

Agronomic feasibility of bioenergy crop cultivation on polluted soils in Sardinia: Insights and opportunities for land use design and environmental suitability

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INTRODUCTION

Anthropogenic soil diffuse pollution with heavy metals is of increasing question because of its potential effects on environment and ecosystem, as well as human health and safety. Heavy metal accumulation in agricultural and productive soils can be transferred to the food and feed or dispersed and lixiviated on freshwater, ground water, and rivers. The cultivation of dedicated energy crops across unavailable soils for food production could be a possible pathway for restoring contaminated and polluted soils, fostering land amelioration and rural development, responding to the European Union (EU) 20-20-20 targets and the EU's Renewable Energy Directive. This work reports the results of the agronomic feasibility of bioenergy crop cultivation on polluted land in the **Sulcis area** (Sardinia, Italy) (Fig. 1) within the framework of the EU project **FORBIO** (Fostering Sustainable feedstock Production for Advanced Biofuels on underutilized land in Europe). The area is contaminated with heavy metals (Pb, Cu, Zn, Co, As) (Fig. 2) from industrial plants located in the municipality of Portoscuso, as well as by old previous mining activities.

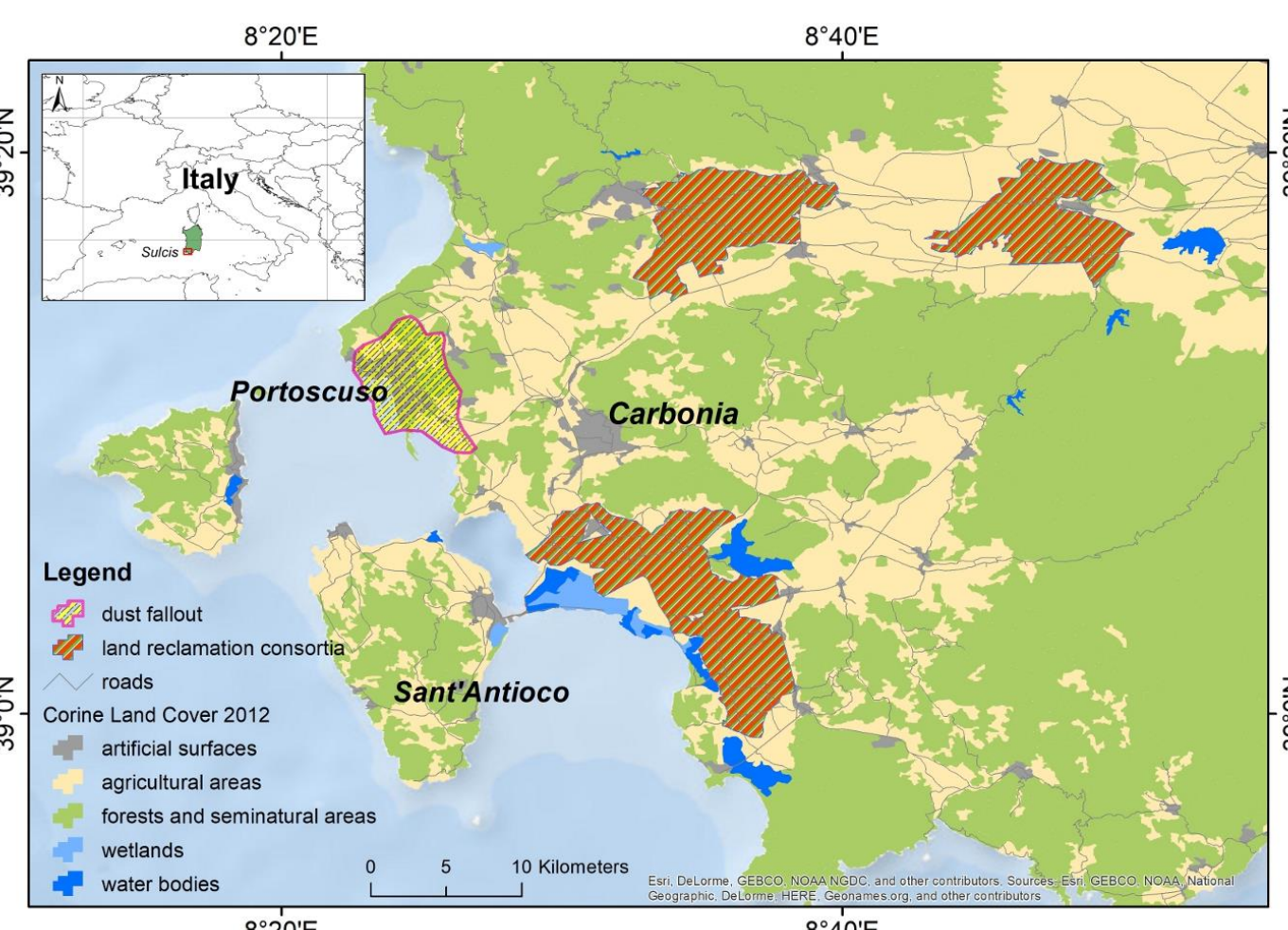


Fig. 1: Map of the study area

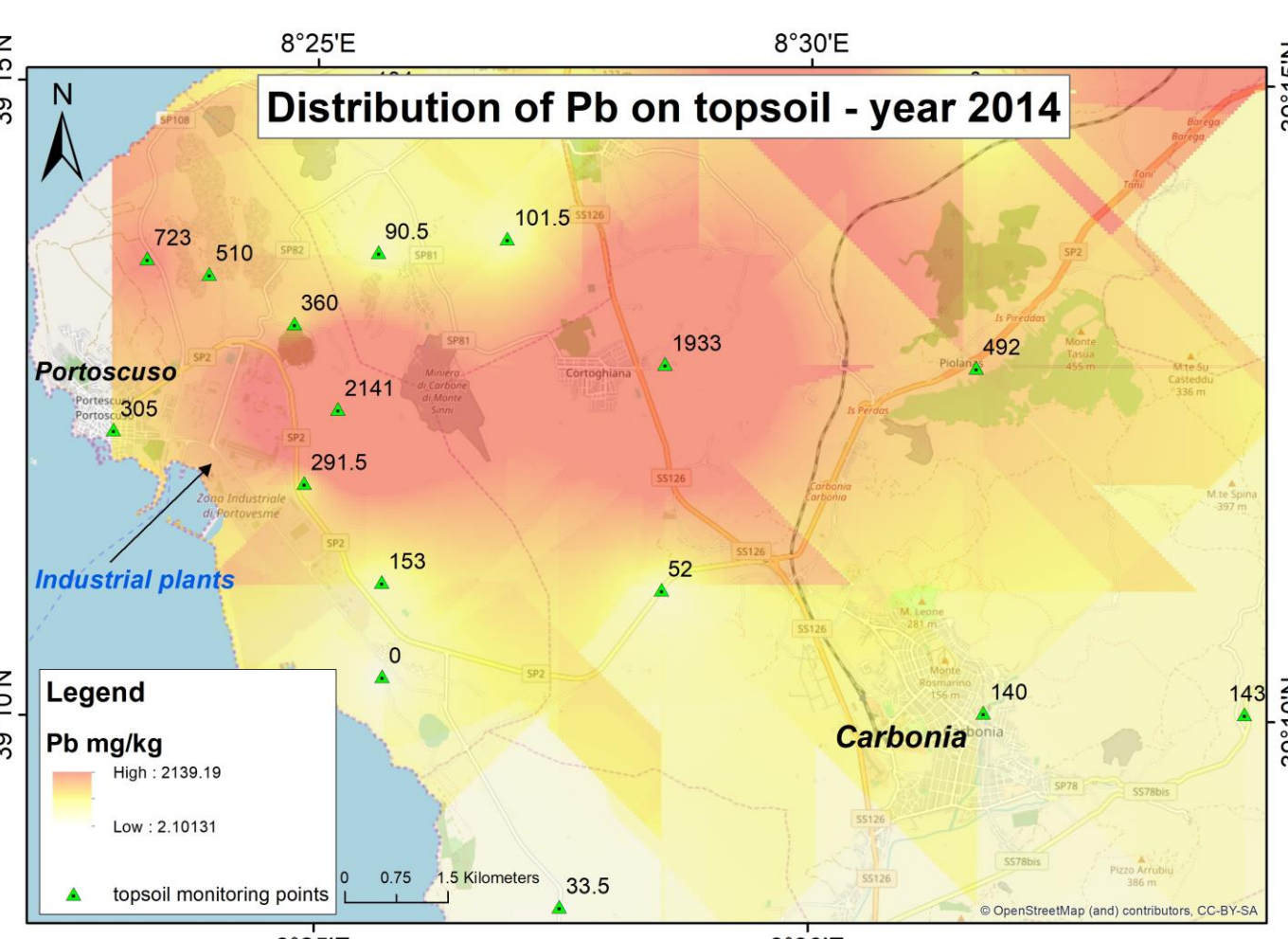


Fig. 2: Spatial distribution of Pb on topsoil

MATERIALS AND METHODS

The work was carried out with three major steps: (1) development of a detailed database on bioenergy crops (Tab.1) suitable for the region based on literature search, unpublished data and field trials results; (2) comparison of agronomic aspects and yield potentials; (3) landscape design based on **GIS evaluation** and remote sensing data (Fig. 3) for land environmental suitability and production potential. The results of the study will provide a useful reference for the overall feasibility of sustainable biomass cultivation, considering a future scenario of expansion on polluted soils in this region.

Tab. 1: Typologies of biomass crops analysed

Typology	Herbaceous plants		Tree plants
	Annual	Perennial	
<i>Lignocellulosic crops</i>	Globe-artichoke Milk thistle	Giant reed Miscanthus Switchgrass Smilo grass Tall fescue Ryegrass Cocksfoot Cardoon	Eucaliptus
<i>Oleaginous crops</i>	Rapeseed	Ethiopian mustard	
<i>Sugar crops</i>	Sweet-sorghum		
<i>Starch crops</i>	Maize Durum-wheat triticale		

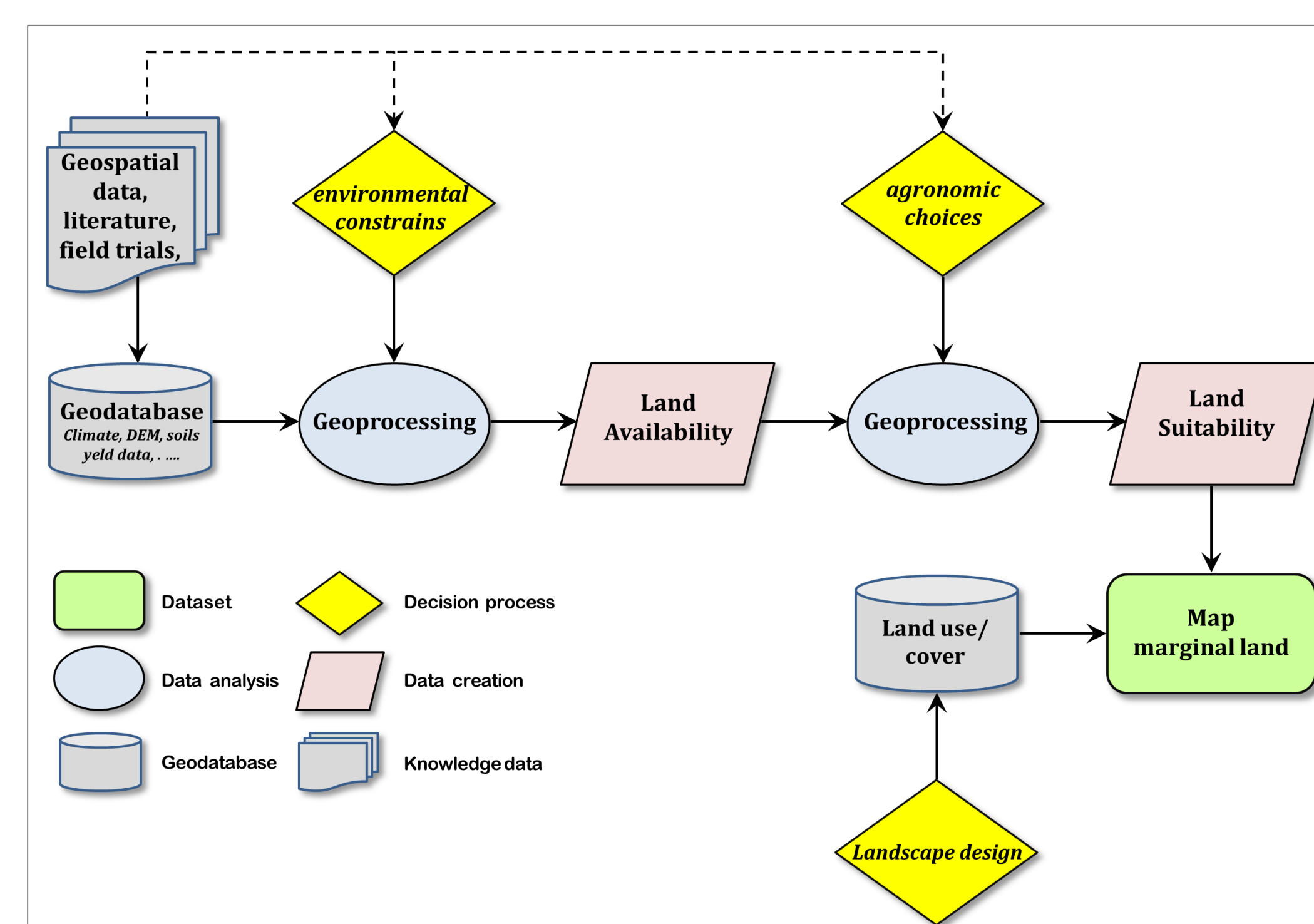


Fig. 3: Flowchart of the suitability analysis

MAIN RESULTS

According to our findings, annual crops most suitable for growing on polluted soils in the Sulcis area are milk thistle and sorghum thanks their phenotypic plasticity in terms of drought tolerance, water demand and evapotranspiration rate. Among perennial crops, giant reed, cardoon and native germoplasm of perennial grasses are the most suitable considering their stable biomass yields, low input, fermentable sugars, and adaptability in the Mediterranean environment (Fig. 4). Results from land suitability indicated that about **1,000 ha** are available for feedstock cultivation in the most contaminated area.

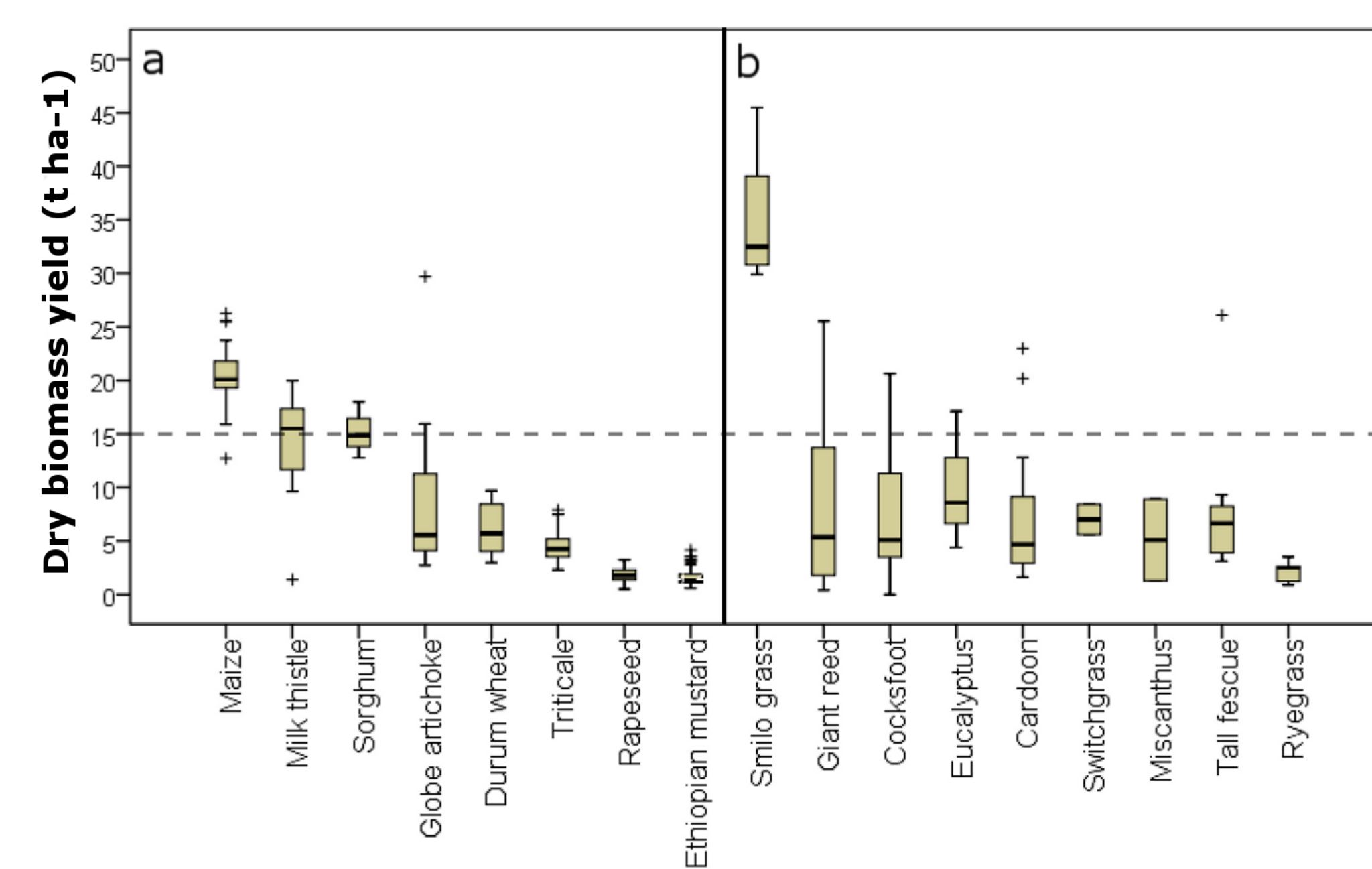


Fig. 4: Box-plot of biomass yield for annual crops (a) and perennial crops (b)

CONCLUSIONS

Based on the findings gathered in this study, the following conclusions can be drawn:

- dedicated bioenergy crops such as **giant reed** and **Cardueae** species can be potentially grown on polluted soil for providing biomass and raw materials in the supply chain for a biorefinery;
- according to our GIS-based multi-criteria approach, the most contaminated area, unequipped for irrigation, is suitable only for rainfed crops.

The present study provides a comprehensive assessment for providing biomass for a biorefinery in one of the most polluted industrial areas in Italy. Moreover, creates knowledge required for further land use actions for reducing heavy metal accumulation on polluted soils.

References

Pulighe, G.; Bonati, G.; Fabiani, S., et al. *Assessment of the Agronomic Feasibility of Bioenergy Crop Cultivation on Marginal and Polluted Land: A GIS-Based Suitability Study from the Sulcis Area, Italy*. *Energies* 2016, 9, 895.

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