BIORAISE GIS platform with actualized information of sustainable biomass resources available and costs and stakeholders relevant data for residential heating solid biofuels production, logistics and use in each participating country

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	CO	Confidential, only for members of the Consortium (including the Commission Services)	
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AGB: Map of forest biomass increment

DM: dry matter

ha: hectare

LHV: Lower heating value

MAPV: Mean annual productivities values

NPP: Map of Net primary productivity

RPR: Residue to product ratio

t: tonne

t WM: tonnes of wet matter

t DM: tonnes of dry matter

WM: wet matter

yr: year

1. THE BIORAISE PLATFORM: INTRODUCTION

This deliverable D2.4 describes the work developed in task 2.3, "Extension of the BIORAISE GIS online platform information to new countries". Within WP2, task 2.3 aims at the updating and extension to new Mediterranean countries of the web service BIORAISE.

The first version of BIORAISE was developed in the EU VI Framework Programme "CHRISGAS" for Spain (except for Canary Islands), Portugal (except for Azores and Madeira), France, Italy and Greece and was updated in 2012, in the framework of the H2020 Project BIOMASUD.

Specifically, the tool estimates georeferenced information about agriculture and forestry potential and availability of biomass resources on an annual basis in a selected location, and also estimates its energetic equivalent content. Harvesting and transport costs from the field to a user-choice destination are calculated as well, and market related stakeholders locations displayed. Additionally, environmental risks associated to the use of biomass resources can be visualized, aimed at showing sensitive areas.

As stated in the Document of Work of the BIOMASUD PLUS Project, the BIORAISE previous version has been updated and extended to new Mediterranean countries participating in the project (Slovenia, Croatia and Turkey).

Consistent with the first BIORAISE version, the current improved version will also be built upon agriculture and forestry resources, environmental risks and socioeconomic data. Statistical and geospatial data will be integrated and subject to geoprocessing to guarantee data coherence and realistic figures prediction. The target is quantification of resources for solid biofuels production, estimating field productivities and availability on the basis of environmental constraints and efficiency in the harvesting processes. Transport to transforming plants is considered in the logistics assessment of the biomass supply chain.

In the new version a main target is to improve the reliability of the integrated databases and enhance the functionalities of the tool. The objectives accomplishment implies the adoption of new input variables for geospatial analysis, methodology review and results verification. Verification and homogenization of databases are key aspects in the renewal of the BIORAISE Platform.

The final objective is that the upgraded version of BIORAISE becomes a user friendly tool that embeds sustainable biomass resources, energetic contents, costs and environmental risks visualization for most of the Mediterranean countries.

Expected impacts are to generate confidence, to increase cooperation between authorities-market actors, provide traceability communication and in the end foster production and use of Mediterranean solid biofuels. The new improved BIORAISE platform will complement the BIOMASUD certification label developed for Mediterranean residential solid biofuels in this Project, by defining sustainable biomass supply chains, costs optimisation and traceability mechanisms.

2. THE BIORAISE PLATFORM: METHODOLOGY

2.1 GENERAL ASPECTS OF THE TOOL, UPDATES AND EXTENSIÓN

The new BIORAISE platform tool have been constructed over the latest version (year 2012) available of the CORINE LAND COVER forestry, agriculture and shrubland surfaces complete for EU28 and Turkey. However some other necessary Pan-European products do not include Turkey nor off-shore islands in Portugal and Spain and permissions for country cartography have been especially restrictive for Turkey.

This version of BIORAISE implements also environmental risks. 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 therefore an intuitive representation regarding a sustainable management.

As in the previous version, the resources exploitation logistic chain consists of harvesting, piling and transport costs, that BIORAISE produces as €/tonne of dry matter computations. 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 databases, consisting of producers (raw biomass producers, wood, olive oil, nut hulling, and wine sector –distilleries- industries) and other 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 biofuel producers), have also been updated and extended to the new countries. Confidentiality issues are covered.

As stated, verification, reliability and homogenization are prioritized in the upgrading of BIORAISE. To meet this objective, data requirements were defined and discussed among partners to account for local variability where plausible (e.g., residues productivity rates, biofuels production data, stakeholders). Specifically with regards to the market stakeholders database, a questionnaire was sent for discussion. Methodological aspects are covered in detail in D2.2.

The tool computes resources on the fly from user-selected points, considering a circular area. Another option regarding the region of interest for the user is requesting the tool to provide the figures for administrative regions: NUT3 territorial units in the European Union databases in EUROSTAT and municipalities. This is explained by the architecture and computation capabilities of the server: the processing of resources in the larger NUT2 surfaces compromises the request response of the tool.

2.2 BIOMASS RESOURCES

Land use data provides the geospatial framework where statistical data from agriculture crops and forest inventories is integrated.

It must be taken into account that biomass resources destined to the energy market are actually the residues of agriculture and forestry production. This is to say, statistics normally provide data about main products in the case of agriculture and leave out the straw or other resources outside the food or wood markets. This is a major remark to be kept in mind regarding the methodology of the biomass resources estimations explained below.

2.2.1 AGRICULTURE POTENTIAL AND AVAILABLE BIOMASS RESOURCES

In the case of agriculture resources, EUROSTAT data regarding productivity and surfaces have been linked to the geospatial data of CORINE. As statistics refer to agriculture production, the potential biomass resources are derived from applying residue-to-production ratios. Next, available biomass resources are derived from the former considering efficiency rates related to harvesting processes. In this manner, we have attempted to provide realistic available resources that could be destined to bioenergy uses. Specifically, potential and available biomass resources are given in tonnes of dry matter/year for the following categories: irrigated crops, rainfed crops, rice, vineyard, orchards and mixed crops (i.e., agroforestry systems consisting of herbaceous crops under sparse tree cover).

Production and area data from EUROSTAT, which is the main statistics data source in the UE, (http://ec.europa.eu/eurostat/data/database, see Figure 1) and TURKISTAT (provided by the Turkish partner) have been compiled at national and NUT2 (regional) levels for winter cereals (common wheat and spelt, durum wheat, rye and winter cereal mixtures -maslin-, barley, oats, spring cereal mixtures -mixed grain other than maslin-, triticale, grain maize and corn-cob-mix and rice, industrial crops (rape and turnip rape seeds, sunflower, soya, cotton fiber) and permanent crops (fruits, berries and nuts, excluding citrus fruits, grapes and strawberries), citrus fruits, grapes and olives. To compute productivity and surfaces statistics in BIORAISE, maize was considered a rainfed crop in areas with average annual precipitation lower than 700 mm, and irrigated crop otherwise. To account for annual variabilities, the mean productivity in tonnes per hectare was computed from annual data for a decade (2005-2014). In some cases regional data was not available in EUROSTAT, and the databases incompleteness required additional annual national and regional agriculture statistics.

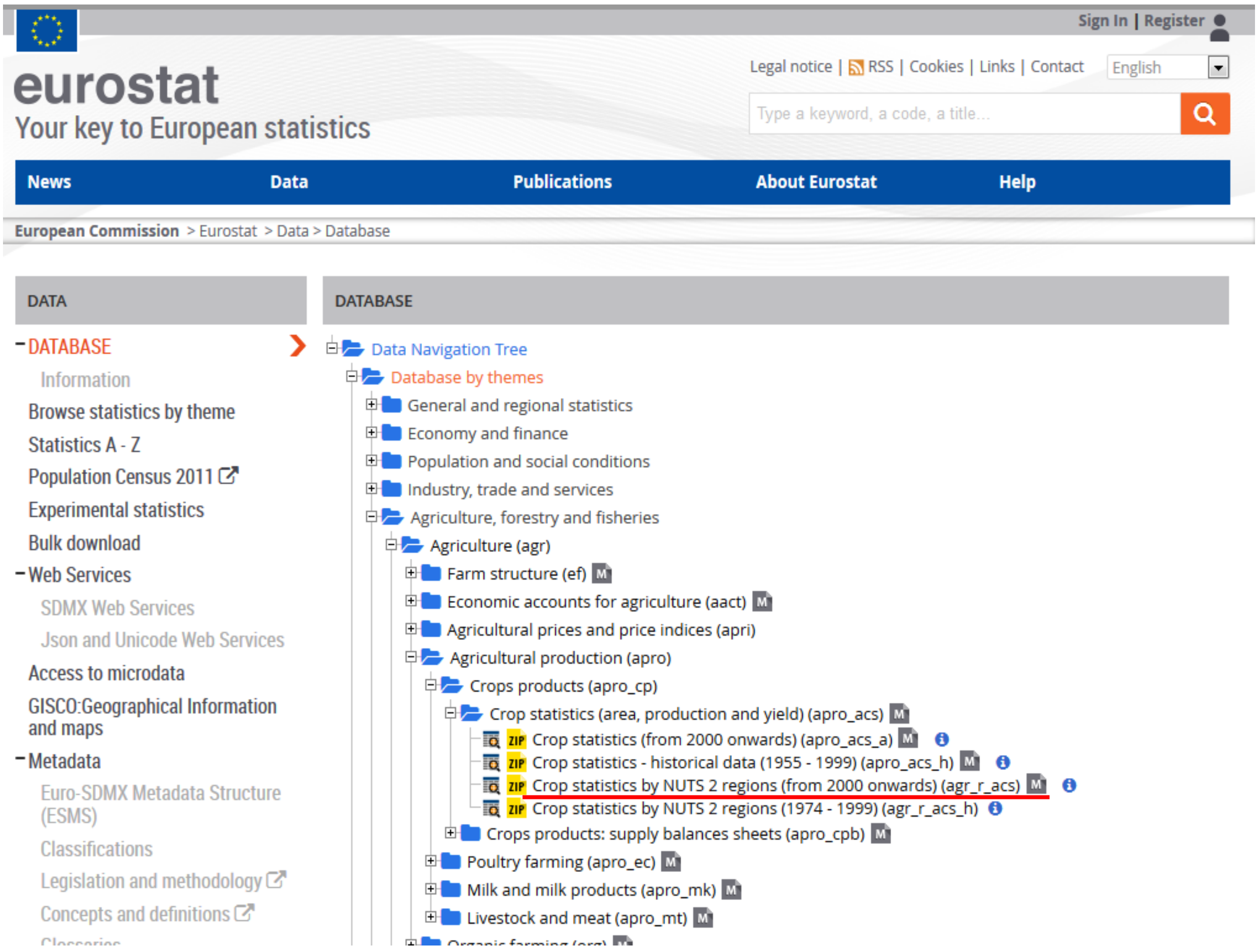

Figure 1: EUROSTAT production and surface data download access link (red underline)

As aforementioned, the crops in turn were aggregated to a more general CORINE LAND COVER agriculture code: irrigated crops, rainfed crops, rice, permanent crops (vineyard, olive and orchards) and mix (herbaceous crops under permanent crops: e.g., agroforestry). This generalization is assumed to account for crops rotation. CORINE LAND COVER provides the location of these agriculture categories. From these surfaces, applying the productivity (tonnes/hectare) and the Residue-to Product Ratios (RPR) for the corresponding crops (Table 1), potential biomass is obtained (tonnes of dry matter). Among the references reviewed for residue-to product ratios, those specified in section 1 of the references have been used for the current version of BIORAISE.

In those countries where RPR references were not found, ratios from the country where the crop production was similar were applied.

Table 1: Residue to Product Ratios (RPR) used for selected crops.

Crops	RPR (t DM/t WM)							
	Spain	France	Italy	Greece	Portugal	Turkey	Croatia	Slovenia
Barley	0.70	0.80	0.70	0.70	0.70	0.70	0.70	0.70
Durum wheat	1.00	0.85	1.00	0.85	0.85	1.10	1.00	-
Soft wheat	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Rye	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
Soya	2.10	2.10	2.10	2.10	-	2.10	2.10	2.10
Sunflower	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
Rape	3.80	3.80	3.80	3.80	-	3.80	3.80	3.80
Maize	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10
Cotton	0.53	-	-	0.53	-	0.53	-	-
Rice	0.75	0.75	0.75	0.75	0.75	0.75	-	-
Vineyard	0.30	0.35	0.35	0.50	0.30	0.30	0.37	0.37
Olive	0.50	-	0.50	0.50	0.50	0.40	0.40	0.40
Orchard	0.35	0.35	0.35	0.35	0.35	0.35	0.35	-

Examples of surfaces and production statistics from EUROSTAT (Spain NUT2 level):

Table 2: Areas (ha).

In some cases, the EUROSTAT statistics have been complemented with national annual agrarian statistics data (MAPA in the case of Spain)

CROPS Grapes
STRUCPRO **Main area (1000 ha)**

	Source	MAPA	EUROSTAT	MAPA	MAPA	MAPA	EUROSTAT	EUROSTAT	EUROSTAT	EUROSTAT	EUROSTAT
Code	GEO/TIME	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
ES11	Galicia	28,83	33,70	29,97	19,85	19,44	25,31	25,04	24,94	24,90	24,84
ES12	Principado de Asturias	0,11	0,10	0,09	0,09	0,09	0,09	0,09	0,08	0,07	0,06
ES13	Cantabria	0,04	0,10	0,00	0,06	0,04	0,08	0,08	0,10	0,14	0,13
ES21	País Vasco	13,00	13,50	13,38	13,36	13,45	13,87	13,78	13,84	14,20	14,38
ES22	Comunidad Foral de Navarra	24,45	26,00	24,94	24,03	22,03	19,60	18,90	18,72	18,55	18,46
ES23	La Rioja	41,72	44,20	42,09	42,15	43,08	45,74	44,34	44,31	44,74	46,00
ES24	Aragón	47,07	47,70	41,83	41,89	42,34	39,42	38,77	38,60	37,97	37,56
ES30	Comunidad de Madrid	13,77	16,00	9,46	8,33	6,88	12,53	12,05	11,42	11,16	10,88
ES41	Castilla y León	69,72	71,70	68,94	68,06	67,37	72,03	73,91	74,11	74,10	74,72
ES42	Castilla-la Mancha	529,60	533,50	499,51	504,31	476,77	471,45	442,28	435,00	442,00	442,93
ES43	Extremadura	82,45	89,80	83,60	83,64	83,49	85,95	84,35	81,96	81,67	81,62
ES51	Cataluña	59,98	65,50	60,03	58,53	55,37	55,53	56,32	55,39	54,84	54,98
ES52	Comunidad Valenciana	78,64	85,20	81,90	82,85	79,77	78,79	73,10	70,63	70,14	68,59
ES53	Illes Balears	1,38	1,80	1,35	1,35	1,44	1,44	1,63	1,32	1,83	1,89
ES61	Andalucía	41,55	40,80	39,35	38,47	35,72	34,49	31,35	31,87	8,64	30,38
ES62	Región de Murcia	44,28	46,70	43,80	42,90	39,31	37,01	35,43	32,20	30,92	31,14
ES63	Ciudad Autónoma de Ceuta (ES)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
ES64	Ciudad Autónoma de Melilla (ES)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
ES70	Canarias (ES)	18,86	19,00	18,81	18,90	8,78	8,79	8,76	8,73	8,64	8,64

Table 3: Production (t yr^{-1}).

In some cases, the EUROSTAT statistics have been complemented with national annual agrarian statistics data (MAPA in the case of Spain)

CROPS Grapes
STRUCPRO **Harvested production (1000 t)**

	Source	MAPA	MAPA	MAPA	MAPA	MAPA	MAPA	MAPA	MAPA	MAPA	MAPA
Code	GEO/TIME	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
ES11	Galicia	252,36	269,93	254,07	128,36	133,58	144,09	218,54	125,04	164,44	131,29
ES12	Principado de Asturias	0,61	0,63	0,43	0,40	0,30	0,25	0,24	0,21	0,18	0,16
ES13	Cantabria	0,13	0,25	0,00	0,27	0,19	0,43	0,43	0,43	0,60	0,51
ES21	País Vasco	90,73	92,33	84,60	85,08	89,43	83,99	84,16	73,73	74,56	92,36
ES22	Comunidad Foral de Navarra	156,45	170,40	146,99	127,13	144,27	129,89	113,20	101,17	110,23	121,93
ES23	La Rioja	318,74	296,42	297,45	275,17	287,14	285,02	271,18	252,62	260,72	298,62
ES24	Aragón	147,05	189,34	212,69	121,03	187,53	160,25	148,82	141,40	161,10	172,98
ES30	Comunidad de Madrid	37,48	54,95	31,63	24,88	19,33	23,76	16,62	15,06	23,88	17,78
ES41	Castilla y León	235,28	285,16	219,46	197,32	206,31	252,36	254,79	264,13	306,89	335,01
ES42	Castilla-la Mancha	3044,04	3.280,87	2906,52	3.137,83	2735,31	3.219,69	2.835,90	2.755,97	4.299,77	3.346,00
ES43	Extremadura	437,58	422,39	403,26	503,92	423,83	526,78	580,42	432,60	570,45	582,21
ES51	Cataluña	384,41	452,68	432,09	411,46	439,83	437,33	451,20	372,26	499,71	451,91
ES52	Comunidad Valenciana	484,40	540,86	495,35	420,66	413,77	365,83	400,48	381,50	488,11	259,48
ES53	Illes Balears	6,92	7,43	6,40	5,93	6,87	7,32	7,47	7,74	8,23	8,50
ES61	Andalucía	239,99	266,84	262,65	248,19	216,55	243,35	221,83	175,11	249,30	195,14
ES62	Región de Murcia	195,42	230,21	194,42	240,35	216,46	215,28	193,33	216,68	244,44	187,54
ES63	Ciudad Autónoma de Ceuta (ES)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
ES64	Ciudad Autónoma de Melilla (ES)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
ES70	Canarias (ES)	26,03	34,37	16,69	23,62	14,65	12,01	10,72	16,52	19,94	20,32

Available biomass resources are computed considering technical restrictions (e.g., harvesting efficiency rates). Strictly speaking, some constraints are highly local or specific. Nonetheless, a default constraint has been applied on the basis (Table 4) that it was not possible to apply every factor affecting particular regions.

Table 4: Harvesting efficiency rates for each CORINE LAND COVER code

Crops	**Harvesting efficiency rates (%)**	**Source**
Rainfed	50	Value obtains from sector's professionals personal communications
Irrigated	50	(Shinners *et al.* 2007)
Rice	40	(Delivand *et al.* 2011)
Vineyard	70	(Cavalaglio and Cotana, 2007) (Frąckowiak *et al.* 2016)
Olive	94	(Assirelli *et al.* 2013) (Pari *et al.* 2012)
Orchard	75	(Frąckowiak *et al.* 2016)
Crop mixture	50	Value obtains from sector's professionals personal communications
Forestry (meadow, broadleaves, conifers, mixtures)	60	(Cuchet *et al.* 2004) (Márquez 2006) (De Jong *et al.* 2017)

It must be noted that crop surfaces from EUROSTAT and other statistical sources do not always match within the CORINE Land Cover spatial frame for the corresponding categories. This is easily explained by the fact that CORINE Land Cover provides a static land use frame for a specific year (e.g., 2012 in the current BIORAISE version) and that the specific crops in EUROSTAT are to fit within the wider categories considered in BIORAISE for crops on the basis of CORINE, plus the fact that to account for year variabilities, the statistics have been compiled in a decadal average. Therefore, the surfaces obtained from the agriculture statistics (EUROSTAT or equivalent, depending on the availability) were checked against the corresponding CORINE surfaces.

2.2.2 FORESTRY AND SHRUBS POTENTIAL AND AVAILABLE BIOMASS RESOURCES

Productivity tables derived from national forest inventories were used where available, considering a 20 years period between forest activities producing biomass resources. As these data was not consistently available for all the regions in the BIOMASUD area, the mean annual productivities values(MAPV) of residual biomass for each forest type (Table 5) were mainly selected from the data processing carried out in the previous version (**Esteban *et al.* 2010**) and were checked against remote-sensing derived forest maps. Pan-European Map of Forest Biomass Increment (Mg ha^{-1} yr^{-1}) (Busetto *et al.* 2014) and the European Environment Agency Net Primary Productivity (NPP) (g m^{-2} yr^{-1}), available at http://bio.discomap.eea.europa.eu/arcgis/services/NPP/NPP/ImageServer *that* were finally selected to derive productivity models. These geospatial products have the advantage of being available for all the countries under study. However, these are only for forest areas and the resolution does not match the CORINE land uses surfaces nor dates perfectly. Accordingly, where the Forest Biomass Increment (shortened to “AGB” in this document) was not available, the MAPV was used to avoid underestimation caused by the fact that CORINE surfaces were larger than the AGB map extent.

Analogously, the methodology is applied to the CORINE shrubland codes for the subcategory “Scrub and/or herbaceous vegetation associations”, embedding natural grasslands, moors and heathland sclerophyllous vegetation and transitional woodland-shrub, only that the NPP raster is applied instead of the AGB product as the spatial coverage of the former matches more consistently the shrublands CORINE layer.

Table 5: Mean Annual Productivity Values (MAPV) for forest species (t DM ha^{-1} yr^{-1})

Species	MAPV (t DM/ ha^{-1} yr^{-1})
Abies alba	1.27
Fagus sylvatica	0.76
Larix spp.	1.27
Pseudotsuga menziessi	0.87
Castanea sativa	1.27
Pinus cembra	0.65
Pinus halepensis	0.42
Pinus mugo	0.65
Pinus pinaster	1.10
Pinus pinea	1.49
Pinus sylvestris	0.65
Quercus cerris	0.74
Quercus faginea	1.51
Quercus frainetto	2.76
Quercus ilex	1.51
Quercus petraea	0.74
Quercus pubescens	2.73
Quercus robur	0.81
Quercus suber	0.42
Quercus pyrenaica	2.76
Conifers	0.96
Broadleaves	1.45
Mixtures	1.22
Scrub	0.60
Agro-forestry areas	0.42

As in the previous BIORAISE version, the category CORINE LANDCOVER with code 244 (agro-forestry areas) is supposed to be managed every 20 years and a constant production value is assumed: 0.42 t DM ha^{-1} yr^{-1}.

BIORAISE contains also specific the Joint Research Centre (JRC) forest species distribution maps more relevant in the Mediterranean countries considered: *Pinus sylvestris*, *Pinus pinea*, *Pinus pinaster*, *Pinus halepensis*, *Pinus mugo*, *Pinus cembra*, *Pseudotsuga* sp., *Abies alba*, *Abies* sp., *Castanea sativa*, *Fagus sylvatica*, *Larix*, *Quercus ilex*, *Quercus petraea*, *Quercus pubescens*, *Quercus pyrenaica*, *Quercus suber*, *Quercus robur*, *Quercus cerris*, *Quercus faginea*, and *Quercus frainetto* (http://data.jrc.ec.europa.eu/collection/fise). A conservative criterion was applied to minimize productivity errors: from the distribution areas of these species, only dominant stands were considered (main species above 50% of forest cover). Therefore, as a consequence of this conservative approach, the species forest surface is underestimated, although the inclusion of the more generic CORINE surfaces partially overcomes this fact. In addition, it must be noted that the tree specific layers are only available for visualization purposes. A user might be interested in a specific tree species, and more accurate productivities could be applied to the spatial frames from the corresponding tree productivities.

In the case of forestry and shrubs resources, a first constraint to derive available biomass resources from potential biomass is related to slopes. Although forest technology has improved and harvesting machines are powerful and stable enough to extract forest resources even in complex terrains, a generic threshold of 20% slope rise is considered in BIORAISE. In addition to slopes, the following constraints matrix has been applied considering soil erosion risk and top soil organic carbon content:

slope (%)		< 20	20-60	> 60
Erosion risk	0-2	60	50	0
t ha^{-1} yr^{-1}	2-10	40	30	0
	> 10	0	0	0
Organic Carbon	0-1	0	0	0
(% in 30 cm top soil)	1-2	40	30	0
	> 2	60	50	0

Figure 2: Biomass available (% regarding potential biomass resources) in different conditions of slope, erosion risk and organic carbon in top soil.

The erosion risk values are derived from the PESERA Soil Product: Soil erosion estimates (t ha^{-1} yr^{-1}) 2000-2003 available at https://esdac.jrc.ec.europa.eu/themes/pesera-model) and the Soil organic carbon content (fine earth fraction) in g per kg at depth 0.30 m from SoilGrids (Hengl *et al.* 2017). PESERA is not available for Turkey, so in that case, only the soil organic carbon constraint has been applied.

Each constraint is applied separately and the most restrictive result is finally selected for available biomass resources computation.

2.3 BIOMASS HARVESTING AND TRANSPORT COSTS

2.3.1 AGRICULTURE BIOMASS HARVESTING COSTS

2.3.1.1 Herbaceous crop residues: irrigated and raindfed crops

The collection method assumed for straw, stalks and other residues from annual crops is based on the use of baling machines followed by an self-loading bale trailer (type Arcusin) that collects the bales and transports them to roadsides where it tips the load (8 bales) and constructs piles. For baling costs, a costs function (Figure 3) in relation to the baling workflow has been fitted on the basis of agriculture machinery costs from the Ministry of Agriculture, Food and the Environment (http://www.mapama.gob.es/es/ministerio/servicios/informacion/plataforma-de-conocimiento-para-el-medio-rural-y-pesquero/observatorio-de-tecnologias-probadas/maquinaria-agricola/hojas-calculo-maqui.aspx).

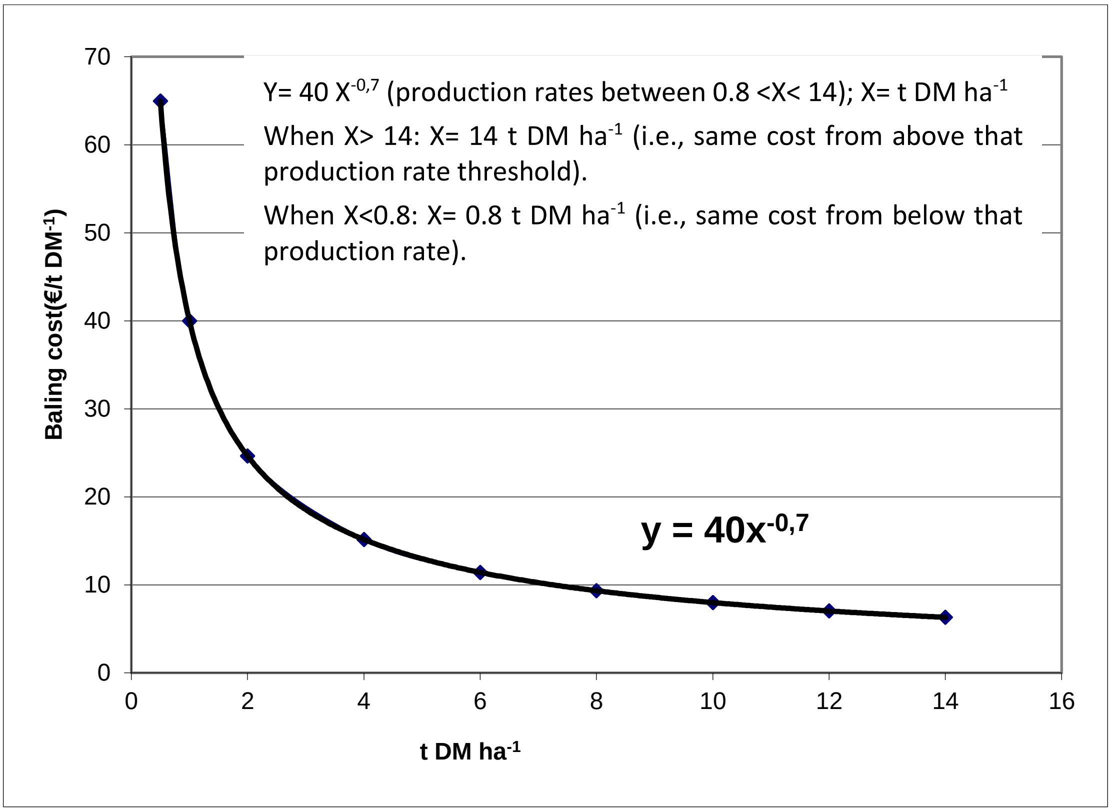

Figure 3: Baling costs according to productivity.

Likewise, for the collection costs, forwarding and piling operations costs, references from the machinery costs spreadsheets from the same source. Accordingly, a fix cost has been applied: 8.9 € t DM^{-1}.

2.3.1.2 Woody crop residues: olive, vineyard, orchards

For permanent crops (olive trees, vineyard and orchards) the total costs include pruning chipping, stocking, extraction, loading and transport to manufacturer costs. The data from these costs have been obtained from studies conducted by Sociedad Andaluza de Valorización de la Biomasa (SAVB) (personal Communication). These are constant costs for chipping, stocking, extraction and loading: respectively 47 € t DM^{-1} for vineyard, 50 € t DM^{-1} for orchards and 38 € t DM^{-1} for olive trees.

For crop mixture, the cost has been obtained from the average of the costs of permanent crops residues (i.e., woody crops), resulting in (45 € t DM^{-1}).

2.3.2 FORESTRY AND SHRUBS BIOMASS HARVESTING COSTS

The base costs of the biomass harvesting operations including felling, piling, hauling and baling (Table 6) have been extracted from different sources, which are specified in section 2 of the references. These costs are summarized in the table below.

Table 6: Base costs (€ t DM^{-1}) used for the calculation of harvesting costs

Species	Harvesting cost*
Conifers	49.00
Broadleaves	42.00
Mixtures	44.33
Agroforestry areas	44.23
Shrubs	43.03

**Harvesting costs include the felling, piling, hauling and baling operations.*

The costs of biomass harvesting applied to each forest species have been obtained by correcting the base costs (Table 6) according to the amount of residue per hectare of each of species, using a linear function that multiplies the maximum observed value by 1.1 and the minimum observed value by 0.9.

$$Y = COEF\ 1 - COEF2 * av20$$

Where

Y (costs of the biomass harvesting operations including felling, bundling, hauling and baling (€/t dry matter))

COEF 1 (species-dependent constant): see Table 7 below.

COEF2 (species-dependent constant): see Table 7 below.

av20: Available biomass estimated at harvest (t DM)

The costs have been estimated for different species categories (conifers, broadleaved, mix stands, agroforestry areas and shrublands). Furthermore, due to the influence of the topography on forest machinery operational costs, two different situations have been considered: slopes higher or lower than 20%. For this reason, COEF1 and COEF2 vary considering slopes below 20%, as shown in the following table.

Table 7: COEF1 and COEF2 values considering slopes below 20% (€ t DM^{-1})

	Total cost: harvesting + packing	
	Slopes < 20%	
	COEF1	COEF2
Conifers	54.2675018311	0.34993699193
Broadleaves	46.4637985229	0.189844995737
Mixtures	48.8777999878	0.339233994484

Agroforestry areas	49.3386001587	1.04358005524
Shrubs	47.33306493	0.193508648

The costs in tiles with slopes greater than 20% are estimated 30% higher.

2.3.3 BIOMASS TRANSPORT COST

The expression used for calculating biomass transport costs was obtained from Esteban (Esteban et al, 2004):

Transport cost= (A+P)/Ws *X +(B+P)/Ws*Y+C/Ws

Where

X = path distance (one way km)

Y = road distance (one way km)

Ws =load dry weight (t DM)

A = constant: 4.12156961

B = constant: 1.60283263

C =constant: 78.878769

P =variable=2 *Cc

Cc = cost per km in €/km (variable)=c*p

c = consumption per km in l km^{-1} (constant): 0.385

p = fuel cost in € l^{-1}(variable): 1.1 default value to be used in BIORAISE

2.4 SUSTAINABILITY: ENVIRONMENTAL RISKS VISUALIZATTION

Topographic databases included a digital elevation model (i.e., altitude values in m) raster of 30 m spatial resolution (Farr *et al.* 2007) from where slopes have been derived. As has been aforementioned, slopes are used as a technical constraint in available forestry resources computations, together with soil erosion risk and topsoil organic carbon content. Slopes are also an influence exploitation factor in the biomass chain, specifically in the application of transportation and harvesting costs function fitting.

In addition to such considerations in computations, even though there are not strict regulations regarding biomass resources exploitation considering soil attributes or other derived potential environmental risks, the current version of BIORAISE embeds new inputs showing some relevant parameters ranges in this regard. For instance, soil erosion factors considering rainfall rates that could derive in soil loss if the resources exploitation is not carried out under sustainability criteria. To this purpose, BIORAISE displays the following environmental factors related to soil, topography and climate: soil organic carbon stocks in tonnes per hectare for a depth interval of 0.3 m coarse fragments volumetric in % at 0.05 m depth, absolute depth to bedrock (cm), 0-100% of R horizon from SoilGrids products (www.soilgrids.org) (Hengl *et al.* 2017) , and the R factor of the RUSLE erosion equation from the European Soil Data Centre (ESDAC JRC), esdac.jrc.ec.europa.eu, European Commission Joint Research Centre (Panagos *et al.* 2015) data have been integrated. Therefore, higher vulnerability areas can be identified through the platform. The more sensitive areas are shown in purple-reddish colours versus the locations with lower risk are displayed in green colours. This choice is because it is the colour range familiar to most users that intuitively associate the warning to red and the safety to green (as the traffic lights colour code). Due to server capabilities and processing constraints, the slope and altitude layers are not visualized in BIORAISE. However, the relief visualization option in the tool, gives the user the visualization of the latter and accordingly a proper idea of the slopes, as the typical Google Map configuration options (i.e., map view, relief view, satellite view) are active in the server.

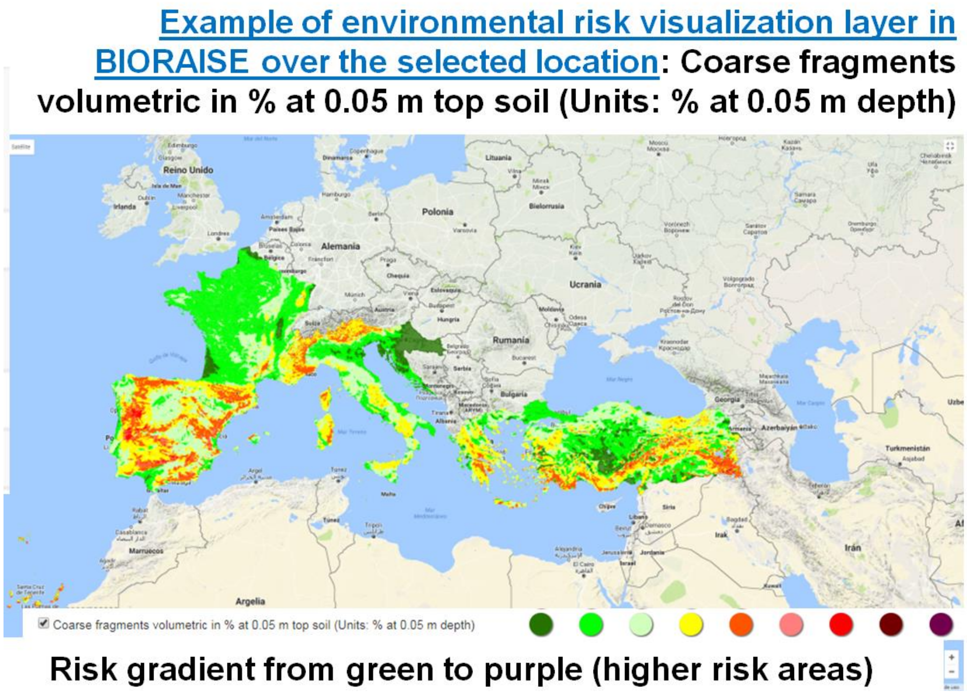

Figure 4: Coarse fragments layer over the relief view option in the BIORAISE server

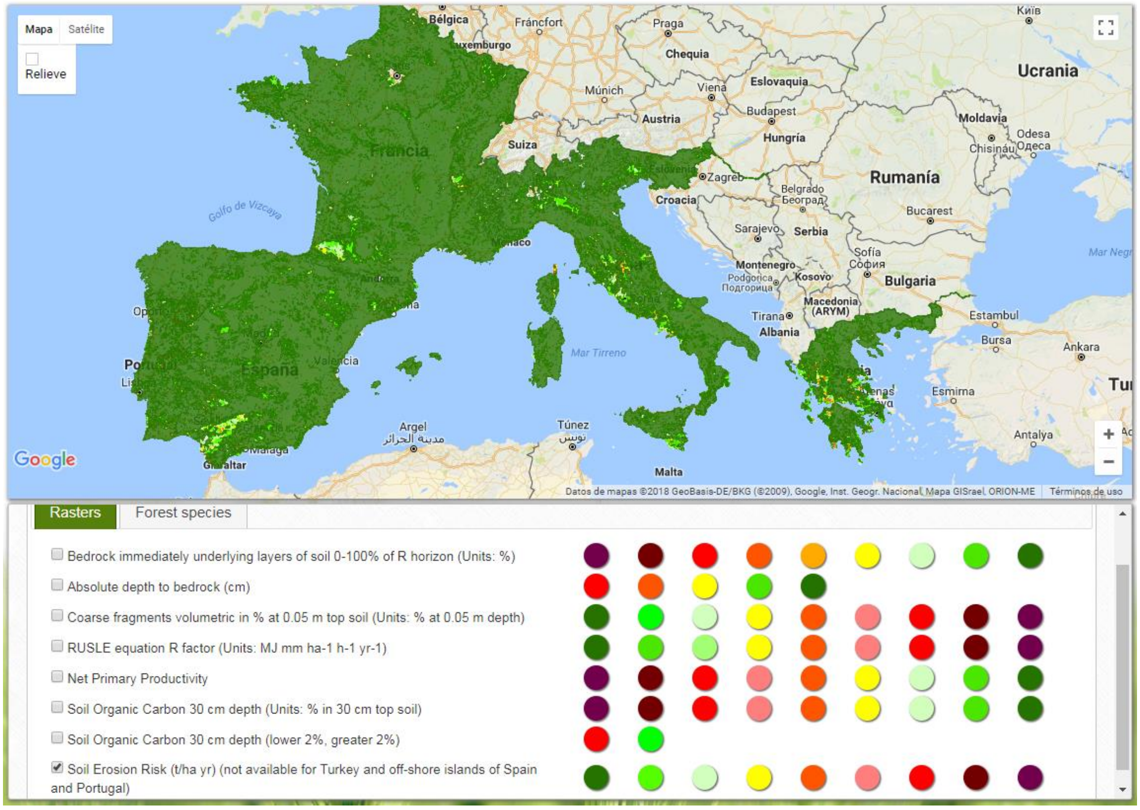

Figure 5: Soil Erosion Risk visualization and the rasters of environmental layers available in BIORAISE

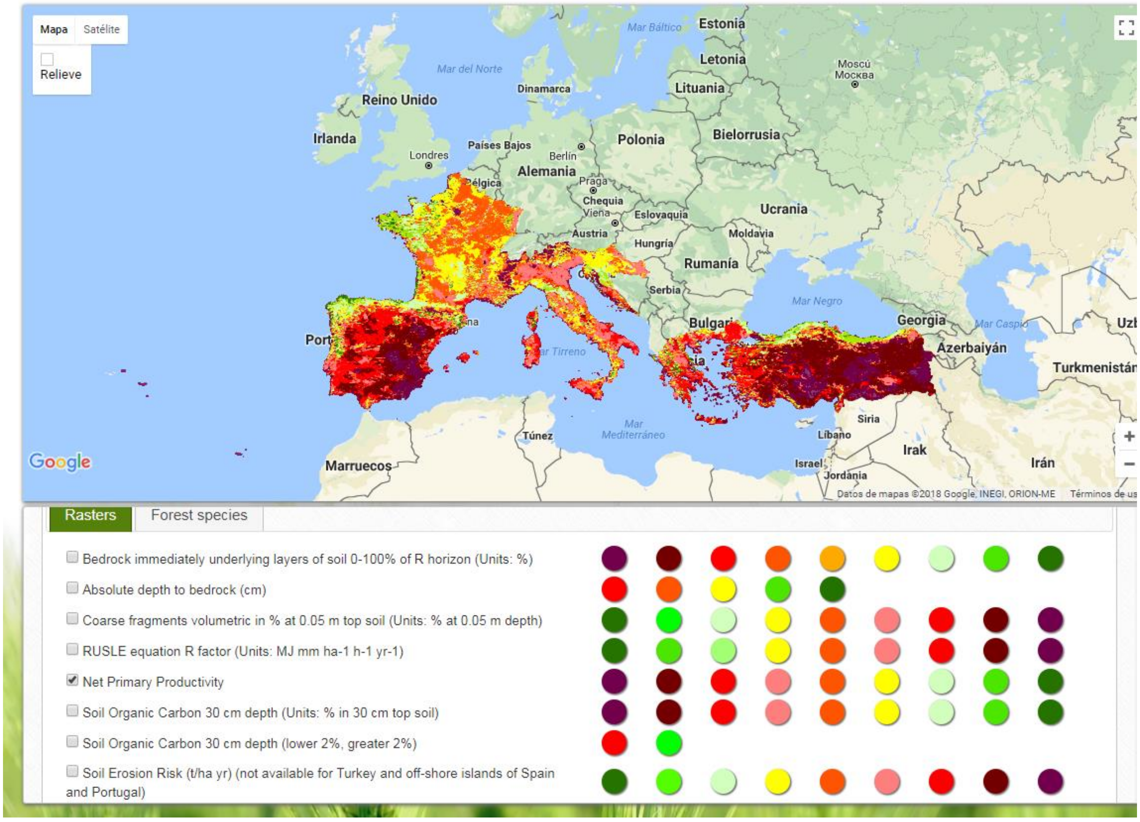

Figure 6: Net primary productivity gradient over the map view option in BIORAISE

2.5 STAKEHOLDERS DATA

2.5.1 STAKEHOLDERS DATABASE CLASSIFICATION

The database contains companies dealing with solid biofuels products and services in the BIORAISE area.

The agro industries (oil and nut companies), biomass and biofuel producers and suppliers, boiler and stove manufacturers, installers and energy services companies (ESCos) are included.

All the participants have contributed by supplying national relevant data as well as providing sensible restriction factors to the use of biomass potentials in their respective regions. TFS performed software adaptations to update the database and to introduce the new countries data in the extended BIORAISE platform.

Biofuels are the products from the transformation of available biomass resources. From WP2 and WP3, CIEMAT coordinated the stakeholders databases obtained from all partners. Data include locations of biomass and biofuels producers, manufactures and distributors. Data provided meet the EU regulation on data protection (General Data Protection Regulation (EU) 2016/679).

The database is classified in two main groups. The first group is composed by the agro industrial raw biomass producers. The raw biomass producers include: wood industry, olive oil industry, nut hulling industries (almonds, pine nuts, hazelnut, walnut, pistachio), and wine sector.

The second group includes: equipment and machines for industry, services and facilities, manufacture of biofuels and biomass valorisation, biofuel dealers, research centres, large consumers, and BIOMASUD PLUS biofuel producers.

2.7 ENERGETIC CONTENT COMPUTATION

The lower heating value (LHV) (GJ tDM^{-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). These data are shown in Annex 1.

Several steps are required for calculating the energy content (GJ yr^{-1}) according to the biomass moisture content. In the first step, the BIORAISE platform transforms the LHV on dry basis ($LHV_{p,o}$) to a specific humidity ($LHV_{p,x}$). For that purpose, the following dry-to-wet-basis formula has been applied:

$$LHV_{p,x} = LHV_{p,o}\,(1\text{-}0.01X) - 24.43X$$

Where

$LHV_{p,x}$ = lower heating value on wet basis (GJ t WM^{-1})

$LHV_{p,o}$ = lower heating value on dry basis (GJ t DM^{-1})

X = biomass moisture content (% WM)

In the second step, the BIORAISE platform transforms available biomass on dry basis (t DM yr^{-1}) to wet basis (t WM yr^{-1}). Finally, to compute the energy content (GJ yr^{-1}), the available biomass on wet basis (t WM yr^{-1}) is multiplied by the lower heating value on wet basis (GJ t WM^{-1}).

3. PLATFORM FUNCTIONALITIES

BIORAISE platform, http://bioraise.ciemat.es/ , integrates the biomass resources layers, environmental risks and stakeholders data.

The service evaluates the biomass field resources available from agriculture and forestry, including shrublands.

From user selected locations, the platform provides, on the fly, the following information: biomass resources, harvesting and transport costs and energy content. The application includes diverse stakeholders related to solid bioenergy sector.

The landpage shows several tabs, from where to choose either Map or Satellite Google basemaps, the Options and Legend features

The Visualizations tab shows environmental maps of risks layers related to edaphology facets: Soil Erosion Risk, Bedrock immediately underlying layers of soil 0-100% of R horizon, Absolute depth to bedrock, Coarse fragments volumetric in % at 0.05 m top soils, RUSLE equation R factor and Soil Organic Carbon at 30 cm depth. In addition, the Net Primary Productivity layer is also displayed in an analogous gradient from high productivity areas (green) to lower productivity surfaces (red/purple tones).
The layers are displayed in categorized values showing a risk gradient from green (lower risk) to red/purple (higher risk)..

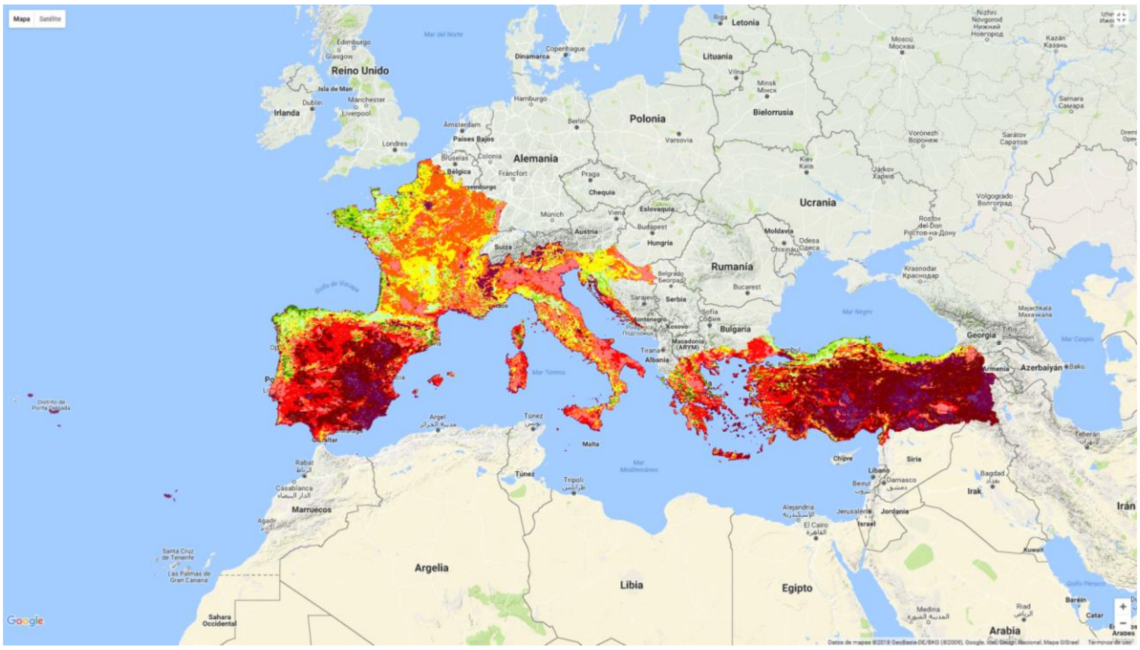

Figure 7: Example of visualization layer in green-purple gradient for Net Primary Productivity: higher productivity areas are depicted in purple.

A subtab displays dominant stands of tree specific maps selected from the JOINT RESEARCH CENTRE (http://data.jrc.ec.europa.eu/collection/fise) in case the user wants a more refined view of specific forest data:.

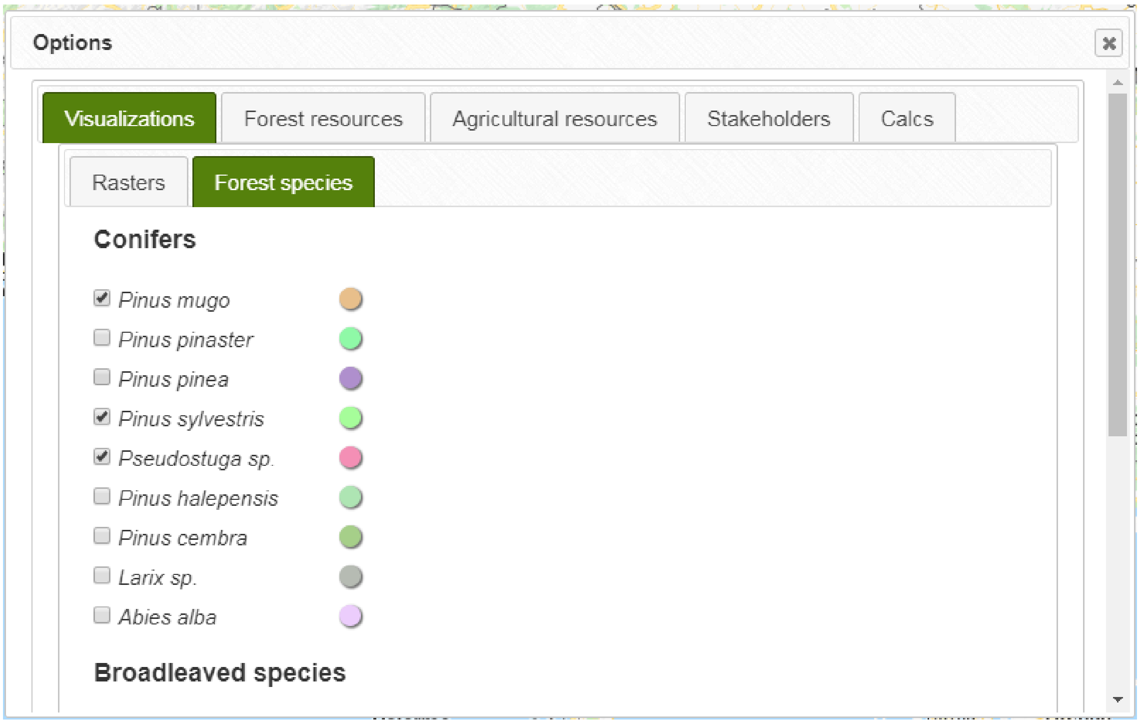

Figure 8: Forest species subtab

The **Forest Resources and Agriculture Resources** tabs enable the user to select among the agriculture, forestry and shrubland land uses from CORINE LAND COVER.
Agriculture contains field resources from herbaceous crops (rainfed crops, rice, and irrigated crops), orchards, vineyards, olive trees and mix crops (agroforestry herbaceous crops).
The forestry categories include conifers, broadleaved, mixed stands, agroforestry systems (e.g., dehesas) and shrublands.

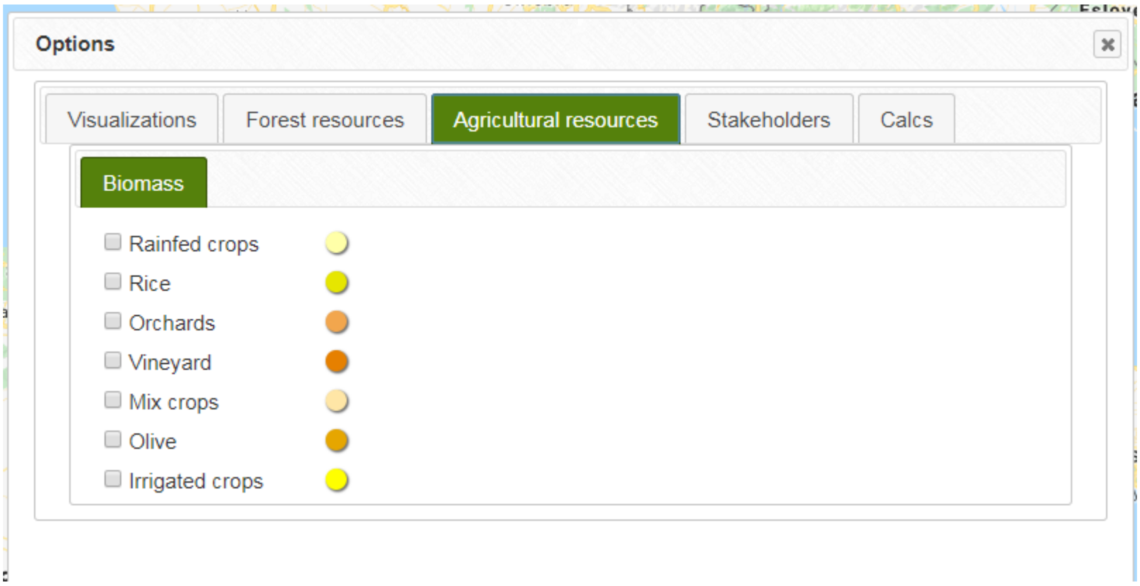

Figure 9: Screenshot of the land uses available in Agriculture subtab within the Potential Biomass choices.

The **Calculations** tab allows the user to choose a location for the area of interest and pick up point. For computations, either a circular radio (from 1 to 100 km) or administrative limits (NUT3 regions -e.g., province in Spanish administrative divisions- or subregion -e.g., municipality boundary-) are required.

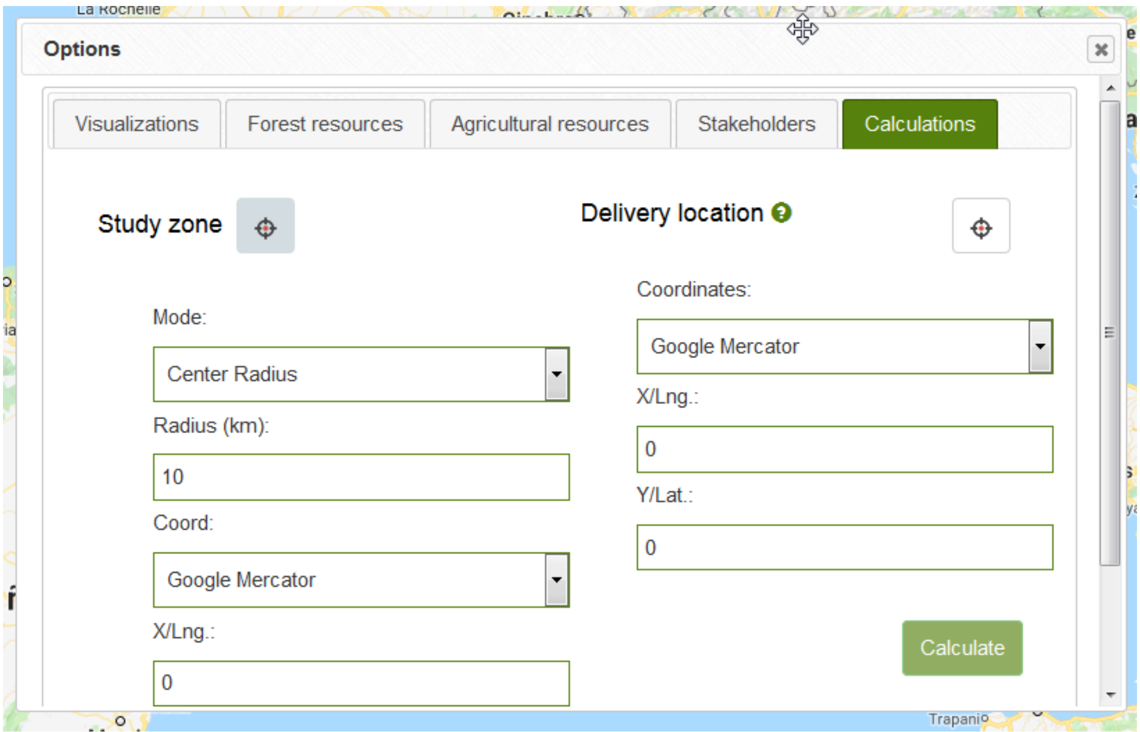

Figure 10: Calcs tab: where the user selects a location in the map for on the fly computations of biomass resources, costs and energy content

One having clicked “calculate”, a dialogue window shows the results. Potential biomass is provided in tonnes of dry matter per year (t DM year^{-1}), surfaces are given in hectares and average harvesting and transport costs in €/tonne. Due to the efficiency really attainable in harvesting processes, not all the field resources reach the biomass production chain: therefore, a more realistic available biomass is also computed.

Calculation results

Resources and costs

Agricultural Biomass	Potential resources (tDM/year)	Available resources (tDM/year)	Average cost of collection (€/tDM)	Resources surface (ha)	Average transport cost (€/tDM)
Rainfed crops	5,550.03	2,775.01	41.67	2,087.54	5.69
Irrigated crops	338.36	169.18	21	30.67	5.59

Figure 11: Example of potential and available agriculture biomass resources (t DM yr^{-1}), surfaces (ha), average harvesting/piling cost (€ t DM^{-1}) and transport cost (€ t DM^{-1})

Regarding agriculture field resources, due to the efficiency really attainable in harvesting processes, not all the field resources reach the biomass production chain: therefore, a more realistic available biomass is also computed.

In the case of the forestry resources, soil erosion risk and top organic carbon in 30 cm depths limit the potential resources. In addition, technical constraints are applied considering a 20% percent rise slope threshold in costs computations.

Forest Biomass	Potential resources (tDM/year)	Available resources (tDM/year)	Average cost of collection (€/tDM)	Surface of potential resources (ha)	Surface of available resources (ha)	Average transport cost (€/tDM)
Conifers	2,822.58	1,027.19	55.83	3,332.27	3,317.79	5.62
Broadleaved species	3,699.04	1,474.32	45.26	3,977.46	3,972.25	5.58
Mixed	380.15	127.3	49.68	380.52	379.71	5.64
Shrub	2,771.03	1,053.48	40.52	4,281.6	4,257.07	5.58

Transportation fuel cost 1,2 €/liter Apply

Center: -3.3384

Figure 12: Example of potential and available forestry biomass resources (t DM yr^{-1}), surfaces, average harvesting/piling cost (€ t DM^{-1}) and transport cost (€ t DM^{-1})

Regarding transport costs, the user can select fuel costs “Transportation fuel cost”, which are highly variable across time and regions. The default option is 1.2 €/l.
Transport costs do not include VAT considerations (variable among countries).

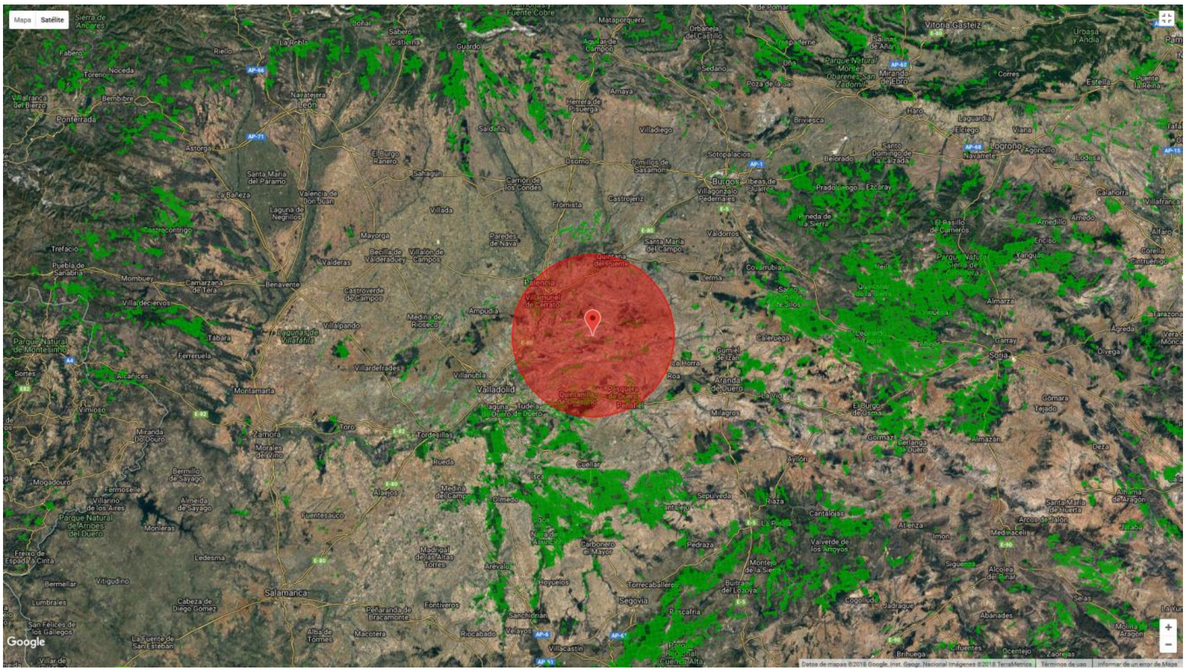

Figure 13: Example of forest biomass resources map and a user-choice area of interest radio

The energy contents are also computed: the user can apply different moisture contents by moving the % wet base bar.

Calculation results

Energetic content

Agricultural Biomass	Available resources (tDM/year)	% wet base	Available resources (tWM/year)	Ash value mean reference (% d.b.)	Energetic content (GJ/year)	Average cost of collection (€/GJ)	Average transport cost (€/GJ)
Rainfed crops	2,775.01	35	4,269.25	6.1	43,744.03	2.64	0.36
Irrigated crops	169.18	35	260.28	7.8	2,630.36	1.35	0.36

Forest Biomass	Available resources (tDM/year)	% wet base	Available resources (tWM/year)	Ash value mean reference (% d.b.)	Energetic content (GJ/year)	Average cost of collection (€/GJ)	Average transport cost (€/GJ)
Conifers	1,027.19	35	1,580.29	2.7	18,124.23	3.16	0.32
Broadleaved species	1,474.32	35	2,268.18	3.7	24,069.05	2.77	0.34
Mixed	127.3	35	195.85	3.2	2,162.19	2.93	0.33
Shrub	1,053.48	35	1,620.74	3.1	18,277.4	2.34	0.32

Figure 14: Example of forestry biomass resources energy contents results

The STAKEHOLDERS tab compiles data locations and details from the raw solid biomass producers: wood industry, olive oil industries, nut hulling, and wine sector –distilleries- industries, and other actors: equipment and machines for industry, services and facilities, biofuels producers, biofuel dealers, research centres, large consumers, and certified BIOMASUD PLUS biofuel producers and dealers.

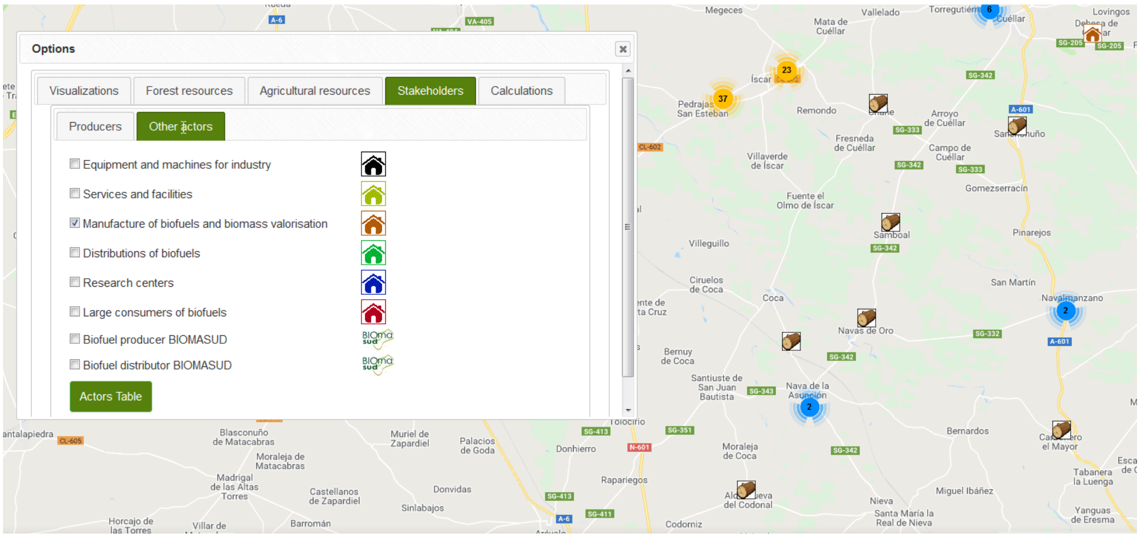

Figure 15: Stakeholders tab user choices under the producers and other actors subtabs

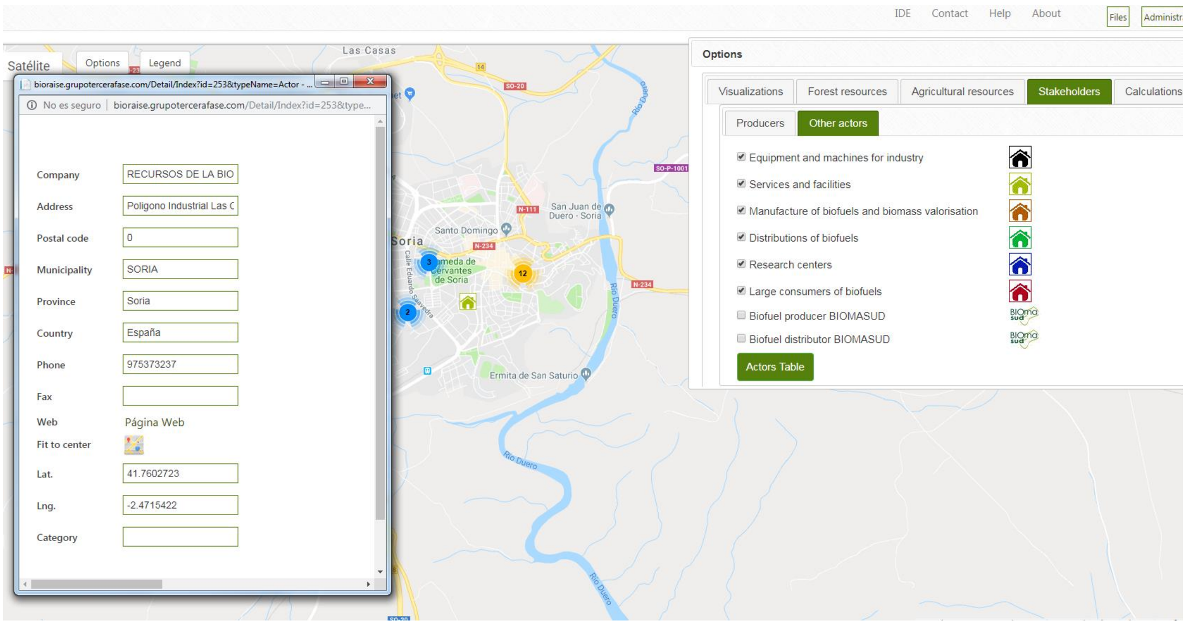

Figure 16: Example of stakeholders locations. The wood log icon represents wood producers.

At the end of the results window, the user can click the "Download results" button and a **zip file** is provided containing a csv and a shapefile.

The corresponding attributes in the shapefile are:

- Origin: land use category (i.e., Agriculture or Forestry).
- Biomass: resource type in accordance to the Agriculture or Forestry Corine Land Cover subcategories (e.g., Rainfed Crops, Conifers, etc.)
- SurAgrAvl: surface of available agricultural categories (ha).
- SurAgrPot: surface of potential agricultural categories (ha).
- SurForAvl: surface of available forestry categories (ha).
- SurForPot: surface of potential forestry categories (ha)
- BiomassPot: potential biomass (t DM/year).
- BiomassAvl: available biomass (t DM/year).
- CostCollec: harvesting cost (€/t DM).
- CostTrans: transport cost to from the tile centroid to destination point (€/t DM) .
- distX: euclidean distance from the tile centroid to the closest road (m).
- distY: distance by road to destination point.

The CSV provides the summarized results for the area of interest:

	A	B	C	D	E	F	G	H	I	J	K	L
1	Centro: Lat. 41,9461 Lng. -3,6021	Radio: 5,00 Km	Punto recogida: Lat. 41,7659 Lng. -2,4922	Fuel price: 1.3 €/L								
2												
3	Type of biomass	Surface of potential resources (ha)	Surface of available resources (ha)	Potential resources (tDM/year)	Available resources (tDM/year)	Average cost of collection (€/tDM)	Average transport cost (€/tDM)	% wet base	Ash value mean reference (% d.b.)	Energetic content (GJ/year)	Average cost of collection (€/GJ)	Average transport cost (€/GJ)
4	Secano	813.16	813.16	2,161.89	1,080.95	41.67	20.00	35	6.10	17,039.52	2.64	1.27
5	Frondosas	1,662.50	1,646.28	1,075.64	424.22	45.33	19.88	35	3.70	6,925.67	2.78	1.22
6	Forestal mix	634.69	633.76	440.84	175.97	46.69	20.18	35	3.20	2,988.73	2.75	1.19

Figure 17: Example of CSV results table

Following the European directive of INSPIRE (INfrastructure for Spatial InfoRmation in Europe), the BIORAISE tool offers WMS services of the bioenergy Stakeholders. The WMS service can be accessed through the following address:

http://bioraise.grupotercerafase.com/WMS

The HELP section is to contain a brief methods report and main references. Contact with the authors is possible and user feedback encouraged as a way to increase the testing of the tool, understand the limitations of the methods and enhance the functionalities to better meet user requirements unaccounted for in this version that would be addressed in further updates.

CIEMAT has been verifying the consistency of results and would like to still improve some of the computations in the geospatial layers of BIORAISE.

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ANNEXES

ANNEX 1

LOWER HEATING VALUE (LHV) AND ASH CONTENT (% DM) VALUES APPLIED

Lower heating value (LHV) (GJ t DM^{-1}) and ash content (% DM) applied for biomasses.

Biomass type	Code	Description	Ash (% DM)	$LHV_{p,0}$ (GJ t DM^{-1})
	Corine			
field	211	RAINFED	6.1	17.08
field	212	IRRIGATED	7.8	16.86
field	213	RICE (Rice straw)	15.2	14.71
field	221	VINEYARD	4.3	17.78
field	222	ORCHARDS	3.4	17.12
field	223	OLIVE	6.0	17.88
field	241	DEHESAS WITH ANNUAL CROPS (MIXED CROPS)	4.6	17.30
field	244	DEHESAS (AGROFORESTRY AREAS)	4.3	17.40
field	311	BROADLEAVES	3.7	17.64
field	312	CONIFERS	2.7	18.96
field	313	MIX CONIFERS-BROADLEAVES	3.2	18.30
field	321.322.323.324	SHRUBS	3.1	18.67
	Biomasud Plus			
industrial	111	WOOD INDUSTRY (CHEMICALLY UNTREATED WOOD BY-PRODUCTS)	0.4	18.76
industrial	112	WOOD INDUSTRY (BARK)	3.3	19.59
industrial	113	WOOD INDUSTRY (OTHER BY-PRODUCTS)	2.2	18.40
industrial	121	OLIVE INDUSTRY (OLIVE STONES/OLIVE KERNEL)	0.7	18.86
industrial	122	OLIVE INDUSTRY (EXHAUSTED OLIVE CAKE)	8.7	18.55
industrial	131	NUT HULLING INDUSTRY (ALMOND SHELLS)	1.6	18.33
industrial	132	NUT HULLING INDUSTRY (HAZELNUT SHELLS)	1.2	19.21
industrial	133	NUT HULLING INDUSTRY (PINION SHELLS)	1.6	19.32
industrial	134	NUT HULLING INDUSTRY (CHOPPED PINE CONE)	1.1	18.90
industrial	135	NUT HULLING INDUSTRY (WALLNUT SHELLS)	1.2	19.38
industrial	136	NUT HULLING INDUSTRY (PISTACHIO SHELLS)	0.5	17.75
industrial	151	DISTILLERIES (GRAPE PIPS)	3.8	21.27
industrial	152	DISTILLERIES (DRY GRAPE POMACE)	7.3	19.56