BECOOL
Brazil-EU Cooperation for Development of Advanced Lignocellulosic Biofuels

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1. Introduction

Biomass is the largest renewable energy source in Europe with respect to current use and will be the major contributor into the future, according to future projections. Based on the evaluation of the NREAPs data, the ECN/EEA report[1] indicates, among others, that solid (lignocellulosic) biomass accounts for 78% renewable heating and cooling output. Unexploited biomass quantities could play a significant role in increasing the penetration of biomass in the European, national and regional energy balance supporting member states to meet their 2020 and beyond energy targets.

There are a number of studies on biomass resources on global and European level published over the last 20 years and numerous projects carried out in the EU (i.e., EUBIONET, BEE, Biomass futures, S2BIOM, etc), which quantified the actual and potential biomass availability in/and outside Europe. In 2013, the total biomass harvested in the EU and used from the EU agricultural and forestry sectors was estimated by JRC at 805 Mt dry matter (578 Mt from agriculture, 227 Mt from forestry), and another 119 Mt were grazed in pastures[2]. In this study, feed and food uses was the most important category adding up to almost 62% of the biomass, while bioenergy and bio-materials were quite balanced accounting for circa 19% of the total biomass in the EU-28. However, it is important to note that biogas and bioelectricity have not been considered while bioenergy and biomaterials may have been underestimated due to large data gaps.

Among the EU biomass resources, agricultural residues are the most abundant and with the highest availability. A review made by Esteban and Carrasco[3] in 2011, over 11 EU countries representing 77% of the total EU territory, estimates the potential of agricultural residues of 364,50 Tg y-1, of which 56% are available to be used under sustainable conditions, which is equivalent to almost 4% of the present EU gross inland energy consumption. Recently, it was estimated that agricultural residues could potentially supply 16% on the road transport fuel needed in 2030, generating more than 60% GHG savings and up to 300,000 jobs, mostly in the rural areas[4]

[1] L.W.M. Beurskens and M. Hekkenberg. Renewable Energy Projections as Published in the National Renewable Energy Action Plans of the European Member States Covering all 27 EU Member States. ECN/EEA, 2011

[2] Camia A., Robert N., Jonsson R., Pilli R., García-Condado S., López-Lozano R., van der Velde M., Ronzon T., Gurría P., M'Barek R., Tamosiunas S., Fiore G., Araujo R., Hoepffner N., Marelli L., Giuntoli J., Biomass production, supply, uses and flows in the European Union. First results from an integrated assessment, EUR 28993 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN978-92-79-77237-5, doi:10.2760/539520, JRC109869

[3] Esteban L.S and Carrasco J.E. Biomass resources and cost assessment in different EU countries. Biomass and Bioenergy 35, S21-S30, 2011.

[4] Wasted, Europe's untapped resource, An Assessment of Advanced Biofuels from Wastes & Residues, 2014

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2. Objectives and approach

This work is carried out in the frame of the BECOOL 'Brazil-EU Cooperation for Development of Advanced Lignocellulosic Biofuels' project. The main objective of the BECOOL (EU) and the counter project BioVALUE (Brazil) is to strengthen EU-Brazil cooperation on advanced lignocellulosic biofuels. Information alignment, knowledge synchronization, and synergistic activities on lignocellulosic biomass production logistics and conversion technologies are key targets of both projects and will bring mutual benefits. Both projects are structured in 3 main pillars covering in a balanced way the whole range of activities of the biofuels value chain (biomass production, logistics, conversion and exploitation).

This deliverable D1.1 refers to the first work-package WP1 'Biomass production and feedstock diversification for advanced biofuels' and more specifically to 'Task 1.1. Literature review on biomass assessments', which aims at the comprehensive assessment of the available agricultural, forest, and industrial lignocellulosic residues of potential interest for advanced biofuels in EU and Brazil.

In this deliverable the assessment criteria of the literature review assessment are set so as to identify biomass feedstocks of common interest with Brazil. Following these criteria, a list of at least 10 major EU projects and tools are identified and will be reviewed during the second year of the project.

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3. The assessment criteria to identify biomass feedstocks of common interest with Brazil

a/a	Name of criterion	Description
1.	Geographic coverage	The inventory will cover Southern EU regions, so as to allow synergies with the Brazilian partners. Focus on studies that provide data at national level in Greece, Italy and Spain.
2.	Biomass types	The inventory will focus on lignocellulosic feedstocks of potential interest for advanced biofuels in Europe and Brazil: cereal residues, pruning and forest residues, bagasse, lignin rich process residues.
3.	Biomass potential types	The inventory will cover all types of biomass potential assessment (theoretical, technical, economic, sustainable), depending on the existing information.
4.	Time coverage	The inventory will include recent information (after 2010)
5.	Literature coverage	The inventory will review studies/articles/tools produced in EU funded projects, with focus on those that are also tested in case-studies
6.	Information coverage	The inventory will include information on: - biomass quantities, availability, - existing harvesting and logistic options, - relevant fuel analytical characteristics, - market prices, cost and supply curves Any other information on testing of these material in gasification, pyrolysis or fermentation units (scale and duration of experiments, results, advantages and constraints

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4. Assessment tools/projects to identify biomass feedstocks of common interest with Brazil

A search in past projects, studies and relevant literature reviews was carried out in order to identify assessment tools and project findings that could be used in this project in order to identify biomass feedstocks of common interest with Brazil. The required information will cover Southern EU regions, so as to allow synergies with the Brazilian partners.

a/a	Name	Description
1.	Bioraise	A web tool with GIS functionalities that focus on residual agricultural and forestry biomass and cover five EU Mediterranean countries: Spain, Portugal, France, Italy and Greece. A product of Biomasud Plus project.
2.	Bioraise SE	A web tool with GIS functionalities developed to asses the potential of selected energy crops in Spain.
3.	LocaGIStics	It is a local assessment tool for biomass delivery chains, developed in the frame of the S2BIOM project (see number 7 of this table). This tool supports the user to design optimal biomass delivery chains and networks at regional level and analyze in a comparative way (for different biomass delivery chains) the spatial implications and the environmental and economic performance, taking into account biomass cost-supply curves, conversion and pre-treatment technology options. This tool provides support to more regional and local stakeholders in making strategies for best ways to develop their bio-based economy and making use of sustainable local biomass resources potentially available to them.
4.	BeWhere	BeWhere is a techno-economic engineering model for renewable energy systems optimization. It identifies the localization, size and technology of the renewable energy system that should be applied in in a specific region. BeWhere was developed at IIASA and Luleå University of Technology, Sweden, from 2006 onwards. In 2010 it was expanded by IIASA from the local and national levels to the EU27 level.

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5.	Bioloco	The biomass logistics computer optimalization (Bioloco) tool was developed by WUR and it is a model which optimizes the biomass value chain to a set of pre-defined economic, energy and Green House Gas (GHG) efficiency targets. The model calculates the optimal bio-energy chain (within certain constraints), considering biomass types, transport types, storage facilities, pre-treatment methods, conversion techniques, based on a chosen optimization criterion (financial, energetic or emission) or combination (goal programming). Typical biomass constraints taken into account by the model are the seasonal fluctuations in supply and demand of biomass, losses of water due to drying (positive effect), losses of dry matter due to heating (negative effect).
6	BIOMASUD PLUS (www.biomasudplus.eu) June 2016- May 2019	Biomasud Plus 'Developing the sustainable market of residential Mediterranean solid biofuels' aimed to develop tools and databases with information about sustainable biomass resources to have a global vision and identifying sustainable solid biofuels supply chains.
7.	S2BIOM (www.s2biom.eu) Sept 2013-Oct 2016	S2BIOM toolset contains data, tools, documents and reports generated in the S2BIOM project regarding the sustainable delivery of non-food biomass feedstock at local, regional and pan European level. Most of the results of the BEE project (see number 8 of this table) have been incorporated in the S2BIOM toolsets. Furthermore, it was building on the results of the logistical project LOGISTEC (number 9), INFRES (number 10) and EUROPRUNING (number 11).
8.	BEE Biomass Energy Europe (www.bee.eu) March 2008 – Nov 2010	It was focused to improve the accuracy and comparability of future biomass resource assessments for energy by reducing heterogeneity, increasing harmonization and exchanging knowledge.
9.	LOGISTEC – improving logistics for energy crops (www.logistecproject.eu) Sept 2012 – Feb 2016	It aims to develop new or improved technologies of the biomass logistics chains.

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10.	INFRES (www.infres.eu) Sept 2012 –August 2015	It aims to accelerate the technological development and to open paths to EU´s renewable targets by producing research based knowledge, technological solutions and service innovations for forest residue feedstock supply.
11.	EUROPRUNING (www.europruning.eu) April 2013- June 2016	The project aims to the development of new improved logistics for pruning residues. This includes harvesting, transport and storage for agricultural pruning (fruit tree, vineyards and olive grove pruning and branches from up-rooted trees).
12	Proforbiomed (www.proforbiomed.eu) February 2011-October 2014	Proforbiomed 'PROMOTION OF FOREST BIOMASS IN THE MEDITERRANEAN' aims to develop and promote the use of forest biomass for the creation of a sustainable energy production chain in Mediterranean forests.
13.	AgroCycle (www.agrocycle.eu) (June 2016 – May 2019)	The agricultural waste value chain assessment, aims to map, characterize and quantify the available agricultural waste co-products and by-products.
14.	EUBIONET II (www.eubionet.eu) 2002	The EUBIONET II - European bioenergy network analyzed current and future biomass fuel market trends and biomass fuel prices. Country reports.
15.	SIMWOOD – Sustainable mobilization of wood (www.simwood-project.eu) Nov 2013 - October 2017	The SIMWOOD project aims to increase the mobilization of wood from forests and woodlands in Europe.
16	The GREEN-AgriChains (www.green-agrichains.eu/) 2013-2015	It aims at tackling all aspects of Green Supply Chain Management (SCM) and Logistics, focused on the Agrifood sector. It will deal with sustainable farming, reverse logistics, green procurement and sourcing, waste management and packaging reuse, transportation, etc.

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5. The Bioraise model: A GIS tool for sustainable biomass assessment in Southern Europe

Apart from the literature survey, two GIS tools have been developed by CIEMAT for the evaluation of biomass forest, agricultural and industrial residues (BIORAISE) and energy crops biomass availability (BIORAISE CE). These models will be used in the assessments of biomass resources in the BECOOL project and for scaling up scenarios of results taken from WP1, and specifically from Task 1.2 'Dedicated annual lignocellulosic crops', Task 1.3 'Dedicated perennial lignocellulosic and SRF crops' and Task 1.4 'Harvesting logistics'.

5.1 BIORAISE Platform description

BIORAISE background

BIORAISE is a GIS tool for the assessment of agri-forest residues availabilities and costs in Mediterranean countries.

BIORAISE first version was developed in 2009 under the framework of the UE 6FP Project CHRISGAS. A new and updated version was produced in 2012 under the framework of the Interreg Sudoe project BIOMASUD, where sector stakeholders' information was also incorporated to the tool. The scope of the tool at this stage was the countries of the EU Sudoe Region. Currently, under the H2020 project BIOMASUD Plus, the tool is being deeply updated and improved, and extended to new Mediterranean countries, in order to provide a more accurate and reliable calculations. The new BIORAISE will therefore cover the following countries: Croatia, France, Greece, Italy, Portugal, Slovenia, Spain and Turkey.

Objective

BIORAISE (improved version under elaboration) is a GIS tool that provides quantified information of biomass resources available and exploitation costs, together with the biomass types and relevant information of bioenergy sector stakeholders. It derives potential biomass resources from field productivities to biomass availabilities taking into account environmental constraints and efficiencies of the harvesting processes. Transport to conversion plant gate is also considered and costs evaluated in the logistics assessment of the biomass supply chain.

The new improved BIORAISE version, that will be available on line shortly, will be used to help in the biomass resources assessments in BECOOL project.

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Methodology and information provided

As mentioned, BIORAISE platform methodology is being updated and radically improved (regarding models and databases used) in 2018, and extended to new Mediterranean countries.

The new BIORAISE tool considers biomass potentials from two types or resources: agricultural residues, and forest and shrub land resources. In the case of agriculture resources, the biomass potentials are calculated utilizing relevant EUROSTAT data, and surfaces have been linked to the geospatial data of CORINE LAND COVER (version 2012). As statistics refer to agriculture production, the biomass resources are derived from applying residue-to-production ratios. Efficiency rates related to harvesting processes are considered to compute the available resources that could be destined to bioenergy uses. Therefore, potential and available biomass resources are given for several categories: irrigated crops, rainfed crops, rice, vineyard, orchards and mixed crops (agroforestry systems consisting of herbaceous crops under sparse tree cover).

Forestry and shrub land resources are computed for the categories of broadleaved species, coniferous mixed stands, shrub lands (Scrub and/or herbaceous vegetation associations) and dehesas (agroforestry areas) in CORINE LAND COVER, integrating the Pan-European Map of Forest Biomass Increment[5] (Mg ha^{-1} yr^{-1}) and net primary productivity NPP[6] (g/m^2 yr) with productivity tables derived from national forest inventories from the countries included in the tool, where available. Estimations of the available resources are applied when the national forest inventories do not perfectly match the CORINE land uses, neither surfaces nor dates. Available resources consider environmental restrictions related to terrain slope, erosion risk values from the areas covered by the PESERA Soil Product[7] (Soil erosion estimates) in t ha^{-1} yr^{-1}) for 2000-2003 and the Soil organic carbon content (fine earth fraction) in g per kg at depth 0.30 m from SoilGrids[8]. In addition, dominant stands (> 50% principal species) of tree specific geospatial data from the JOINT RESEARCH CENTRE[9] are shown in case the user wants to download the surfaces and apply a particular productivity rate.

BIORAISE (actualised version) implements also environmental risks (see Figure 1). As there are no clear definitions regarding exploitation of resources for the diversity of stakeholders, it was decided to depict visually the vulnerability of the areas considering variables like slopes, depth to bedrock, coarse fragments, RUSLE equation erosion due to rainfall, net primary productivity, soil organic carbon content and soil erosion risk. It is an intuitive representation regarding a sustainable management.

[5] https://data.europa.eu/euodp/es/data/dataset/38a3b611-eae1-423f-a4aa-c5cfdea03bd9
[6] http://bio.discomap.eea.europa.eu/arcgis/services/NPP/NPP/ImageServer
[7] https://esdac.jrc.ec.europa.eu/themes/pesera-model
[8] https://soilgrids.org/
[9] http://data.jrc.ec.europa.eu/collection/fise

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The resources exploitation logistic chain consists of harvesting, storage and transport costs, that BIORAISE calculates as €/tonne of dry matter. The tool computes resources on the fly from user-selected points, considering a circular area, and provides the numbers for administrative regions (NUT2 regions, which is the statistical territorial units in the European Union databases). The energy content (GJ yr^{-1}), and ash content (% dry matter) result from average references obtained from laboratory characterization of selected samples (calorific values are updated according to moisture content choices).

The stakeholders' database contained in the present BIORAISE version is also being extended to the new countries and updated for the existing ones. It provides information of producers (raw biomass producers, wood, olive oil, nut hulling, and wine sector –distilleries- industries) and other market related actors (e.g., equipment and machines for industry, services and facilities, manufacture of biofuels and biomass valorisation, biofuel dealers, research centres, large consumers, and BIOMASUD PLUS label biofuel producers).

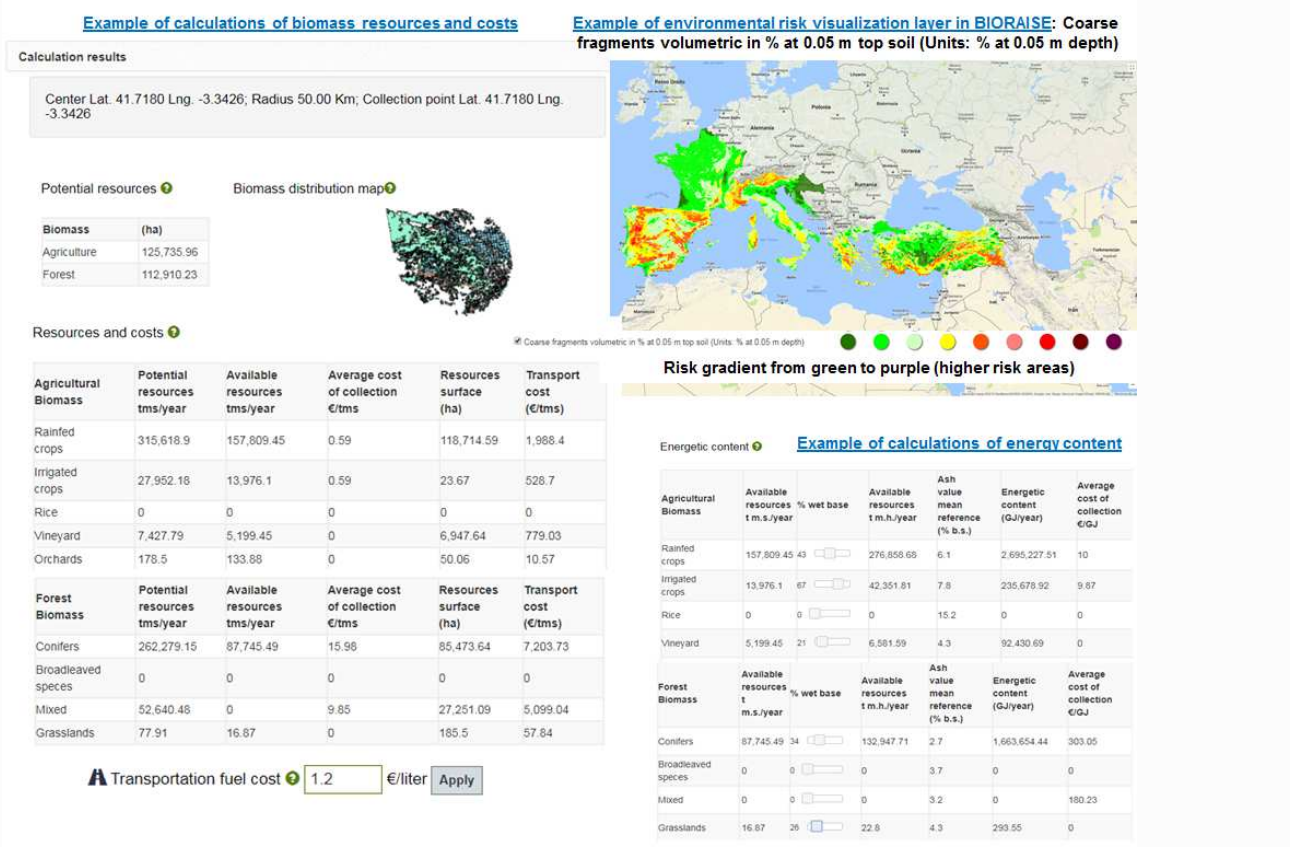

Figure 1: Example of results provided by BIOMASUD PLUS.

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Clean Hydrogen-rich Synthesis Gas (CHRISGAS). Funded by the European Union under the Program for Energy Valorization of Wastes (6th Framework Program) from September 2004 to September 2008.

Developing the sustainable market of residential Mediterranean solid biofuels (BIOMASUD). Funded by the European Union under the framework of the Interreg IV B programme from January 2011 to December 2013.

Developing the sustainable market of residential Mediterranean solid biofuels (BIOMASUD PLUS). Funded by the European Union under the framework Horizon 2020 from January 2016 to December 2018.

5.2 BIORAISE CE Platform description

Bioraise CE background

Bioraise CE is a tool for the assessment of energy crops potential in Spain. This tool has been developed in 2015 under the framework of the Spanish project DECOCEL (2012-2015) (INNPACTO Programme) considering the knowledge and results acquired during the development of the Spanish project ONCULTIVOS (2005-2012).

Objective

BIORAISE CE is a GIS based online tool whose objective is to provide the amount of biomass than can be potentially obtained from the cultivation of energy crops (cardoon, triticale, sorghum and poplar) in an area in Spain that can be chosen by the users. The tool provides data regarding potential productivity, biomass production costs, energy balances and greenhouse gases emissions of crops in the selected area.

Methodology

The methodology used allows applying the knowledge acquired during years of demonstrations of energy crops in several RD projects that have reach pre-commercial level to a free online GIS tool capable to identify the areas of the Spanish geography with the best potential for energy crop development taking into account its sustainability.

The methodology lies on the development of georeferenced layers, functions, patterns and constrains that interact to obtain results of potential biomass productivity, environmental impacts, energy balances and costs of the energy crops suitable for the zones chosen. The Figure 1 summarizes the methodology framework of BIORAISE CE. For the obtaining of results, two georeferenced layers are calculated: first the Area with Potential Aptitude for Energy Crops (APAEC) and then the Homogeneous Agroenergy Area (HAA) these layers interact with environmental constrains, productivity functions, crop patters among others model parts to obtain the results (See Figure 2).

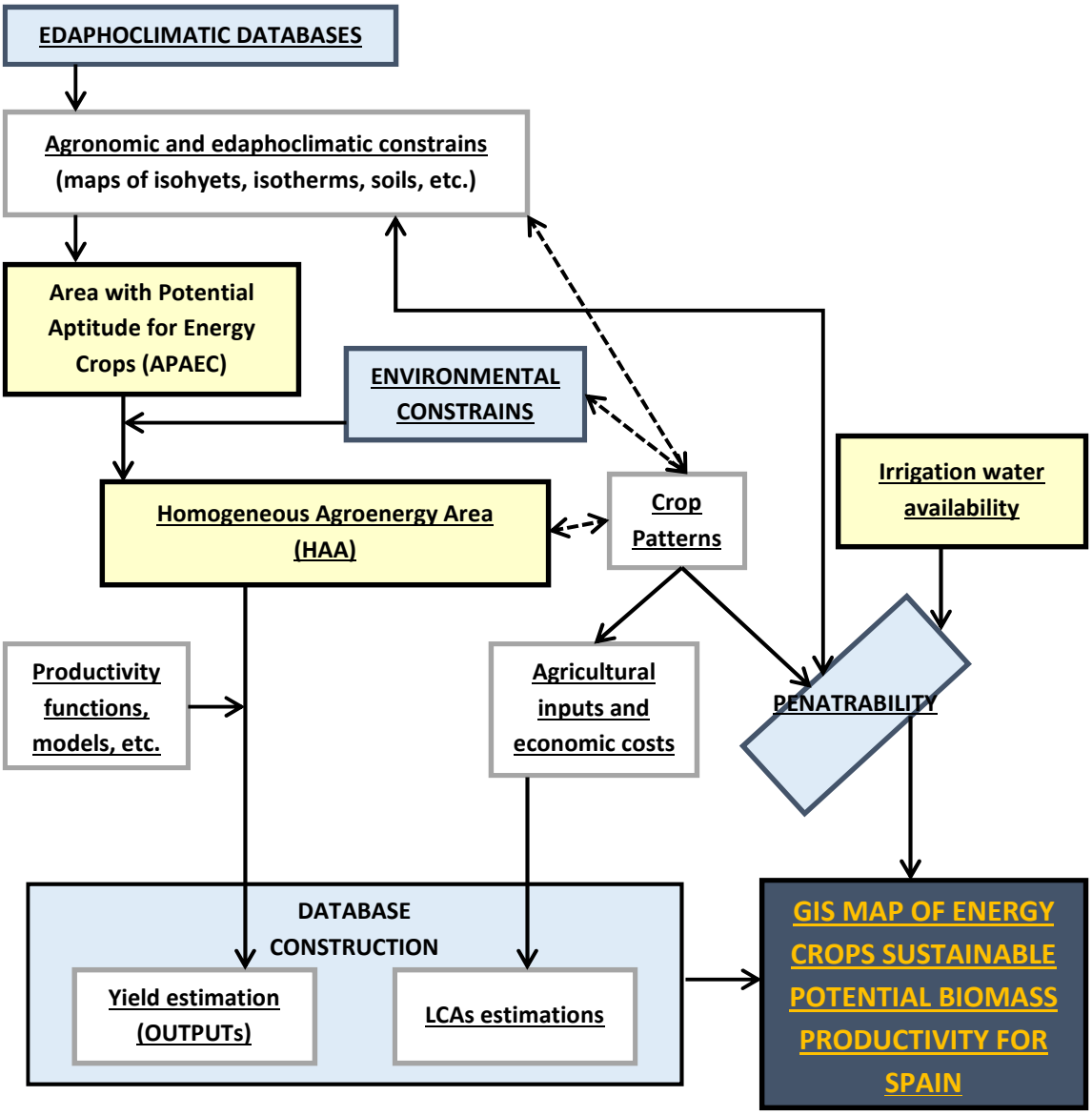

Figure 2: Methodology framework of BIORAISE CE

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Development of patterns and Homogeneous Agroenergy Areas (HAA).

Homogeneous Agroenergy Areas (HAAs) have similar management with respect to inputs and the machinery used for each type of crop. One area has a narrow variability range of energy crops annual yields ($dmt \cdot ha^{-1} \cdot y^{-1}$), this allow a rational use of inputs according to expected productivity and the use of homogeneous crop patterns for each crop on each AHH. The conduction of LCAs taking into account crop patterns in AAHs permits to obtain costs and GHG emissions per dry matter tone of biomass harvested.

Sustainability criteria and constrains

Protected area constrains

The available potential area for crops cultivation has excluded natural areas protected by the Spanish legislation (Ley 42/2017) like "Parque Natural" and "Parque Nacional" protection types. The rest of protection types appearing in previous Spanish law as well as figures that appear in other natural areas protection frameworks (Natura 2000 network according to Habitats Directive 92/43/CEE, Birds Directive 2009/147/CE, Man & Biosphere from UNESCO, etc.) are not considered as a limitation because they do not specifically limit human agricultural activities.

Nitrates vulnerable areas and BSPAs

The layer of nitrates vulnerable areas have been considered according to the cartography available in the Spanish Ministry of Food, Agriculture and Environment. The Birds Special Protection Areas (BPAs) has specific directives with respect to energy crop cultivation depending on the areas and the species protected.

Water availability

Future possible scenarios considering climate change effects have been taken into account. Different temporal scenarios have been considered, they calculate water availability at sub-hidrological basin level (117 in Spain). The temporal scenarios considered reach the year 2027 with an annual growing restriction of water availability due to climate change effects. Water availability for each basin/sub-basin considers conventional own resources (rivers, lakes and aquifers) and non-conventional ones (regenerated water, desalinated water, etc.) and external water resources and has been calculated according to current and in development hydrological plans.

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Information provided

This application calculates for the area chosen by the user:

- Total potential area available for rain-fed an irrigated agriculture (ha).
- Potential area for each crop (ha).
- Maximum potential biomass (dmt/y)
- Maximum percentage of land available with respect to total arable lands for each crop depending of the cropping system followed (rain-fed or irrigated agriculture)

When the user selects a penetrability percentage, the area calculated could be chosen taken into account different criteria:

- From lowest to highest distance to the collection point.
- From best to worst energy balance.
- From lowest to highest crop growing and harvest costs.
- From lowest to highest greenhouse gases emissions
- From lowest to highest crop yield.

Then the tool generates one table per crop including the following information:

- Surface (ha)
- Potential biomass (dmt/ha)
- Crop cultivation cost including biomass collection (€/dmt)
- Ratio between energy consumption and biomass energy content calculated with its Lower Heating Value (LHV)
- Greenhouse gases emissions (t CO_2 eq./t)
- Biomass transport costs (€/ dmt) from the area chosen to the collection point selected. The tool allows to update fuel cost.
- The impact on water used; shown as the percentage of water consumed with respect to the water available for agricultural uses in the basin/ sub- basin.

BIORAISE-CE provides georeferenced images of the most sustainable and realistic options among the different energy crops in the Platform to be grown in rain-fed and irrigated conditions.

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