FOR BIOENERGY PRODUCTION

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INTRODUCTION

Energy crops are industrial species (woody, perennial and annual species, algae, among others) that can generate biofuels, energy, and bioproducts. Due to their tolerance, there is an interest to grow energy crops in marginal, contaminated, and degraded soils, avoiding Indirect Land Use Change (ILUC) burdens. ArcGIS software was used as a Geographic Information System (GIS) tool and parameters associated with areas considered to be marginal in mainland Portugal were identified. Generated data identify strategic areas of mainland Portugal where crops can be grown for energy purposes and represent a possible solution to increase the sustainability of the marginal land and clean bioenergy/biofuel production. This work is relevant to who are developing studies related to the geolocation of suitable areas for the implementation of cultures on an industrial scale such as biorefineries and biomass power plants, and on a smaller scale, such as farmers willing to invest in new agricultural species (in non-marginal soils) or in the market sector as the industrial one, based on the production, availability, and sale of feedstocks, namely, energy crops on marginal soils.

OBJECTIVE

This study aims at the development and use of GIS tools to spatially relate land use selection and optimal species allocation, as a useful decision support systems (DSS), modelled to determine adequate marginal areas, inadequate for food and feed crops, for the implementation of selected energy crops in mainland Portugal.

1. MARGINAL CRITERIA BY EUROPEAN COMMISSION (EC) - JOINT RESEARCH CENTRE (JRC)

Criterion	Definition	Threshold Regulation EU (1305) 2013 – Annex III
Climate		
Low Temperature	Length of growing period	≤ 180 days
	thermal-time sum (degree-days)	≤1500 degree-days
Dryness	Precipitation/potential evapo-transpiration	≤ 0.5
Climate and soil		
Excess Soil Moisture	Number of days at or above field capacity	≥ 230 days
Soil		
Limited Soil Drainage	Areas which are water logged for a significant duration of the year	Wet 80cm > 6 months, or 40cm > 11 months
		Poorly or very poorly drained
		Gleyic colour pattern within 40cm
Unfavourable Texture and Stoniness	Relative abundance of clay, silt, sand, organic matter (weight %) and coarse material (volumetric %) fractions	≥ 15% of topsoil volume is coarse material, rock outcrop, boulder (▲)
		Texture class in half or more (cumulatively) of the 100 cm soil surface is sand, loamy sand (■)
		Topsoil texture class is heavy clay (≥ 60% clay)
		Organic soil (≥ 30%) of at least 40cm (▼)
		Topsoil contains 30% or more clay and there are vertic properties within 100cm of soil surface (♦)
Shallow Rooting Depth	Depth (cm) from soil surface to coherent hard rock or hard pan	Rooting depth ≤ 30cm (▶)
Poor Chemical Properties	Presence of salts, exchangeable sodium, excessive acidity	Salinity ≥ 4 dS/m in topsoil
		Sodicity ≥ 6 ESP in half or more of the 100 cm surface layer
		Soil acidity topsoil pH (H_2O) ≤ 5 (●)
Terrain		
Steep Slope	Change of elevation with respect to planimetric distance (%)	Slope ≥ 15% (◀)

2. DATA SOURCES

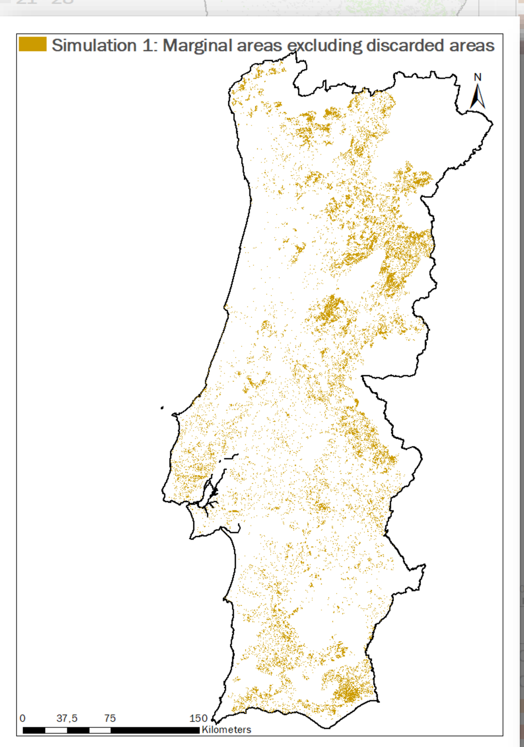
European: JRC European Commission

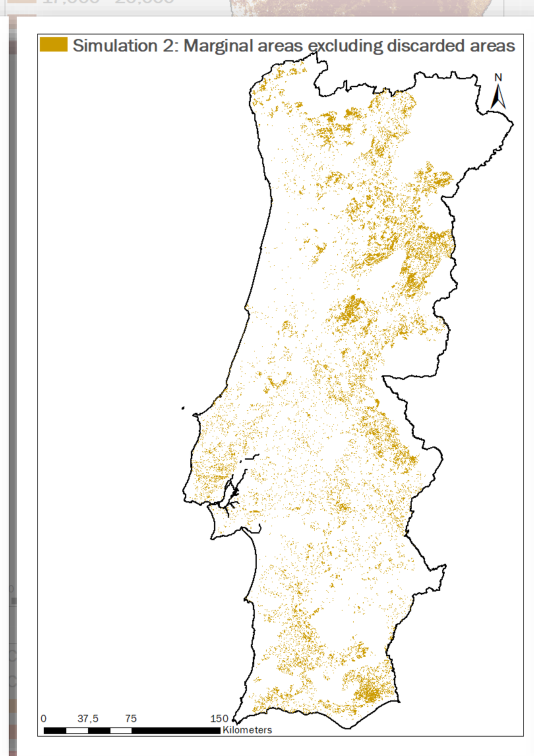
Portuguese: Instituto Superior de Agronomia – Universidade de Lisboa; INIAV – Instituto Nacional de Investigação Agrária e Veterinária, I.P.; ICNF – Instituto da Conservação da Natureza e das Florestas; DGADR – Direção-Geral de Agricultura e Desenvolvimento Rural; dgTerritório

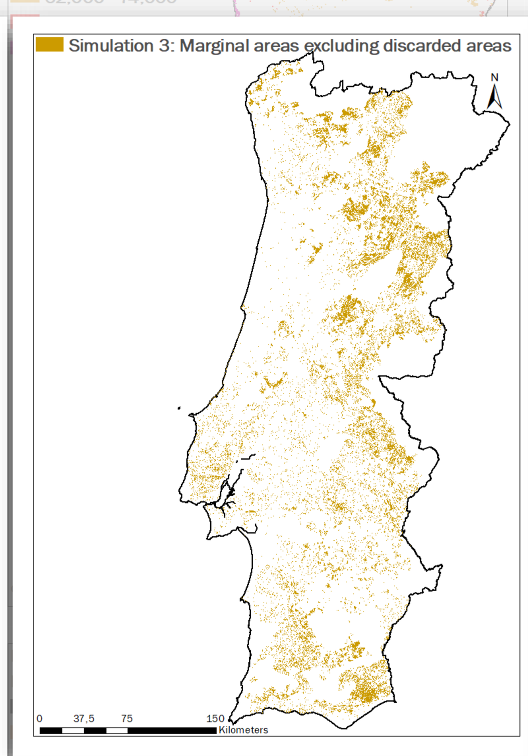
3. COLLETED AND UTILIZED DATA IN EACH SIMULATION WITH BASE IN THE CRITERIA HIGHLIGHTED IN GOLD BACKGROUND IN POINT 1

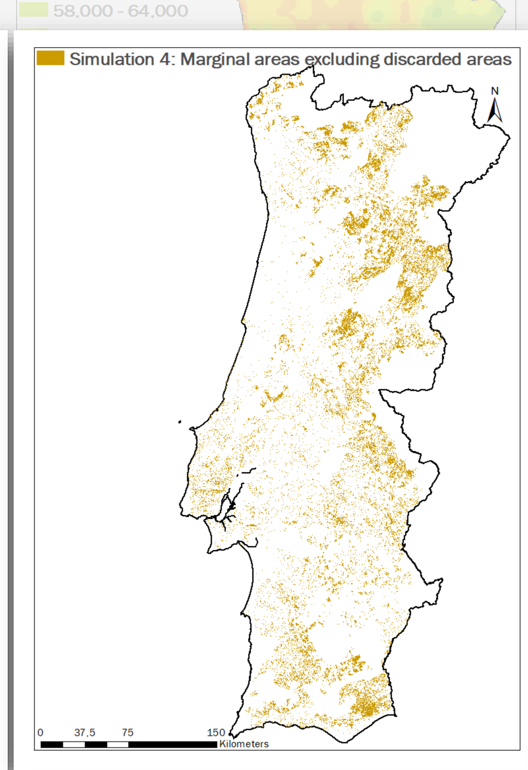
	Simulation 1	Simulation 2	Simulation 3	Simulation 4	Simulation 5
UNION OF ALL DATA SELECTED TO CREATE A UNIQUE MAP FOR EACH SIMULATION	Topsoil coarse fragments [European Soil Data Centre (ESDAC)-JRC] 2013 (▲)	Coarse fragments (ESDAC-JRC) 2015 (▲)			-
	Sand content (ESDAC-JRC) 2013 (■)				Sand content map (INFOSOLO-INIAV) (■)
	Organic content (ESDAC-JRC) 2013 (▼)	SOC content (ESDAC-JRC) 2016 (▼)	Organic content (ESDAC-JRC) 2013 (▼)	SOC content (ESDAC-JRC) 2016 (▼)	-
	Topsoil clay content (ESDAC-JRC) 2013 (♦)	Clay (ESDAC-JRC) 2015 (♦)			Clay content map (INFOSOLO-INIAV) (♦)
	Depth avaliable to roots (ESDAC-JRC) 2013 (▶)				Soil thickness [EPIC WebGIS-ISA (UL)] (▶)
	pH in H_2O (ESDAC-JRC) 2019 (●)				pH map (INFOSOLO-INIAV) (●)
	Slopes [EPIC WebGIS – ISA (UL)] (◀)				
DISCARDED AREAS	Protected areas (ICNF)				
	Portuguese National Agricultural Reserve (RAN) (DGADR)				
	Criteria (artificialized land, agriculture, forest, agro-forestry systems, beaches, dunes, wetlands, among others) from Land Use and Land Cover (COS 2018) (DGT)				

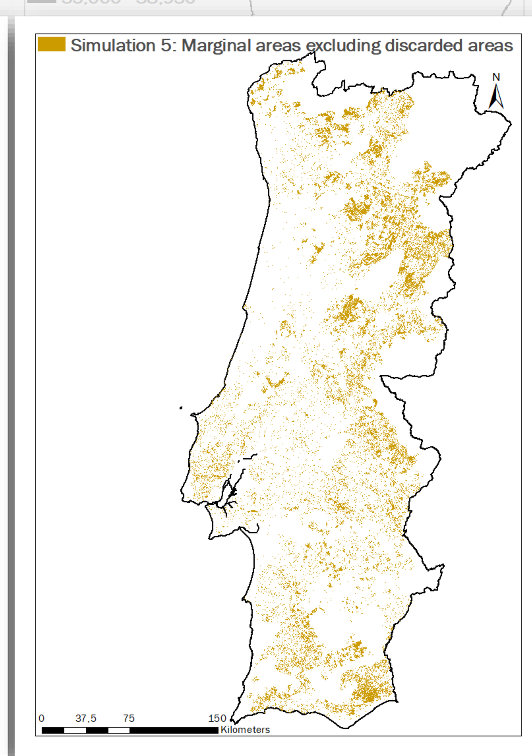
4. MARGINAL AREAS (EXCLUDING PROTECTED AREAS, PORTUGUESE NATIONAL AGRICULTURAL RESERVE AND SOME COS CRITERIA - DISCARDED AREAS)











5. MARGINAL SOILS AREAS AND PERCENTAGE OF THE PORTUGUESE TERRITORY

	Area (kha)	Percentage (%)
Simulation 1	755.57	8.48
Simulation 2	755.56	8.48
Simulation 3	866.68	9.73
Simulation 4	866.04	9.72
Simulation 5	880.05	9.88

CONCLUSION

The obtained area in each simulation does not differ too much from each other, being used maps from the same source (e.g. ESDAC-JRC) but from different years to the same criterion. Simulation 1 is considered the selected final map of marginal areas, as it uses the most accurate data being almost all from the same year (2013) and source (ESDAC-JRC).

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Geographic information data provided by the Joint Research Centre (JRC), Instituto Superior de Agronomia (ISA) - Universidade de Lisboa (UL), Instituto Nacional de Investigação Agrária e Veterinária, I.P. (INIAV, I.P.), Instituto da Conservação da Natureza e das Florestas, I.P. (ICNF, I.P.), Direção-Geral de Agricultura e Desenvolvimento Rural (DGADR) and Direção-Geral do Território (DGT).

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