BIOPLAT-EU

Promoting sustainable use of underutilized lands for bioenergy production through a web-based Platform for Europe

D4.1

Report on the selection of case studies in the target countries

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List of acronyms

BPP	Biomass Processing Plant
BPS	Biomass Processing Site
CLC	Corine Land Cover
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GAEZ	Global Agro-Ecological Zones
GBEP	Global Bioenergy Partnership
GHG(s)	Green House Gases
GIS	Geographic Information System
GSI	GBEP Sustainability Indicators
IIASA	International Institute for Applied Systems Analysis
iLUC	Indirect Land Use Change
JR	Joanneum Research
JRC	Joint Research Centre EU
LUC	Land Use Change
MAGIC	Marginal lands for Growing Industrial Crops
MUC	Marginal, Underutilized and Contaminated
RED II	Renewable Energy Directive II
SEEMLA	Sustainable exploitation of biomass for bioenergy from marginal lands in Europe
SRC	Short rotation coppice
SRTM	Shuttle Radar Topography Mission

Executive Summary

The aim of Work Package 4 is to support the development of the Web-GIS platform of BIOPLAT-EU through a series of case studies to test the model, the STEN engine, its user interface and functionalities before publication. This operation is key to identify possible bugs, flaws and inefficiencies of the system and solve them, thus it is important to dedicate a specific work package and collaborative efforts to ensure that additional perspectives and viewpoints are considered when testing the tools developed under WP3. In order to make sure that the testing is effective, a set of representative case studies is a necessary attribute. Moreover, they will serve as a mean to bridge the expertise internal to the BIOPLAT-EU Consortium with that of local stakeholders as the case studies represent the basis for the work under WP5. Clearly then, the role of the selection of representative case studies is pivotal to the successful testing of various potential scenarios of use for the WebGIS platform and it must be a participated process by all relevant Consortium partners. Such process has indeed seen the outstanding contribution of partners in each of the case study countries.

In this report, we analyse the defining characteristics of the selection of case studies, the selection process itself, and present each of the selected cases in the test countries, namely Germany, Hungary, Italy, Romania, Spain and Ukraine.

The results of this exercise returned a broad representation of the various contexts in which the webGIS platform will operate. Specific integrations to each case study selection have been made to accommodate the need for further representativity of the testing (inclusion of multiple scenarios for the testing of bioenergy pathways based on the same case study and feedstock selected) but these will be the subject for further Deliverables of the project.

Summarizing, in all six countries marginal and underutilized lands have been selected. Contaminated sites are found in Italy, Hungary, and Romania and abandoned agricultural lands have been selected as test case in Germany, Hungary, Spain and Ukraine. The simulations will interest all major agricultural feedstocks produced in Europe with a predominance of short rotation coppice (SRC) and other lignocellulosic crops (miscanthus, giant reed, as well as straw) for direct combustion or, to a lesser extent, advanced ethanol production. Oil crops for biodiesel and other vegetable oil-derived bioenergy pathways are also very well represented in the case studies as it is biogas production from dedicated crops such as maize or sorghum.

In the selection process, national project partners had the prominent role of scouts and proponents based on their knowledge of local conditions. Among the features considered for the selection that was an at least indicative information concerning the MUC status of these lands, which was confirmed by a site visit by members of the Consortium, and a set of socio-economic or environmental parameters to support the condition of marginality of the areas selected.

In order to verify the aforementioned indications and map with the highest accuracy these lands, project partners collected different EU-wide and national datasets as a basis for further processing into high definition (TIER II) maps within BIOPLAT-EU. These datasets were used to select potentially interesting areas and/or to exclude areas not usable for bioenergy use due to different reasons.

To carry out this task, EU-wide/Copernicus data sets were collected and pre-processed. The preparatory steps included downloading, selecting relevant classes (CLC, LUCAS), thresholding (forest - tree cover density product, imperviousness) and calculating additional features (e.g. slope from SRTM digital elevation model). This precision work required the employment of extensive resources, particularly from JR, as several aspects needed correction and calibration through reiterated discussions with local partners, local stakeholders and landowners.

Figure 1. Distribution of BIOPLAT-EU case studies across Europe.

The map above gives a graphical representation of the geographical distribution of the case study sites across Europe and Ukraine.

1 Introduction

The primary aim of WP4 is to test the characteristics and functionalities of the webGIS prototype before its public release. The identification of representative case study sites is therefore a first step towards understanding and benchmarking the capabilities of the software developed in BIOPLAT-EU. Moreover, a further - but not less important - use of the outcomes of the testing will be directly employed in the context of the project to build up a multi-stakeholder working group that locally will further analyse the options available for developing a bioenergy value chain. Thus, this WP and its tasks have a two foci type of relevance: A) they are needed to provide testing bed for the webGIS platform and to backstop its results with real-world data, and B) to represent the stepping stone for a more detailed feasibility assessment which includes economic and financial considerations that are strictly case-specific.

The priority for an effective testing is representativeness of the sample to match the various scenarios users can ultimately run. Since the webGIS platform considers an array of possible biomass feedstock and related bioenergy pathways, one aim was to look for potentially the broadest set of biomass-bioenergy combinations to cover most (if not all) the combinations that future users may simulate. In the context of BIOPLAT-EU we refer to *Biomass Production Site* (BPS) to identify the Marginal, Underutilized or Contaminated (MUC) land in Europe and Ukraine mapped in the project that represents an existing surface of land that can be employed for the production of biomass for bioenergy purposes. A user can carry out simulations and related assessments assuming that the BPS is under his/her control. In order to calibrate the model and software on the webGIS platform to run such analyses, real BPS have to be identified and used as samples for BIOPLAT-EU. The case study selection took into consideration the need to test both small as well as large continuous BPSs in the various locations tested. Concerning the type of feedstock that could be grown on those BPSs, the actions behind Task 4.1 looked at including the following:

- Starchy crops
- Lignocellulosic crops
- Oil crops

At least one of each category of crops should be selected as possible test biomass for the BIOPLAT-EU case studies.

Additionally to crop type, the selection has carefully looked at including each of the most representative bioenergy pathways diffused in Europe. Again, in order to ensure representativeness of the testing based on the case studies, partners received guidance to propose suitable bioenergy pathways among the list of most common ones in Europe:

- Ethanol
- Straight Vegetable Oil (SVO)
- Biodiesel
- Hydrogenated Vegetable Oil (HVO)
- Biogas
- Solid biofuels (e.g. wood chips, pellets, briquettes)
- Biomass to Liquid (BtL)
- Gasification/Pyrolysis

Especially for advanced biofuel pathways, there has been little receptivity among local stakeholders in favour of traditional, “safer” technologies (and infrastructures) which have been selected in virtually every case study. To make up for this apparent lack of interest towards advanced biofuels, the case studies where suitable feedstocks have been identified will be tested for both traditional (e.g. solid biofuels) and advanced bioenergy pathways (e.g. lignocellulosic ethanol) based on the same biomass type.

It is expected that during the activities under WP5, particularly those led by local partners, the stakeholders are also sensitized towards the potential of advanced biofuel developments in Europe and neighbouring countries also in light of the RED II and other supporting policies.

The selection of the case studies took the mapping of Marginal, Underutilized and Contaminated lands to a higher level, through the combined use of Copernicus, Corine Land Cover and LUCAS points information and the resulting products are identified as *TIER II maps*. These represent the highest possible accuracy maps of MUC lands available to date in Europe and were produced by Johanneum Research (JR) in collaboration with the case study partners.

The exercise, however, was not free of hurdles. As expected when dealing with MUC lands, in fact, the opportunity to get on the ground and double check with local stakeholders the actual status of surfaces of land that by definition are neglected (being underutilized) or whose status remains controversial (contaminated) for an array of reasons did not equally materialize in all case study countries. The identification of the second case study in Romania for instance, took longer than originally planned but in the end this site was officially confirmed, and its selection consolidated. In Spain, on the other hand, a first case study has been quickly identified in the region of Albacete, where underutilized lands are found and where the local partner has vast knowledge of the landscape and its features. A second site was investigated in the Northern side of the country (former mining site) following a desk research put forward by FAO, but unfortunately no ground-truthing was possible within the timeframe of this task, partially because the travel restrictions applied during the first outbreak of the COVID-19 pandemic hindered the opportunity of staff from UCLM to physically verify this site and above all get in touch with local stakeholders. Due to these difficulties, the second case study site has been identified within the region of Cuenca and will test the use of similar crops in a comparable setting as in the province of Albacete.

2 Case studies selection: methodology

In the selection process, national project partners had the prominent role of scouts and proponents based on their knowledge of local conditions for the sites to take into consideration for the final selection. As per project proposal, a minimum of two case study sites in each country was necessary. Where needed, further so-called “backup” case study sites were proposed, in case the mapping would not produce sufficient or accurate MUC lands. However, the remote sensing-based results of mapping underutilized lands for the selected case study areas (TIER-2) show sufficient potential areas with adequate accuracies, decreasing the probability that an integration of the backup areas will be necessary. Among the features considered for the selection of the case studies, the indicative information concerning the MUC status of these lands was the primary step of the methodology. This was confirmed by one or more site visits carried out by members of the Consortium, and a set of socio-economic or environmental parameters to support the condition of marginality of the areas selected.

In order to verify the aforementioned indications and map these underutilized lands with the highest accuracy, project partners collected different EU-wide and national datasets as a basis for further processing into high definition (TIER II) maps within BIOPLAT-EU. These datasets were used to select potentially interesting areas and/or to exclude areas not usable for bioenergy use due to different reasons.

To carry out this task, EU-wide/Copernicus data sets were collected and pre-processed. The preparatory steps included downloading, selecting relevant classes (CLC, LUCAS), thresholding (forest - tree cover density product, imperviousness) and calculating additional features (e.g. slope from SRTM digital elevation model).

Among the available data sets, the following ones were found to be most useful for the selection of the case study areas:

- Corine Land Cover (CLC): CLC data was used to identify classes, which are potentially underutilized, e.g. 321 Natural grasslands; 323 Sclerophyllous vegetation; 324 Transitional woodland/shrubs; 333 Sparsely vegetated areas.
- LUCAS points hinting at specific aggregation of underutilized areas, e.g. in Spain

For the exclusion of unsuitable areas, the following layers were employed:

- Copernicus High Resolution Layers Forest, Water&Wetlands, Imperviousness
- SRTM Slope map with threshold of 15°: Previous projects focusing on identification of marginal and underutilized lands (e.g. MAGIC) identified large areas in mountainous regions. While these mountainous areas with steep slopes might be well useful for bioenergy production from forest, they are usually not suitable for more intensively cultivated energy crops. Within BIOPLAT-EU, areas steeper than 15° were therefore excluded as cultivation of energy crops is difficult under such conditions.

- Protected areas: all European protected areas (Natura2000) were excluded from the potentially useful case study areas. This led for example to removing an initially foreseen case study area in Hungary, as large parts of that specific area are under protection.
- Open Street Map (OSM) settlement layer was specifically useful to exclude settlement areas in Ukraine, where no Copernicus HR layer exists.

Further, the collection of national datasets also greatly assisted the selection of case study areas. Through their national agencies, statistical data (as for example in the case of Ukraine) supported the selection of specific areas. In other words, if two areas were considered as potentially interesting, the one with higher amount of potentially underutilized lands in the statistics was chosen for further investigation/verification on the ground. In other countries, national data search revealed maps of contaminated lands other than the heavy metal contamination in top soils, which is instead used at pan-European level. Using such national maps, contaminated areas suffering from other pollutants could also be taken into account, as for example in Italy for the Val Basento region or the reserve case study area of Umbria.

Last, but not least, the review of existing project results also revealed potentially interesting areas. As a pre-cursor project, FORBIO results identified interesting areas where bioenergy value chains could take off, such as the Brandenburg area in Germany or Sulcis region in Sardinia, Italy. Results of the SEEMLA project also informed this work about several potentially interesting sites finally selected as case study areas, e.g. the Ukrainian case study area of Chmelnyzky and the Sulcis area as well.

In Romania, the use of Google Earth historic data revealed previous mining areas in the case study area of Gorj. Some of these former mining areas (both excavation and deposit plants) are overgrown with vegetation and thus no longer distinguishable using satellite imagery alone. To validate areas abandoned for long enough to be undistinguishable from the satellite, local BIOPLAT-EU partners made a series of site visits in various locations and documented from ground level the status of the land. Subsequently they reported to the BIOPLAT-EU colleagues in charge of the mapping exercise to complete the high accuracy TIER II maps for the case study sites.

Such precision work required extensive human resources deployment, particularly from JR, as several aspects needed correction and calibration through reiterated discussions with local partners and local stakeholders. The final product of this work is a solid set of case studies that will be employed for the testing of the WebGIS platform but that will provide a consolidated starting point for the multistakeholder discussions to set the basis for the development of biomass value chains in any of these areas.

Dense high spatial resolution time series data from Sentinel-2 were employed to map underutilized lands in the twelve selected case study areas (see Figure 1A). With the above-mentioned available pan-European and national data sets a set of training data was generated to perform the classification as well as a set of reference data was compiled to make sure that unsuitable areas are excluded from the MUC map. The results show a very good overall performance despite the very different condition in the case study areas throughout different bio-geographical regions of Europe. More information on the TIER-2 approach to map of underutilized lands in selected case study areas can be found in Deliverable 2.4.

For contaminated lands, project partners from the respective case study countries have been investigating the use and availability of national data sets to replace the TIER-1 result. To be in line with the TIER-2 approach, also additional acquired contaminated lands were refined with the cut-out mask. As many countries do not have national map of contaminated lands, we decided to merge the TIER-1 results with the results gathered by the case study partners. The figures in Table 1 thus represent the combined amounts. For all details and limitations of these contaminated land layer, please see D2.3.

Table 1 further provides an overview of the results of the remote sensing-based TIER-2 approach to map underutilized lands in the selected case study areas. Statistics correspond to the whole mapped area per case study region (polygons in Figure 2). However, case study partners were free to choose the whole mapped area, a larger administrative unit or only parts of the mapped areas. For that reason, area statistics provided in Table 1 may deviate significantly from the numbers of statistical analyses on available MUC lands in the descriptions of case study area selections in Chapters 2.1 – 2.6. Further reasons for deviations are the date and source of statistical data used or different definitions of underutilized land.

Table 1. Result of remote sensing-based mapping of MUC lands for selected case study areas

Country	Case Study Area	Area [ha]	Underutilized land [ha]	Contaminated land [ha] (TIER-1+ nat. data)
Germany	Dahme-Spreewald	228,188	899	0
	Spree-Neiße	166,274	2,725	316
Hungary	Bács-Kiskun and Csongrád county	1,192,070	1,968*	105
	Hungary Northwest (Balaton Uplands region: Veszprém County and Fejér County)	1,219,271	10,028*	2,445
Italy	Sulcis area	35,802	2,220	8,284
	Val Basento area	1,218,812	7,625	3,731
Romania	Bacău County	530,235	5,332*	0
	Gorj County	92,760	3,567	0
Spain	Albacete & Cuenca	2,304,810	4,393*	37,352
Ukraine	Khmelnytskyi and Ternopil regions	1,254,216	32,788	NA
	Kyiv and Chernihiv regions	581,309	44,795	NA

(*Preliminary result)

Figure 1a. Overview of the areas mapped with the remote sensing-based TIER-2 approach

2.1 Germany

2.1.1 Case study 1

Location (area name): Spree-Neiße

MUC status: underutilized (lignite mining reclamation sites)

BPS Approx surface (ha): up to approx. 2,100 ha in total, field size from 6 to 175 ha

Potential crop(s): Sorghum *(Sorghum bicolor, S. bicolor x S. sudanense*), Black locust (*Robinia pseudoacacia*)

Potential bioenergy pathway(s): biogas/biomethane (*Sorghum*), solid biofuels for heat/electricity (Black locust)

Existing BPP: Several biogas power plants as well as CHP and heating plants within a 100 km radius from the potential BPS

Selection process

The case study area 1 – the district *Spree-Neiße* – is situated in the Lusatian Lowland in the southeastern part of the Federal State Brandenburg. The landscape is shaped by sediments of the Lusatian glacial period, which cover lignite bearing Tertiary strata from the Upper and Middle Miocene. The area is influenced by a western sub-atlantic to eastern sub-continental climate. The regional climate situation (climate normal period 1971-1990) can be described as moderate dry to dry lowland climate. The mean annual temperature ranges from 7.0 to 9.5 °C and the average annual precipitation varies between 580 and 660 mm yr^{-1}, with half of the rainfall in the vegetation period. The climatic water balance in the growth period is strongly negative – it varies between -50 and -200 mm.

Currently four opencast lignite mines are still in operation within the Eastern German lignite district (Lusatia), two of them in the selected case study area. The potential biomass production sites (BPS) are located in the reclaimed area of the running opencast mines. Approximately 90% of abandoned mine land are sands and loamy sandy substrates with a rather low plant available water storage capacity - usually limiting plant growth. There are two basic types of loose rocks, according to the stratigraphic sequence: Tertiary sediments (carboniferous and pyrite-containing substrates) overlaid by Quaternary deposits. Soil-forming substrates are free of recent organic matter (humus) and lack plant-available nutrients. For cropping purposes, the soil fertility has to be improved by special site-adapted reclamation measures, like amelioration, N, P, K fertilization and humus-forming crop mixture within the first and second crop rotation period[1]. The overriding issue of this so-called 'biological rehabilitation' is the establishment of basic ecological soil functions with an increase of soil fertility and cropping

[1] HAUBOLD-ROSAR, M. (2018) Methods of agricultural recultivation of post-mining landscapes in Northeastern Germany. In: SYCHEV, V.G., MUELLER, L. (eds.) Novel methods and results of landscape research in Europe, Central Asia and Siberia, Vol. V Landscape planning, management and rehabilitation, 178-183.

capacities[2]. Although in general the most valuable substrates, such as calcareous boulder clays or sandy loams, are used for agricultural reclamation, it is important to emphasize that mine reclamation soils in the region are rather unproductive in the first years of cropping. However, in the long-term (30-50 years) the yielding potential is quite similar to 'natural' agricultural soils of the region. Nevertheless, the yielding level is less than 30% of the maximum yields that can be expected elsewhere in the best-case scenario for agricultural land in Germany.

Therefore, it is likely that especially in the early stage of biological reclamation the income for the local farmers might be unattractive. On the other hand, the young soils are quite sensitive to improper management, e.g. compaction by heavy machines, humus degradation through cultivation of hums-draining crops. In principle, both soil protection and economic reasons speak for a more extensive, soil conserving farming. Even more the establishment of stress tolerant and undemanding energy crops with low water and nutrient demand could be an attractive cropping alternative. Innovative green technologies can be the initial spark for a new bio-based industry in the regions after the phase-out of coal mining[3].

There are two different owners or administrators of the potential BPS in the case study area: 1) the mining company Lausitz Energie Bergbau AG (LEAG) and 2) the restoration company Lausitzer und Mitteldeutsche Bergbau-Verwaltungsgesellschaft mbH (LMBV). While LEAG rehabilitates recently used land, the LMBV is responsible for the reclamation of lignite mining sites that were abandoned in the context of German reunification at the beginning of the 1990s. In addition, there is a handful of local farmers or farmer associations, like Bauern AG Neißetal or Landwirte GmbH Terpe-Proschim, that manage the selected BPS. They are involved into practical land reclamation, and after one to two crop rotations, when special soil target values are achieved, farmers take over the reclaimed land from LEAG - now passing into a regular (conventional) post-mining agricultural land use without restrictions following the "good agricultural practice" and environmental standards.

The public access to some of the reclamation sites - especially in the LMBV area - is prohibited due to a lack of geotechnical stability of the mining dumps. The agricultural utilization of these areas is partly restricted and therefore they were excluded from the selection process. Nevertheless, concepts are currently tested to establish a higher stability of the material due to measures like vibrofloatation compression or blasting compression. The long-term aim is a return of the agricultural sites to local farmers, which is already fulfilled in some cases.

The considered lignite reclamation sites are located in the district *Spree-Neiße*, which is in the southeast of the federal state Brandenburg. The district surrounds the district-free city of Cottbus, with about 100,000 inhabitants. *Spree-Neiße* is a rural region with small cities and many small to medium villages. The biggest cities are Spremberg (approx. 22,500 inhabitants), Forst (Lausitz) (approx. 18,200 inhabitants), Guben (approx. 17,000 inhabitants), Drebkau

[2] SCHLENSTEDT, J., BRINCKMANN, A., HÄFKER, U., HAUBOLD-ROSAR, M., KIRMER, A., KNOCHE, D., LANDECK, I., LORENZ, A., RÜMMLER, F., STÄRKE, M., TISCHEW, S., WIEDEMANN, D. (2014) Rekultivierung. In: DREBENSTEDT, C., KUYUMCU, M. (eds.) Braunkohlensanierung - Grundlagen, Geotechnik, Wasserwirtschaft, Brachflächen, Rekultivierung, Vermarktung, Springer Vieweg, Berlin, Heidelberg, 487-578.

[3] KNOCHE, D., MERGNER, R., KÖHLER, R., RUTZ, D., JANSSEN, R. (2019) Growing energy crops for biomethane production in the Lusatian Lignite District, Eastern Germany - A contribution to agricultural reclamation. EUBCE 2019. 27th European Biomass Conference and Exhibition, 27-30 May 2019, Lisbon, Portugal, Proceedings, 1636-1641.

(approx. 5,800 inhabitants) and Welzow (approx. 3,500 inhabitants). The district administration is located in Forst (Lausitz). The population in *Spree-Neiße* amounted to 115,456 persons in 2018.

There was a total of 55,800 employees in the district in the year 2018[4]. The unemployment rate was 6.2% in March 2020[5]. About 1,640 persons were working in the sector agriculture, forestry and fishery and more than 15,440 persons in the production industry (in 2017). The average primary income of private households per inhabitant was 19,905 EUR in 2017[6]. The average compensation per employee was 19,111 EUR per year in the sector agriculture, forestry and fishery, whereas it was 46,833 EUR in the manufacturing industry[7].

A main employer and large business factor is the *Lausitz Energie Bergbau AG* (LEAG). LEAG operates the opencast lignite mines *Jänschwalde* and *Welzow-Süd* and also the power plants *Jänschwalde* and *Schwarze Pumpe* within the district and outside the district the lignite mines *Nochten* and *Reichwalde* as well as the power plant *Boxberg* in Saxony. Approximately 7,700 people are employed by LEAG. Additionally, about 3,300 private companies are consultants of LEAG to perform services in the surrounding of the mines and the power plants.

The district contains a few large industrial parks like the industrial park Schwarze Pumpe, the industrial park Guben and the logistic and industry center Forst as well as a lot of smaller and medium-sized industry and business parks in several locations. Additionally, several business and industrial parks exist in Cottbus. Many small and medium-sized enterprises from the manufacturing industry as well as the service sector are located in *Spree-Neiße* and the city of Cottbus. To the neighboring districts *Oberspreewald-Lausitz* in the West, *Oder-Spree* in the North, *Görlitz* in the South and to Poland in the East exist many economic, political and private relationships. And – not to forget – the Brandenburg Technical University (BTU) in Cottbus is an important center of attraction for young, highly educated people and scientists of various disciplines. It has a strong influence on the job market and on the cultural life in the region.

The motorway A15 crosses the district from west to east and further continues to Poland at the border crossing nearby Forst (Lausitz), see figure 5. The net of railroads in the district is centered to Cottbus. Direct lines lead from Cottbus to Spremberg, Forst, Guben, Drebkau and Welzow within *Spree-Neiße* and further to Berlin, Dresden, Leipzig, Görlitz or neighboring smaller and larger Polish cities.

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[4] Amt für Statistik Berlin-Brandenburg (2018): Erwerbstätige – Regionaldaten, https://www.statistik-berlin-brandenburg.de/regionalstatistiken/r-gesamt_neu.asp?Ptyp=410&Sageb=13003&creg=BBB&anzwer=6

[5] Bundesagentur für Arbeit (2020): Arbeitsmarkt im Überblick - Berichtsmonat März 2020 - Spree – Neiße, at https://statistik.arbeitsagentur.de/Navigation/Statistik/Statistik-nach-Regionen/Politische-Gebietsstruktur/Brandenburg/Spree-Neisse-Nav.html

[6] Amt für Statistik Berlin-Brandenburg (2019a): Volkswirtschaftliche Gesamtrechnungen. Verfügbares Einkommen und Primäreinkommen der privaten Haushalte in den kreisfreien Städten und Landkreisen im Land Brandenburg 1995 bis 2017. Berechnungsstand: August 2018. Statistischer Bericht P I 6 - j / 17., Potsdam, 22p., at https://www.statistik-berlin-brandenburg.de/Statistiken/statistik_SB.asp?Ptyp=700&Sageb=82000&creg=BBB&anzwer=11

[7] Amt für Statistik Berlin-Brandenburg (2019b): Volkswirtschaftliche Gesamtrechnungen. Arbeitnehmerentgelt, Bruttolöhne und -gehälter, Arbeitnehmer in den kreisfreien Städten und Landkreisen im Land Brandenburg 2000 bis 2017. Berechnungsstand: August 2018. Statistischer Bericht P I 7 - j / 17. Potsdam, 86p., at https://www.statistik-berlin-brandenburg.de/Statistiken/statistik_SB.asp?Ptyp=700&Sageb=82000&creg=BBB&anzwer=11

The selection of the district *Spree-Neiße* as case study area in BIOPLAT-EU was derived from the FORBIO-Project (FOSTERING SUSTAINABLE FEEDSTOCK PRODUCTION FOR ADVANCED BIOFUELS ON UNDERUTILISED LAND IN EUROPE), where lignite mining reclamation sites in Lusatia were already considered as a potential site for the production of biomass. The former number of approx. 7,200 – 10,100 ha of available agricultural land on reclamation sites (FORBIO) had to be reduced to about 2,000 ha at recently restored sites in the current operating mines *Jänschwalde* and *Welzow-Süd*. Detailed maps of already reclaimed agricultural land (in 2010 and 2012) and planned rehabilitated land are the basis for the selection process (sources: data from mining company and soil surveys). The limiting age of the areas after reclamation is 15 years, since conventional agricultural use should be possible after a maximum of two reclamation crop rotations. These sites still have not been used for common agriculture and therefore a competition to food production does not exists. Additionally, the soil quality of the sites is comparatively low. According to this, they are defined as 'underutilized' in this study.

Not all areas are available now, as some areas are still in the legally binding 'biological reclamation' process. But a total of 2,154 ha may be available in the next years: 1,508 ha in *Jänschwalde* and 646 ha in *Welzow-Süd*. In the future about 1,300 ha may be added. There is detailed information about soil quality, regional climate, expected yield and ownership about these sites.

Black locust and Sorghum were chosen as potential bioenergy plants on lignite miming reclamation sites, because there is already a lot of experience from several trials and small to medium commercial plantings on reclaimed land. Furthermore, the Research Institute for Post-Mining Landscapes (FIB e.V.) carries out several growing trials with black locust and Sorghum in *Welzow-Süd* and with Sorghum in *Jänschwalde* in cooperation with external partners. Thereby, Sorghum shows yields of 9 to 17 Mg DM ha^{-1} yr^{-1} and Robinia can reach up to 11 Mg DM ha^{-1} yr^{-1} on Lusatian lignite reclamation sites - depending on the site conditions and variety selection, already in the first years of cropping on new ground. Already in the 1990s scientist from the Brandenburg Technical University of Cottbus (BTU) performed trials with willows, poplars, and black locust in Jänschwalde with quite promising results. Such short-rotation coppices (SRC, agricultural wood) and agroforestry systems (AFS) make a substantial contribution to enhance the ecological and aesthetic value of post-mining landscapes[8]. However, at the moment such innovative land use systems are hardly profitable, when only looking on the energetic use of biomass[9].

[8] QUINKENSTEIN, A., FREESE, D., BÖHM, C., TSONKOVA, P., HÜTTL, R.F. (2012) Agroforestry for mine-land reclamation in Germany: Capitalizing on carbon sequestration and bioenergy production. In: RAMACHANDRAN, P.K., GARRITY, D. (eds.) Agroforestry - The Future of Global Land, 313-339.

[9] BÖHM, C., QUINKENSTEIN, A., FREESE, D, HÜTTL, R.F. (2011) Assessing the short rotation woody biomass production on marginal post-mining areas. Journal of Forest Science 57, 7, 303-311.

Figure 2. Young Sorghum field at the lignite mine reclamation site Jänschwalde in July 2016 - first crop rotation (Picture by S. Lukas/FIB).

Figure 2a. Sorghum variety-trial on reclaimed land at the lignite opencast mine Jänschwalde in September 2019 (Picture by S. Lukas/FIB).

Figures 3 and 4. Black locust trial (5th year) on reclaimed land of the lignite opencast mine Welzow-Süd (Pictures by R. Köhler/FIB).

In a radius of 50 km around the lignite mines *Welzow-Süd* and *Jänschwalde* about 45 biogas plants exist, with a total installed electrical capacity of approximately 30,000 kW (see figure 5), only in Brandenburg. The capacity of the biogas plants ranges from 165 kW to 3,000 kW. There is only one existing CHP unit with an installed electrical capacity of 2,570 kW for wood and biomass use in the case study district – BHKW Sessele. Unfortunately, no detailed information is currently available on the capacity load of the plants and the biomass used but it is likely that additional woody biomass could be used in the plant.

The feed-in tariff for the generation of electricity from biomass that applies to the plant is linked to the year of commissioning and the installed capacity of the plant, and the law in force at the time. With an amendment of the law for Renewable Energy Development (EEG) in the year 2017, the level of the payment for electricity from biomass was changed from a government-fixed tariff system to a tendering system. Under the EEG 2017, all new bioenergy plants with a capacity of more than 150 kW are subject to mandatory tendering under supervision of the German Federal Network Agency. The tariff ('value to be created' = average market price + incentive) is guaranteed for the following 20 years. In 2019 the average tariff was 0.1247 EUR per kWh.

The current feed-in tariff for electricity from biomass, for which the 'value to be created' is determined by law, is shown in table 2 (source: Erneuerbare-Energien-Gesetz – EEG 2017).

Table 2. Feed-in tariff for electricity from biomass, which is determined by law (EEG 2017, § 42)

Rated capacity	Tariff
<150 kW	0.1332 EUR kWh^{-1}
… - 500 kW	0.1149 EUR kWh^{-1}
… - 5 MW	0.1029 EUR kWh^{-1}
… - 20 MW	0.0571 EUR kWh^{-1}

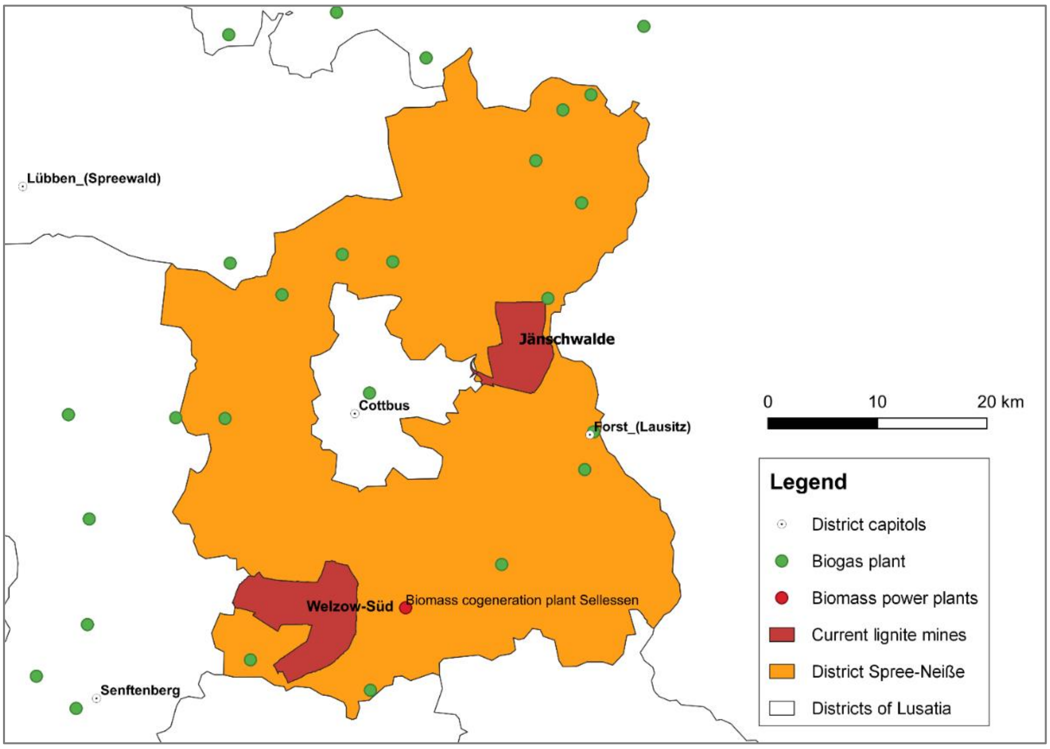

Figure 5. Biomass processing plants in the district Spree-Neiße and neighboring districts (R. Schlepphorst, source: Landesvermessung und Geobasisinformation Brandenburg, 2020[10])

[10] Landesvermessung und Geobasisinformation Brandenburg: (2020) Web Map Service, Bioenergie im Land Brandenburg (WMS-MWE-Bioenergie), Version 1.3.0., at https://isk.geobasis-bb.de/ows/bioenergie_wms?

2.1.2 Case study 2

Location: Dahme-Spreewald

MUC status: underutilized and contaminated (former sewage irrigation fields)

BPS Approx surface (ha): between 5 and 340 ha, (in total 521 ha)

Potential crop(s): Miscanthus, poplar (Populus spec.) in SRC, meadow/current grass vegetation

Potential bioenergy pathway(s): solid biofuels for Heat/Electricity, biogas

Existing BPP: yes

Selection process

The case study area 2, district *Dahme-Spreewald,* is located in the Lusatian Lowland in the southeastern part of the federal state Brandenburg. The landscape is shaped by sediments of the Saale (304,000 - 127,000 yr AC) and Weichselian (115,000 -11,600 yr AC) glacial periods, which cover lignite bearing Tertiary strata from the Upper and Middle Miocene. The region is influenced by a western sub-atlantic to eastern sub-continental climate. Located in the transition zone, there is a moderate rainfall and temperature gradient. Overall, the regional climate situation can be described as moderate dry to dry lowland climate: The mean annual temperature ranges from 7.0 to 9.5 °C and the average annual precipitation varies between 580 and 660 mm yr^{-1}. Although half of the rain falls during the growing season, the climatic water balance in the growth period is strongly negative with -125 to -225 mm. Over 80% of agricultural land are sorption and nutrient poor sandy soils of the glacial outwash plains. Frequently, the plant available water storage capacity per one meter soil depth is less than 90 mm. The groundwater level usually lies 3.0 m below surface and beyond the rooting zone of most crops. Insofar by most cases, water is the plant growth-limiting resource[11]. Dry summers, like 2003, 2006, 2015, 2018 and 2019, can cause a yield reduction by at least one third compared to the average.

The potential biomass production sites (BPS) are located in the disused sewage irrigation fields. They are relics of the late 19th century, and they are constructed as a system of channels, dams, settling basins and irrigation fields (about 85% of the area). Sewage from cities – mainly Berlin - was used to irrigate the fields, were substantial components of the nitrogen- and phosphorous-rich organic substances were filtered in the upper soil layers. The irrigation fields were partially used for market gardening, cultivation of vegetables for the supply of the cities inhabitants as well as grassland and for cultivation of forage legumes. Wastewater irrigation led to a yield improvement during the first decades. In this way, advanced rain-fed farming with liquid manure made a considerable contribution to the catering of the rapidly growing urban population. And in fact, double cropping became profitable and per-hectare yields on some intensively irrigated sewage farms belonged to the highest in Germany.

[11] MLUR - Ministerium für Landwirtschaft, Umweltschutz und Raumordnung des Landes Brandenburg (ed), 2003: Landschaftswasserhaushalt in Brandenburg. Kurzfassung zum Sachstandsbericht mit Konzeption, Projektgruppe Landschaftswasserhaushalt, 1-18.

However, longer irrigation periods with excessive loads of nutrients and increasing pollutants impaired the soil fertility. Irrigation promoted nutrient imbalances and an irreversible degradation of the soil structure. Both "hyper"-trophication and reduced soil aeration caused a considerable plant vitality loss leading to growth retardations and an increasing susceptibility to plant diseases and pests. In addition, hazardous substances of industrial wastewater (e.g. heavy metals) cumulated in the topsoil affecting both plant growth of sensible species and crop utilisation. For instance, on heavy polluted sites the cadmium concentrations in row crops (like potatoes or sugar-beets), maize and cereals were by 10 to 100 times higher as compared to the surroundings. Grazing milk cows had harmful concentrations in liver and kidney. At last, in terms of risk prevention all crops were condemned to be unfit both for consumption and forage[12, 13, 14]. Not least, hygienic aspects restrictions lead to a termination of any cropping in 1983[15]. In the meantime, all irrigation fields are closed and substituted by modern multi-stage sewage-treatment plants.

The Berliner Stadtgüter GmbH, a public real-estate company of the federal state of Berlin, owns most of the former sewage irrigation fields in the surrounding of Berlin. It has been a central partner in the capital region of Berlin-Brandenburg for almost 150 years. The dynamic growth of the emerging industrial metropolis prompted the city leaders to buy up otherwise underutilized and barren land beyond the city limits. Besides the use as sewage irrigation fields the city estates were also intended as storage areas and as agricultural land. The Berliner Stadtgüter GmbH thus laid one basis for the infrastructural development of the young metropolis Berlin. Today, the company is establishing itself as a regional player for landscape compensation and replacement measures, providing also open meadow land for infrastructure projects, the maintenance of the cultural landscape or for renewables[16].

Today the former sewage irrigation fields are mainly used as agricultural fallow land and as a land backup for compensation measures in nature protection. Companies like RWE, Vattenfall, Lignovis and also the landowner (Berliner Stadtgüter GmbH) has tried to establish short rotation coppices with poplar, black locust and willows, with different success (Figure 6, 7). Not surprisingly, management requirements are more demanding as compared to arable land on nearby native sites with well-managed arable land. For example, some first practical experience with short-rotation coppices (SRC) indicate that the costs for planting, weed control, auxiliary planting and harvest are about 30% higher.

[12] Grün, M., Machelett, B., Kronemann, H., Podlesak, W., Schneider, J., 1990a: Cadmiumbelastung von Boden und Pflanze im Gebiet der Rieselfelder südlich Berlins. VDLUFA Schriftenreihe 32, 763-768.

[13] Grün, M., Machelett, B., Podlesak, W, 1990b: Kontrolle der Schwermetallbelastung landwirtschaftlich genutzter Böden in der DDR. VDI Berichte 837, 593-612.

[14] Sowa, E., Nestler, W., Leibenath, C., Uhlmann, W., 1992: Schutzgutbezogene Folgenutzung von Rieselfeldern. In: Rosenkranz, D., Bachmann, G., Einsele, G., Harreß, H.-M. (eds): Bodenschutz 10. Lfg. II/92, Erich Schmidt Verlag, Berlin, 7150-7210.

[15] Schmidt, M., 1995: Planungsrelevante Aspekte einer Rieselfeldnachnutzung im Verflechtungsraum Brandenburg - Berlin. In: Landesumweltamt Brandenburg (ed), 1995: Rieselfelder Brandenburg-Berlin, Studien- und Tagungsberichte des Landesumweltamtes, Band 9, 4-10.

[16] https://www.berlinerstadtgueter.de/

Figure 6. One-year-old short rotation coppice with poplar (clone Hybride 275) on a former sewage farm at Schönwalde-Glien (picture by R. Schlepphorst/FIB).

Figure 7. Young poplars with growth reductions at a former sewage irrigation field nearby Schönwalde-Glien (picture by R. Schlepphorst/FIB).

An explicit limitation to agricultural activities results from the small-scale structure of the fields with a heterogeneous pattern of dams and fields. Field sizes range from below 0.5 ha to about 1 ha (Figure 8). The access to the field with heavy agricultural machines can be difficult. Moreover, the nutrient status is often unclear and some nutrient imbalances can occur, which makes plant cultivation challenging. This specific site condition in combination with the presence of contaminations, e.g. heavy metals, can cause serious growth reductions and plant damages. On heavily polluted sites, the maximum concentrations of cadmium, copper or zinc significantly exceed national threshold values for harmless agricultural land use, sometimes even up to 2,500 times[17, 18].

Figure 8. Small-scale structure of former sewage irrigation fields nearby Königs Wusterhausen (picture by R. Schlepphorst/FIB).

The district *Dahme-Spreewald* (area size of 2,261 km²) extends over about 70 km, from the urban region conterminous to Berlin to a rural region with small cities and villages in the south of Brandenburg. It is attributed to the region Lusatia, which spreads over several districts in the south of Brandenburg and the north of Saxony. The population in *Dahme-Spreewald* amounted to 169,067 persons in 2018[19]. The district administration is located in Lübben (Spreewald), a small town with 14,000 inhabitants. Other cities are Königs Wusterhausen (approx. 37,000 inhabitants), Wildau (approx. 10,000 inhabitants) and Luckau (9,500 inhabitants).

[17] Schlenther, L., Eggert, T., Hoffmann, C., Renger, M., 1992: Bodenökologische Untersuchungen auf den Rieselfeldflächen Buch. Abschlussbericht im Auftrag der Berliner Forsten, 1-215.

[18] Hoffmann, C., Schlenther, L., Renger, M., 1995: Zur Schwermetallbelastung und -dynamik auf einem ehemaligen Rieselfeld. Mitteilungen der deutschen Bodenkundlichen Gesellschaft 76, 293-296.

[19] Amt für Statistik Berlin-Brandenburg (2018): Bevölkerung am 31.12.2018. at https://www.statistik-berlin-brandenburg.de/regionalstatistiken/r-gesamt_neu.asp?Ptyp=410&Sageb=12015&creg=BBB&anzwer=6

The unemployment rate was 4.4% in April 2020[20]. The average primary income per inhabitant was 20,889 EUR in 2017[21]. About 2,100 persons were working in the sector agriculture, forestry and fishery and more than 16,100 persons in the production industry (in 2018). The average compensation per employee in the sector agriculture, forestry and fishery in 2017 was 21,953 EUR per year, whereas in the manufacturing industry it was 29,501 EUR[22].

Many small and medium-sized enterprises from the manufacturing industry as well as the service sector are located in the district. However, the economic structures of the district show a strong north-south gradient. Large industrial parks are particularly concentrated to the northern part of the district nearby the airport *Berlin-Schönefeld* and cities like Königs Wusterhausen and Wildau with its University of Applied Science (TH Wildau). Also smaller cities in the south, like Lübben or Luckau, offer sites for industrial settlements. The southern part of the district is a popular tourist destination (Spreewald), whereas in the southwest agricultural production is more important.

The motorway A13 crosses the district from north to south and the A10 from west to east in the northern part of the district. Railway lines connect the region to Berlin and the cities in the south of Brandenburg.

The selection of the district *Dahme-Spreewald* as case study area in BIOPLAT-EU was derived from the FORBIO-Project where former sewage irrigation fields were already considered as a potential site for the production of biomass. In total 6,707 ha of former irrigation fields are classified as agricultural but only 1,140 ha remain unchanged according to existing landscape programmes and local land use plans. In addition, there are 2,777 ha with no defined use category (unplanned) and 2,790 ha which are temporarily available for feedstock production, i.e. without a decided or legally binding development objective (Diagram 1, Knoche et al. 2019). Looking only on the selected district *Dahme-Spreewald* there are 500 ha of still underutilized land suitable for energy cropping or another eco-friendly land use.

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[20] Bundesagentur für Arbeit (2020): Arbeitsmarkt im Überblick - Berichtsmonat April 2020 – Dahme-Spreewald, at https://statistik.arbeitsagentur.de/Navigation/Statistik/Statistik-nach-Regionen/Politische-Gebietsstruktur/Brandenburg/Dahme-Spreewald-Nav.html

[21] Amt für Statistik Berlin-Brandenburg (2019a): Volkswirtschaftliche Gesamtrechnungen. Verfügbares Einkommen und Primäreinkommen der privaten Haushalte in den kreisfreien Städten und Landkreisen im Land Brandenburg 1995 bis 2017. Berechnungsstand: August 2018. Statistischer Bericht P I 6 - j / 17., Potsdam, 22p., at https://www.statistik-berlin-brandenburg.de/Statistiken/statistik_SB.asp?Ptyp=700&Sageb=82000&creg=BBB&anzwer=11

[22] Amt für Statistik Berlin-Brandenburg (2019b): Volkswirtschaftliche Gesamtrechnungen. Arbeitnehmerentgelt, Bruttolöhne und -gehälter, Arbeitnehmer in den kreisfreien Städten und Landkreisen im Land Brandenburg 2000 bis 2017. Berechnungsstand: August 2018. Statistischer Bericht P I 7 - j / 17. Potsdam, 86p., at https://www.statistik-berlin-brandenburg.de/Statistiken/statistik_SB.asp?Ptyp=700&Sageb=82000&creg=BBB&anzwer=11

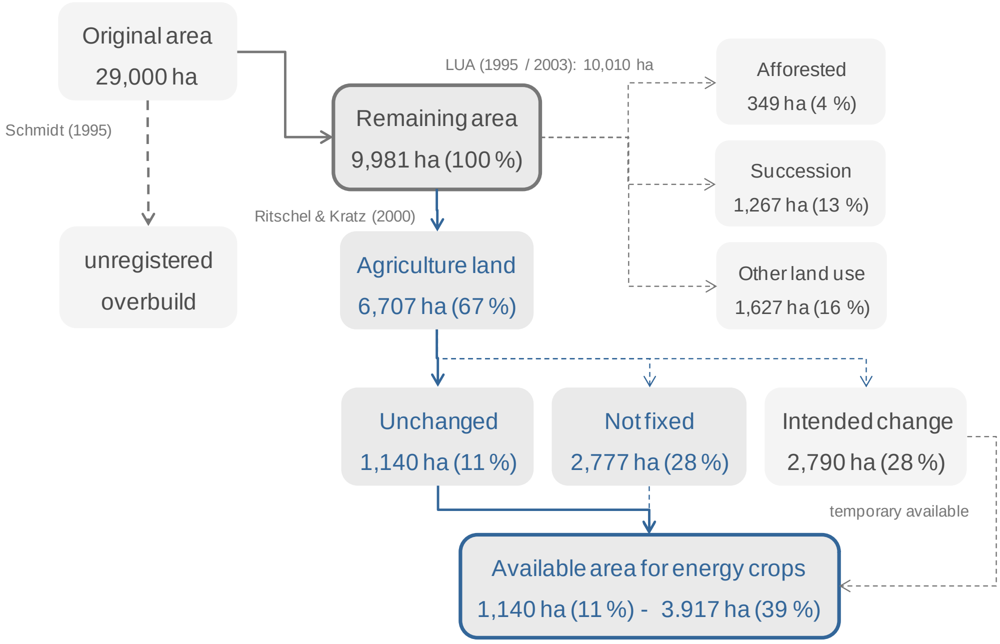

Diagram 1: Land availability for feedstock production on disused irrigation fields in Berlin & Brandenburg considering specific use restrictions[23].

Detailed Maps and an additional visual interpretation of current aerial photographs were the base for the selection process (sources: maps of historic sewage irrigation fields from the landowner). There is information about regional climate, expected average yield and ownership of these sites. Soil quality is heterogeneous, so preliminary soil investigation is required before cropping decisions and cultivation planning are made.

Low demanding *Miscanthus* and poplar were chosen as potential bioenergy plants suitable for disused sewage irrigation fields. Unfortunately, no yield data for *Miscanthus* from former sewage irrigation fields is available at present. It is rather difficult to predict future yield potential under rapidly changing growth conditions due to ongoing mineralization of the soil organic matter. However, there are results from trials on common agricultural sites in the Lusatian region. Thereby, *Miscanthus* can have yields of 5 to 25 Mg DM ha^{-1} yr^{-1}. There is already experience from several trials and small to medium commercial plantings with poplar in the region. Poplar can reach up to 13 Mg DM ha^{-1} yr^{-1} on former sewage irrigation sites. The use of the already existing vegetation (grass) could be an interesting option for the pathway biogas/biomethane. The yield is quite low with 2 to 4 Mg DM ha^{-1} yr^{-1}, but as the management costs are low too, the use (e.g. as additional input material) can be economically viable (Knoche et al. 2019).

[23] Knoche, D., Mergner, R., Köhler, R., Rutz, D., Janssen, R., 2019: Mobilization of disused sewage irrigation fields for sustainable green biomass utilization - An applied feasibility study in the metropolis region Berlin & Brandenburg, Germany. EUBCE 2019. 27th European Biomass Conference and Exhibition, 27-30 May 2019, Lisbon, Portugal, Proceedings, 377-386.

There are 10 existing CHP units with a total installed electrical capacity of 50.9 MW for wood and biomass use within a 50 km radius around the BPS. The capacity ranges from 1.56 MW to 20 MW. In a radius of 50 km around the former sewage irrigation fields in *Dahme-Spreewald* about 60 biogas plants exist, with a total installed electrical capacity of approximately 43,200 kW (figure 4), only in Brandenburg. The capacity of the biogas plants ranges from 444 kW to 2,900 kW.

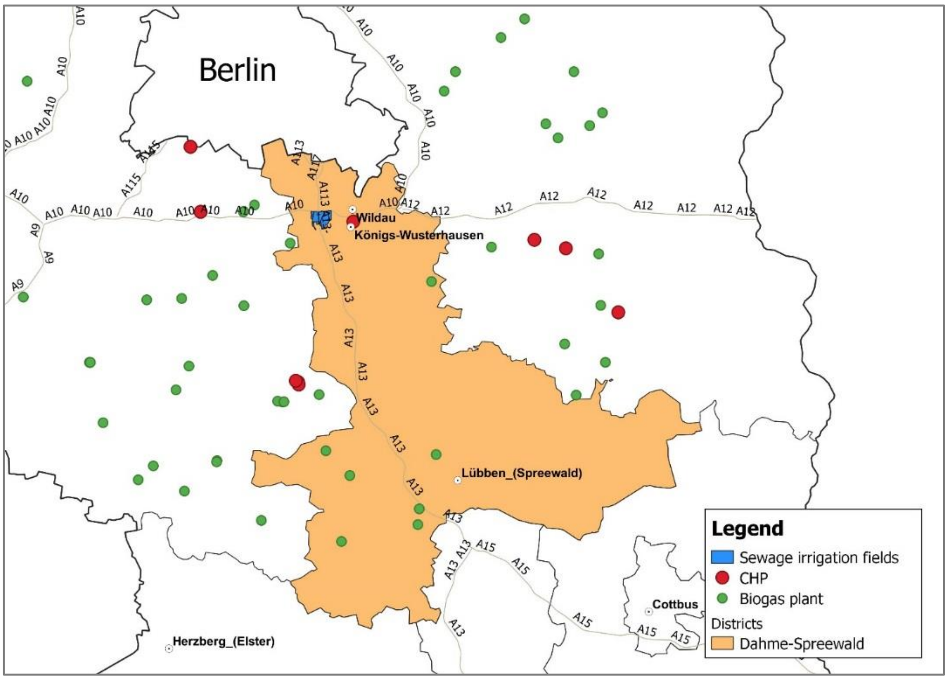

Figure 9. Biomass processing plants in the district Dahme-Spreewald and neighboring districts (R. Schlepphorst, source: Landesvermessung und Geobasisinformation Brandenburg 2020)

2.1.3 Case study 3 (back-up)

Location: Spree-Neiße

MUC status: underutilized (power lines in forests)

BPS Approx surface (ha): up to approx. 550 ha in total, area sizes from 0.1 to 22 ha

Potential crop(s): Black locust (Robinia pseudoacacia) and Poplar (Populus spec.) in SRC or current woody vegetation

Potential bioenergy pathway(s): Solid biofuels for heat/electricity

Existing BPP (yes or no): yes, several heating plants in the district Spree-Neiße and neighboring districts

Selection process

The backup case study area, district *Spree-Neiße,* is located in the Lusatian Lowland in the south-eastern part of the federal state Brandenburg. The regional climatic situation corresponds to case study area 1. This area was selected because it can provide interesting information on how small size MUC patches could be tested in the webGIS platform, in case time allows. Moreover, these areas are formally considered forest and as such they would be excluded from our analysis. However, their potential is interesting and as testing is concerned these seem a useful case.

The landscape is shaped by sediments of the Lusatian glacial period, which cover lignite bearing Tertiary strata from the Upper and Middle Miocene. The area is influenced by a western sub-Atlantic to eastern sub-continental climate. The regional climate situation can be described as moderate dry to dry lowland climate. The mean annual temperature ranges from 7.0 to 9.5 °C and the average annual precipitation varies between 580 and 660 mm yr^{-1}, with half of the rainfall in the vegetation period. The climatic water balance in the growth period is strongly negative – it varies between -50 and -200 mm.

The potential biomass production sites (BPS) are located within the forest below power lines. More than 82% of these sites are sandy soils with a low to very low water holding capacity and mainly without ground- and backwater influence. About 16% of the area are loamy sands with a low to middle usable field capacity. The nutrient supply of these sites is moderate to poor.

The land below the power line belongs to private owners, the federal state of Brandenburg or the federal republic of Germany. Since the areas are legally forest, the federal state forest service (*Landesbetrieb Forst Brandenburg*) with its departments of state forest management and sovereign tasks is the most important contact. The operating company of the electric power line, for instance the *50Hertz Transmission* GmbH, who operates the 220 and 380 kV lines in the eastern part of Germany, compensates financially the landowners for not using the land.

In legal terms, these are not agricultural sites, but forests. Several restrictions apply in German forests, in particular in certified forests, especially regarding the use of herbicides or the use of special tree species. This is the main challenge in the establishment of young stands because the success of the cultivation strongly depends on a good regulation of the accompanying vegetation.

There may be logistical challenges due to the location in the forest and the narrow shape of the BPS (access with large agricultural machines for planting, harvesting and transport of wood chips). Results of a trial at the University of Applied Science Eberswalde showed that a utilization with SRC species like poplar, black locust or even alder is possible in general, but several aspects have to be considered due to the non-agricultural site conditions[24]. General challenges for the establishment of young trees on electric power lines in the region are:

- a strong competition of accompanying vegetation, because chemical weed control is not allowed in forests in Germany and mechanical weed control seems to be not economically viable in this case;
- grazing by wild animals, because fencing of the plantations is not economically viable option either and the surrounding forests are a good habitat, especially for roe deer, the risk of losing seedlings is high;
- predominantly poor and varying site conditions at mainly sandy soils with a poor nutrient capacity and a low water storage capability;
- a limitation in height growth due to the restrictions of the power line company, to prevent any damages to the wires;

The considered electric power lines are located in the district *Spree-Neiße*, which is in the southeast of the federal state Brandenburg. The district surrounds the district-free city of Cottbus, with about 100,000 inhabitants. *Spree-Neiße* is a rural region with small cities and many small to medium villages. The biggest cities are Spremberg (approx. 22,500 inhabitants), Forst (Lausitz) (approx. 18,200 inhabitants), Guben (approx. 17,000 inhabitants), Drebkau (approx. 5,800 inhabitants) and Welzow (approx. 3,500 inhabitants). The district administration is located in Forst (Lausitz). The population in *Spree-Neiße* amounted to 115,456 persons in 2018.

There was a total of 55,800 employees in the district in the year 2018[25]. The unemployment rate was 6.2 % in March 2020[26]. About 1,640 persons were working in the sector agriculture, forestry and fishery and more than 15,440 persons in the production industry (in 2017). The average primary income of private households per inhabitant was 19,905 EUR in 2017[27]. The average compensation per employee was 19,111 EUR per year in the sector agriculture, forestry and fishery, whereas it was 46,833 EUR in the manufacturing industry[28].

[24] Hartmann, H., Schlepphorst, R. Murach, D. (2013): DENTRASS – Dendromasse unter Leitungstrassen im Wald. AFZ-Der Wald 21, 43-45.

[25] Amt für Statistik Berlin-Brandenburg (2018): Erwerbstätige – Regionaldaten, https://www.statistik-berlin-brandenburg.de/regionalstatistiken/r-gesamt_neu.asp?Ptyp=410&Sageb=13003&creg=BBB&anzwer=6

[26] Bundesagentur für Arbeit (2020): Arbeitsmarkt im Überblick - Berichtsmonat März 2020 - Spree – Neiße, at https://statistik.arbeitsagentur.de/Navigation/Statistik/Statistik-nach-Regionen/Politische-Gebietsstruktur/Brandenburg/Spree-Neisse-Nav.html

[27] Amt für Statistik Berlin-Brandenburg (2019a): Volkswirtschaftliche Gesamtrechnungen. Verfügbares Einkommen und Primäreinkommen der privaten Haushalte in den kreisfreien Städten und Landkreisen im Land Brandenburg 1995 bis 2017. Berechnungsstand: August 2018. Statistischer Bericht P I 6 - j / 17., Potsdam, 22p., at https://www.statistik-berlin-brandenburg.de/Statistiken/statistik_SB.asp?Ptyp=700&Sageb=82000&creg=BBB&anzwer=11

[28] Amt für Statistik Berlin-Brandenburg (2019b): Volkswirtschaftliche Gesamtrechnungen. Arbeitnehmerentgelt, Bruttolöhne und -gehälter, Arbeitnehmer in den kreisfreien Städten und Landkreisen im

A main employer and large business factor is the *Lausitz Energie Bergbau AG* (LEAG). LEAG operates the opencast lignite mines *Jänschwalde* and *Welzow-Süd* and also the power plants *Jänschwalde* and *Schwarze Pumpe* within the district and outside the district the lignite mines *Nochten* and *Reichwalde* as well as the power plant *Boxberg* in Saxony. Approximately 7,700 people are employed by LEAG. Additionally, about 3,300 private companies are consultants of LEAG to perform services in the surrounding of the mines and the power plants.

The district contains a few large industrial parks like the industrial park Schwarze Pumpe, the industrial park Guben and the logistic and industry center Forst as well as a lot of smaller and medium sized industry and business parks in several locations. Additionally, several business and industrial parks exist in Cottbus. Many small and medium-sized enterprises from the manufacturing industry as well as the service sector are located in *Spree-Neiße* and the city of Cottbus. To the neighboring districts *Oberspreewald-Lausitz* in the West, *Oder-Spree* in the North, *Görlitz* in the South and to Poland in the East exist many economic, political and private relationships. And – not to forget – the Brandenburg Technical University (BTU) in Cottbus is an important center of attraction for young, high educated people and scientists of various disciplines. It has a strong influence on the job market and on the cultural life in the region

The motorway A15 crosses the district from west to east and further continues to Poland at the border crossing nearby Forst (Lausitz) (see figure 3). The net of railroads in the district is centered to Cottbus. Direct lines lead from Cottbus to Spremberg, Forst, Guben, Drebkau and Welzow within *Spree-Neiße* and further to Berlin, Dresden, Leipzig, Görlitz or neighboring smaller and larger Polish cities.

Usually the forest areas below electric power lines are not cultivated (see figure 10), with some exceptions such as Christmas tree plantations. Furthermore, they do not compete with food production, as forest conversion for power lines is not legally permissible. However, the areas have to be maintained with high efforts, because the vegetation should not affect the wires. Therefore, growing trees are regularly removed with wood mulchers, but the biomass is not used in any way. This unused biomass represents a potential for the further development of bioenergy use.

The BPS were selected through a multi-stage process: 1) Discussion with experts and study of trial results, 2) GIS-supported identification of power lines in the district using existing geodata (source: WMS layer of power supply, Federal Land Survey Office Brandenburg), 3) Visual interpretation and delineation of unused areas using current aerial photographs (GIS).

Black locust and poplar were selected as potential bioenergy plants, because of the positive experience with these tree species in short rotation coppices (SRC) on typical soils in the region. Additionally, there are encouraging results from a trial at the University of Applied Sciences Eberswalde (see description of landowners and limitations). A yield of 3 to 5 Mg DM ha^{-1} yr^{-1} can be expected. Based on the assumption of a three-year rotation the expectable annual biomass volume can approximately amount to 550 to 900 Mg DM.

Land Brandenburg 2000 bis 2017. Berechnungsstand: August 2018. Statistischer Bericht P I 7 - j / 17. Potsdam, 86p., at https://www.statistik-berlin-brandenburg.de/Statistiken/statistik_SB.asp?Ptyp=700&Sageb=82000&creg=BBB&anzwer=11

Figure 10. A young trial with hybrid poplars below a power line within a pine forest. There is a strong accompanying vegetation, which could not be eliminated due to restrictions in the use of herbicides (picture by R. Schlepphorst/FIB).

Figure 11. Natural succession, formerly with black locust and grass, below a 380 kV electric power line in the south of Brandenburg. The shoots of the trees have to be removed in regular intervals with high effort (picture by R. Schlepphorst/FIB).

Within the district *Spree-Neiße* the only power plant, which uses biomass as fuel is the combined heat and power plant Selleseen, nearby the city of Spremberg (see figure 2). However, several biomass-driven CHP plants and heating plants are located in neighboring districts and can potentially act as costumer for wood chips from SRC. The total installed electrical capacity of these plants is more than 60 MW and ranges from 2.6 MW to 20 MW.

Information about feed-in tariffs can be found in chapter 2.1.1 (German case study 1).

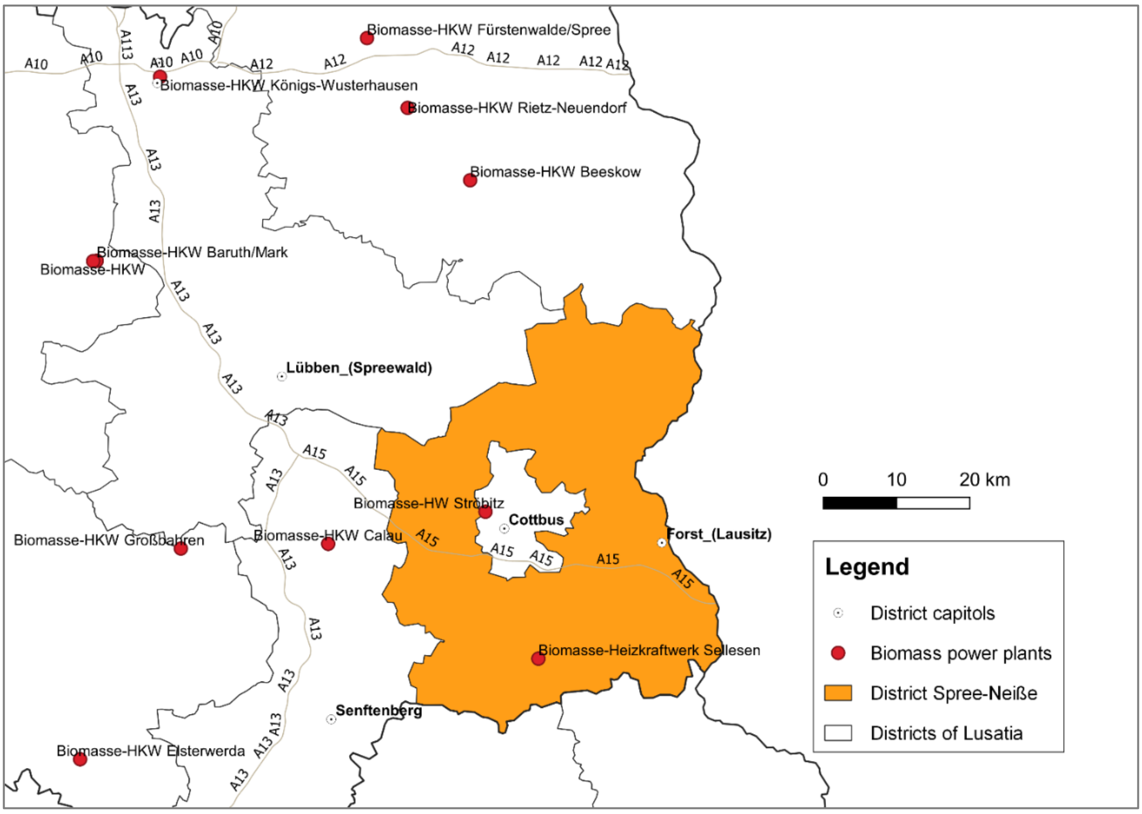

Figure 12. Biomass processing plants in the district Spree-Neiße and neighboring districts in Brandenburg[29]

[29] Landesvermessung und Geobasisinformation Brandenburg: Web Map Service, Bioenergie im Land Brandenburg (WMS-MWE-Bioenergie), Version 1.3.0., at https://isk.geobasis-bb.de/ows/bioenergie_wms?

2.2 Hungary

2.2.1 Case study 1

Location: Bács-Kiskun and Csongrád-Csanád county

MUC status (Underutilized vs Contaminated vs both): marginal - underutilized

BPS Approx surface (ha): >10,000 hectares

Potential crop(s): Short or Mid Rotation Forestry (poplar, black locust), Camelina, Maize, Rapeseed, Lucern, Sorghum

Potential bioenergy pathway(s): solid biofuels, bioethanol, biogas

Existing BPP: yes

Selection process

The majority of the two counties belongs to the so called "Sand region between the Danube and Tisa", a semi-arid area strongly affected by desertification and other climate change-induced impacts.

Soil types vary across the region. Typical are sandy or loamy soils with limited organic matter (Humic Aerosol). Geomorphologically, sand dunes and depressions between the dunes occupy the region and the soil is changing accordingly. In the depressions, where moisture accumulates, there are sparse meadow as some developed soil types are found.

The region does not present an abundant natural surface water network and usually man-made and maintained structures transport or store water. This is a direct consequence of historical (~100 years ago) river and flood control efforts (dykes on both sides of Tisa and Danube and drainage system built on marshlands).

This mid-Hungarian region has an arid-continental climate (precipitation <450mm) that is prone to extreme events like heat waves and long summer droughts.

Private and state-owned lands both exist. State-owned forests are common whereas cropland is predominantly private. Lease contracts (by Kiskunság National Park) and state incentives support new forests or fruit-orchard plantations establishment on these unused lands. For example, agro-forestry (e.g. forest for energetic purpose or for the furniture sector) is supported by a state fund that sets forest management and defines the minimum cultivation period to 20 years. However, the presence of Natura2000 sites and arable land managed by the national park entities have special regimes including limitations on harvesting quantities and restrictions on periods, and these in turn constitute a disincentive to cultivating on these lands.

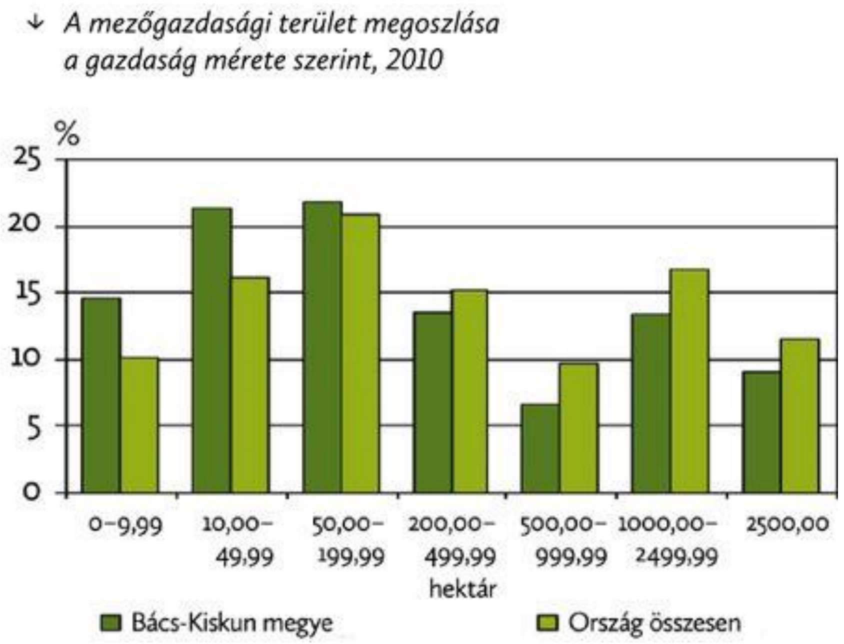

Figure 13. Agricultural land parcels' distribution by size in Bács-Kiskun county (dark green) compared to national average (lighter green) in 2010.

The average farm size is generally small to medium size due to historic reasons. In this region agriculture has been characterized by relatively small parcels (1-10 ha) or medium size parcels (up to 50 – 200 hectares totals almost 40% of the total land in this area) and usually the land owner was living on the land on a farm traditionally named "*tanya*". Tanya is a typical living style in this rural part of Hungary and people are bounded with the minimum surface of land that can support the family. Larger parcels usually can be found on the edges of the sand region as fertility and value of soils go up, thus historically attracting investors.

The population of **Bacs-Kiskun** county is around half a million people. Most people live in cities (~70%) but there is a significant amount of people who live in smaller communities. Unemployment rate is at average levels for Hungary, around 10%. Average income is about 6,000 EUR/year (net). Investment per capita is around 1,000 EUR. People aged between 14 and 64 is around 70% of total population. The share of people employed in agriculture (~8%) is higher than the country's average, as its agriculture's contribution to the GDP is approximately the double (~8% in the case study site vs 4% countrywide).

Arable land and forest land, and other land (cities, infrastructure, industry etc.): ~650,000ha vs ~150,000ha) Agriculture land ~500,000 ha. Top 5 crops (average yields per Ha): maize (7,5 tons), wheat (4,5 tons), sunflower (2,5 tons), rapeseed (3,5 tons), Lucerne (4 tons). There are 750,000 Private Companies registered with an agricultural profile and about 50,000 individual farmers.

The population of the **Csongrád-Csanád county** is around 400,000 people, 75% of which are living in cities. Unemployment rate is around 7%, lower than the national average. Also, in this county the main crops are with the same as in Bacs-Kiskun. Companies registered with agricultural profile are around 380,000, whereas individual farmers are about half those of the neighboring county, at 27,000.

The selection process required three steps: a literature research, multistakeholder consultations, and field investigations/ground-truthing.

A literature research aiming at collecting experiences from previous projects on the topic of MUC lands in Hungary was conducted. No actual projects were found that would map Hungary's underutilized or contaminated lands and assess their use for energy crops. Marginalities have been studied by different institutes like the national soil research institute. This research was mainly based on the biophysical attributes that were set for the purpose of the CAP Less favored Land delineation process. Marginality spreads across the country but significant large areas were delineated between the Danube and Tisa rivers ("Sand region") and on both sides of the Tisa river, where excess water combined with clay soils play a relevant role in the definition of marginality.

Subsequently, an analysis of large surfaces of land left untouched beyond what is normally a fallow management period (i.e. underutilized) was carried out. For this task, Geonardo crafted a GIS based mapping methodology for the purpose of the BIOPLAT-EU project. The process was divided into three main steps:

1. Overview of the Corine Land Classification data (2018) to have a rough understanding of the classes of land available on remote areas of the country.
2. Following up on this first screening, BIOPLAT-EU partners checked what is on an "actual" aerial photo (from Google Earth) to obtain more insights on the land cover type and confirm CLC assets;
3. The team of national partners reached the interesting area for field visits and took photos of the reality on the ground.

The work followed the guidelines set forth in BIOPLAT-EU and agreed among FAO, JR and GEO.

Additionally, for the Bács-Kiskun and Csongrád-Csanád counties a time-series analysis based on Corine was also carried out. This analysis revealed whether a specific area turned from agriculture to one of the categories of underutilized or degraded land defined in D2.1.

Below is an example of this work:

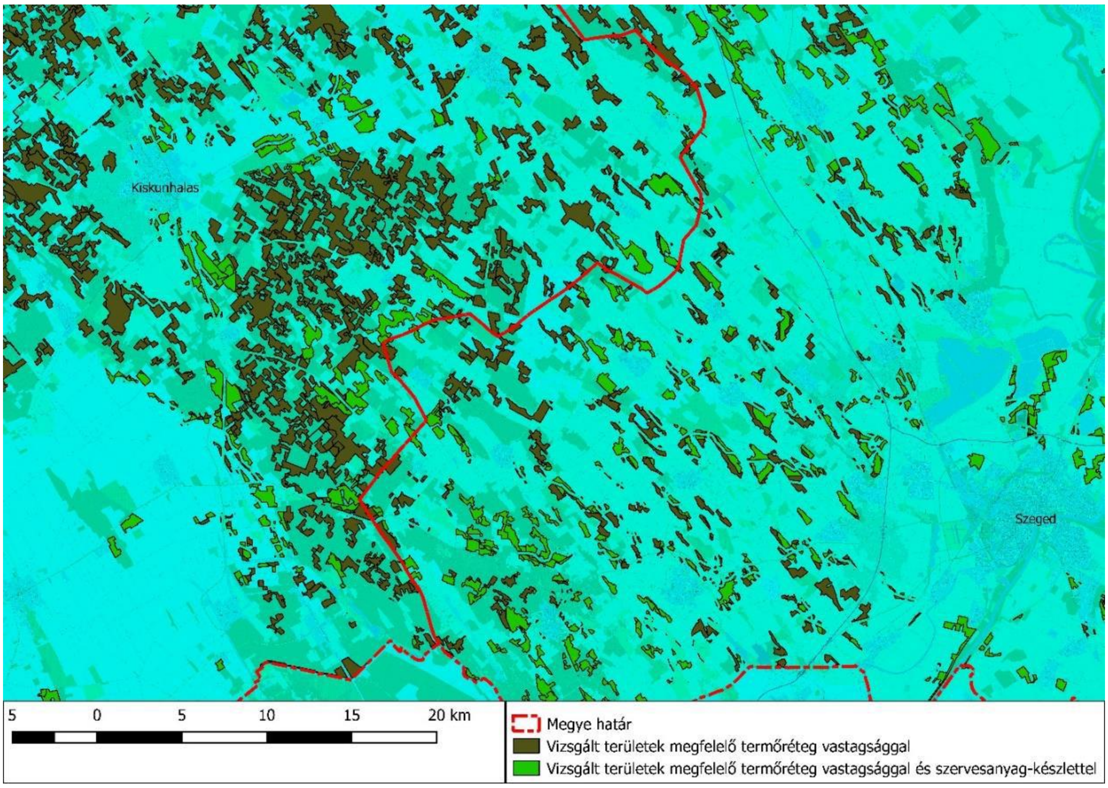

Figure 14. The GIS analysis, run by Geonardo, results for Bács-Kiskun and Csongrád-Csanád counties (Corine LC based polygons overlaid with organic content and "sufficient" fertile soil layer thickness, data taken from the Hungarian soil database)

Another entry point for the literature review was to look at possible experiments or trials involving any of the crops considered in BIOPLAT-EU in Hungary and where such trials had been carried out. It was found that poplar and black locust were tested in short rotations and on marginal soils in the Sand region between the Danube and Tisa. Also, there is a Camelina producer/farmer in the region who has been cultivating the plant for several years now, he was interviewed on site. Stakeholders (producers) of black locust and poplar such as state forest services and dealers of seedlings were also interviewed, and their facilities (plantations) have been visited.

Csongád county

- Ásotthalom

Figure 15. Underutilized agricultural land near Ásotthalom (spring 2019), successive dominant crop is milkweed

- Bordány

Figure 16. Abandoned fruit field near Bordány (spring 2020), successive vegetation is a plain meadow

Figure 17. Underutilized agricultural field (right) near Bordány (spring 2020), successive crops are black locust, silver poplar, milkweed

- Mórahalom

Figure 18. Abandoned farmland near Mórahalom (spring 2019), successive vegetation is milkweed, robinia etc.

Figure 19. Abandoned farmland near Mórahalom (spring 2019), in the background underutilized agricultural land

- Ópusztaszer

Figure 20. DALERD Zrt seedling plantation near Ópusztaszer (left: silver poplar, common aspen clone on the right) - Sept 2019

Figure 21. SRC (poplar) near Ópusztaszer on a private farm (3rd year after cut) - Sept 2019

Figure 22. SRC (poplar) near Ópusztaszer on a private farm (3rd year after cut) - Sept 2019

Figure 23. Abandoned Soviet military base near Ópusztaszer with potential contaminated land - Sept 2019

Bács-Kiskun county

- Bugac

Figure 24. Typical landscape in Bugac – spring 2020

Figure 25. Typical utilization of marginal lands in Bugac: short or mid rotation coppice – spring 2020

- Szank

Figure 26. Shrubland (Corine 3.2.4) near Szank (spring 2020)

Bodoglár

Figure 27. Abandoned farmland with pasture and fruit trees near Bodoglár (spring 2020)

Figure 28. Abandoned fruit yard near Bodoglár (Google streetview)

In this case study area, there are at least three existing Bioenergy Production Plants, one producing bioethanol from maize and two biogas plants using manure mixed with maize and sorghum.

2.2.2 Case study 2

Location: Balaton Uplands region: Veszprém County and Fejér County

MUC status (Underutilized vs Contaminated vs both): marginal (/contaminated)

BPS Approx surface (ha): 10,000 ha

Potential crop(s): Poplar, Maize, Rapeseed, Lucerne, Sunflower, Willow, Black locust

Potential bioenergy pathway(s): bioethanol, biogas, solid biofuels

Existing BPP: yes

Selection process

The majority of the two counties belong to the Balaton Uplands region. In this area a National Park is instituted and within its borders several sub-categories of land uses are found, including agricultural activities. The target of this selection process is the location of underutilized lands classified as arable lands within this region. Among the substantial effects of climate change, the region is prone to extreme weather events, changes in temperature and precipitation, heat waves, the risk of flooding as well as drought periods affecting the local economy.

Fejer county's area is said to be the most geographically diverse in Hungary as mountains, lowlands, large lakes and significant rivers are abundant. There are four landscape protection areas (Vértes, Sárrét, Sárvíz-völgye, Dél-Mezőföld) and 10 natural reserves within its borders. The soil types vary in the region.Iin Fejér the most prominent are chernozem soil whereas in the Veszprem county commonly brown forest soils are found. However, certain areas are characterized by rocky rendzina soils not suitable for agriculture (particularly in Veszprém county).

Part of the area is located within the Balaton Uplands National Park. The area of 56,997 hectares of the Balaton Uplands National Park mainly consists of six landscape protection areas: Kis-Balaton, Keszthely Hills, Tapolca Basin, Káli Basin, Pécsely Basin and Tihany Peninsula. Among its regions Kis-Balaton is also protected by the international Ramsar Convention, serving the protection of wetland habitats.

The area has a mixture of different climatic impacts. Clear weather occurs mainly in the Balaton Uplands, which manages an annual average total of over 2,000 hours of sunshine. The spatial distribution of precipitation varies. The highest regions of the Bakony have the highest annual precipitation, where the annual precipitation is 750-800 mm. The poorest areas of the county in rainfall are located in the east, the driest area is Sárrét.

In Veszprém county lies Bakony, the largest part of the Transdanubian Mountains. These limestone and dolomite hills are covered with deciduous forests, whereas the internal basins are used for agricultural purposes. The landscape is dotted by gorges of the creeks with hundreds of sink-holes, caves and rocky valleys. As for the area's flora, lush vegetation covers the karst plateau of the East Bakony.

Historically, the location of arable lands adapted to the topography and local soil conditions. Currently, due to privatization land has become extremely fragmented. Private and state-owned lands both exist, but croplands are mainly privately owned. The areas belonging to the Balaton Uplands National Park have the largest territorial ratio of meadows and pastures compared to other territories.

The number of farms using arable lands is smaller than the national average in Fejér but have been significantly higher in Veszprém in the last decade as shown in Figure 28.

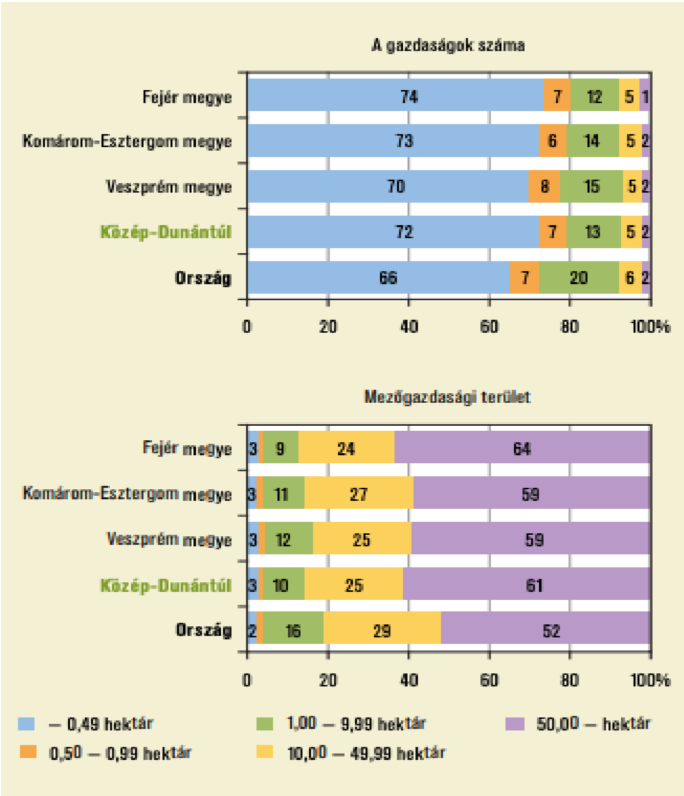

Figure 28: The distribution of the number and size of agricultural farms in the case study area (KSH,2010)

According to the Hungarian Central Statistical Office, farmers utilized 361 hectares in Fejér county and, 301 hectares in Veszprem.

The Veszprém county is mostly made of mid-sized and smaller towns as well as villages populated by less than 500 people and the majority (62%) of the population lives in urban centers. In 2013, 312 economic entities and 14,000 private farms were registered in the county. The landscape of the county is very diverse. The proportion of plough-lands is 32%, lower than the national average, but that of the forests is relatively high (31%) due to the extensive woodlands in the Bakony mountains and the Balaton Uplands. On the arable lands of the north-western parts of the county, farmers produce mostly wheat, maize and oilseed crops. The tradition of viticulture in the region goes back to several centuries. From the total area of 433,000 hectares of Veszprém county, three-quarters are subject to agriculture and farming.

The most profitable and largest companies in the county are active in the industrial – primarily the electric and automotive – sector. The gross income of full-time workers in the county is 355,000 HUF (approximately 970 €) per month. The population between the ages of 15-74 is 165,000, representing 63,4% of the county’s total population.

Fejér county:

Area: 4,358.45 km2, 4,7% of the total area of Hungary.

Population: 418,000.

Fejér is one of the most geographically diverse counties of Hungary. The southern half of the county lies in the Mezőföld, a rolling fertile area of loess soils where maize, wheat, barley, sugar beets, potatoes, and peas are the main crops. Fejér is the country's major producing region of maize. In 2013, 333 economic entities and 20,000 private farms were registered in the county. two thirds of the total area of the county is devoted to agriculture. Most of it lies in the Mezőföld region, which is a prominent cereal-producing area. On the two-thirds of all plough-land, farmers grow wheat, maize and industrial crops, such as sunflower, rapeseed and sugar beet. In 2019, cereals were produced on 64% of all arable lands of the county. On this area, wheat and maize were grown on 62,800 and 80,200 hectares, respectively. These lands yielded 353,900 tons of wheat and 651,500 tons of maize. Wheat and maize were grown on 43% of the county's sown arable land, with rapeseed and sunflower occupying an additional 17% of the sown area among industrial crops.

Fejér has one of the largest regional economies of Hungary. This county produced more than two-thirds of the GDP of the Middle Transdanubia region. The gross income of full-time workers in the county is 368,000 HUF approximately (1070 €) per month. The region has a rather low unemployment rate (2.4%).

As for case study 1 in Hungary, a three-steps approach has been followed to individuate potentially interesting areas and subsequently validate with satellite imagery and field visits the actual situation on the ground.

Figure 29. Shrublands near Gyulafirátót (Veszprém county)

Figure 30. Grassland (under high voltage) between Gyulafirátót and Hajmáskér (Veszprém county)

Figure 31. Natural grassland near Hajmáskér (Veszprém county) with outcropping rocks

Figure 32. Shrubs on underutilized agricultural land near Hajmáskér (Veszprém county)

Figure 33. Marginal soils near Pétifürdő (Veszprém county)

Figure 34. Shrubland near Pétifürdő (Veszprém county)

Figure 35. Shrubland/grasslands underutilized near Pétifürdő (next to the biggest fertilizer production facility in Hungary)

Figure 36. Abandoned mine site near Zámoly (Fejér county)

Figure 37. Abandoned military training field and airport near Zámoly (Fejér country) now grassland.

Figure 38. Partially utilized (with Lucerne) abandoned Soviet military base near Lovasberény (Fejér county)

In the area there are bioethanol, biogas and CHP plants within a 100 km radius from the identified MUC lands of the project.

2.3 Italy

2.3.1 Case study 1

Location: Sulcis area, Southwest Sardinia, Italy

MUC status: Contaminated and underutilized

BPS Approx surface: 6,000 ha

Potential crop(s): Giant reed, milk thistle, cardoon

Potential bioenergy pathway(s): Bioethanol, biogas and biomethane

Existing BPP: no

Site selection

The study area is located in the "Sulcis" district in the southwest of Sardinia, Italy (39°09′ North latitude, 8°29′ West longitude). This area was studied in the FORBIO project and due to its interesting potential for contributing to the market uptake of advanced biofuels in Europe, it was brought forward in BIOPLAT-EU. The case study site is constituted by 5 municipalities (i.e. Carbonia, Portoscuso, San Giovanni Suergiu, Tratalias and Masainas) for a cumulated surface of 35,745 ha. The elevation of these MUC lands ranges from 1 to 475 m above the mean sea level and is characterized by flat and gently undulating terrain. As reported in the FORBIO project, the target area suitable for bioenergy feedstock cultivation covers an area of about 60km^2.

The area is characterized by a Mediterranean semi-arid climate with a bimodal pattern of rainfall distribution (i.e., maximum in the autumn and spring). The mean annual rainfall is about 600 mm and the mean annual temperature is 16° C. For this area a detailed soil map at a scale of 1:50,000[30] is available. This map describes in details the ecopedological characteristics of the watershed. As a result of the extreme variability of lithological and its resulting geography, the northern part of the basin is characterized by poorly drained soils with a slow rate of water transmission and high runoff potential. In contrast, the southern part of the watershed is mainly dominated by well-drained soils with high infiltration rates and high or moderate water transmission.

As for soil, a land-use map at the scale of 1:25,000 with a minimum mapping unit of 0.75 is available[31]. In the northern part, land use is predominantly natural and semi-natural with limited rainfed farming practices. In contrast, the southern part is predominantly agricultural, with the major crops being irrigated crops, rangelands and pasture, and vineyards.

[30] Regione Autonoma della Sardegna - Agenzia AGRIS - Portale del Suolo [WWW Document]. URL http://www.sardegnaportalesuolo.it

[31] Regione Autonoma della Sardegna - Sardegna Geoportale [WWW Document]. URL http://www.sardegnageoportale.it/index.php?xsl=1594&s=40&v=9&c=8753&n=10

The study area is included in the Sulcis polluted "Site of National Interest" (SIN) that includes industrial and mining areas (see Figure 39 below). In the municipality of Portoscuso (surrounding industrial area and enclosed in the SIN) the cultivation and commercialization of agricultural goods and milk production is forbidden for the potential threat to human health by Decree n.9 of the Municipality of Portoscuso dated 06/03/2014 at to date still in existence.

According to the last census of the Sardinia region on population density, the five municipalities included in the study area hosted 41,400 inhabitants on 31 December 2018, with a decrease of 2,132 residents compared to 2010[32]. As a result, all 5 municipalities have negative values of natural and total growth rates being one of the most challenged regions of Italy in terms of development indexes.

The employment rate of the province of Carbonia-Iglesias was equal to 43.8% (employed 15-64 years old) in 2016, significantly lower than the regional (50.3%) and national employment rate (57.2%) in the same year. Moreover, in 2016, the female employment rate was equal to 34.6% of the population, while the male employment rate is 52.9%.

In Sardinia in 2017 the average annual income of households was equal to € 27,748, while the average total income per person is € 17,269, about 15% lower than the national average of € 20,352, some 7.9% higher than the average value for Southern Italy, equal to € 16,003[33].

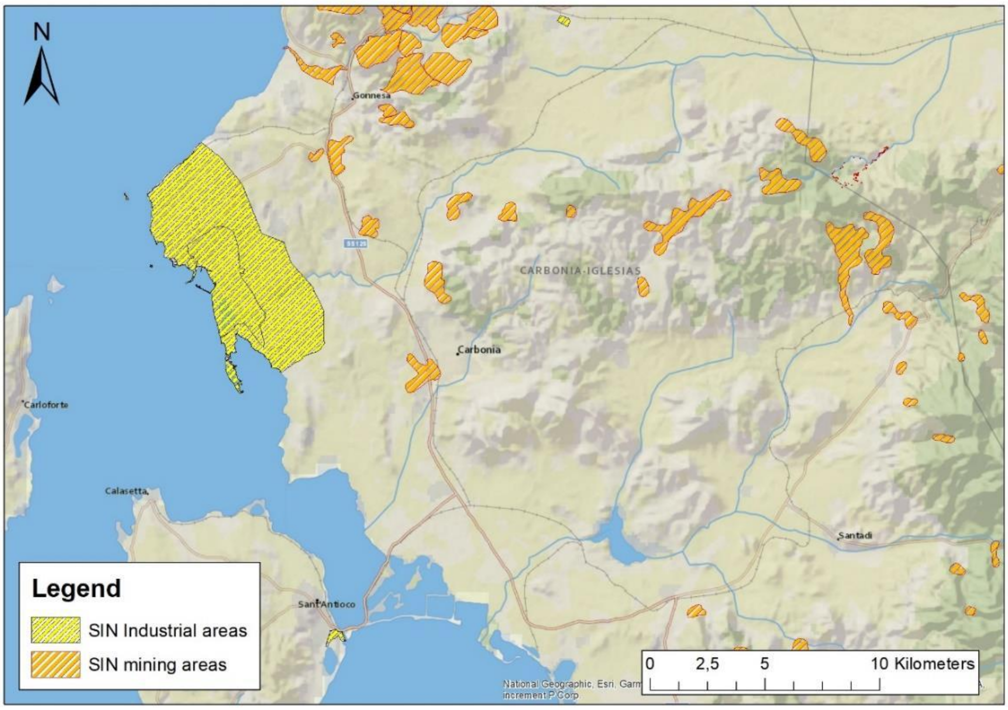

Figure 39. The Sulcis area and geographical boundaries of actual SIN for mining and industrial areas.

32 Sardegna Statistiche - Economia [WWW Document]. URL http://www.sardegnastatistiche.it/argomenti/economia/

33 Sardegna Statistiche - Popolazione e Famiglie [WWW Document]. URL http://www.sardegnastatistiche.it/argomenti/popolazione/

The predominant economic activity for added value in Sardinia in 2018 are commerce and business services (€ 25.59 million), followed by manufacturing and mining (€ 4.35 million), constructions (€ 1.38 million) and agriculture (€ 1.35 million)[34].

The Sulcis study area has been selected as a follow-up from the FORBIO project. Selected stakeholders involved and consulted in the past will be contacted for new activities, while other stakeholders for other bioenergy value chain suggested by the Regional Environmental Energy Plan and guidelines (e.g. biogas pathway) will be considered.

According to the Regional Environmental Energy Plan adopted in 2016 and looking at the "Guidelines for the regulation and promotion of the exploitation of the resources for the construction of bioenergy plants in Sardinia" published in April 2020, (Resolution n°.21/19 21.04.2020) several instruments are foreseen to promote the development of energy generation from biomass. More specifically, the following actions are envisaged and planned:

i) studies for supply chain agreements to produce thermal energy from woody biomass and biofuels from dedicated crops in marginal areas; and

ii) regulations for the management of industrial areas aimed at promoting and/or encouraging the energy generation from biomass, preferably residual.

Nevertheless, in terms of policy orientation, it appears that these guidelines prioritize the biogas pathway including the upgrading to biomethane from dedicated energy crops, while liquid biofuels are seen favorably only for short supply chains using locally available biomass residues.

[34] Sardegna Statistiche - Condizioni economiche [WWW Document]. URL http://www.sardegnastatistiche.it/argomenti/condizionieconomiche/

2.3.2 Case study 2

Location: Val Basento and surrounding area in the province of Matera – Basilicata region (Italy)

MUC status: Contaminated

BPS Approx surface: 4,000 ha

Potential crop(s): oilseeds crops; sorghum.

Potential bioenergy pathway(s): biodiesel; biogas and biomethane.

Existing BPP: Yes

Selection Process

The second case study covers a wide territory in the Basilicata region (Southern Italy). This case study area includes the four municipalities of Ferrandina, Salandra, Garaguso and Pisticci in the "Val Basento industrial area", and six additional municipalities Matera, Montescaglioso, Miglionico, Pomarico and Grottole in the surrounding territory outside the industrial area. In this part of Italy, the study will consider a total surface of more than 4,000 hectares amongst contaminated (3,350 ha) and underutilized lands.

Basilicata falls among the Italian regions most prone to landslides and floods and is located in a seismotectonic background responsible of strong earthquakes. Due to its geological features, the region hosts the largest hydrocarbon reservoir in continental Europe, which has been studied since the beginning of the 20th century by many geologists and largely exploited by numerous oil companies[35].

From 1958 to 1980, the most important anthropogenic activities characterizing this area were represented by chemical industrial plants for the production of tissues and chemical compounds. In particular, these plants turned out vinyl chloride (CVC and PVC), a highly toxic and noxious substance, and ETERNIT, determining a scattered asbestos contamination and serious effects on the working staff's health.

Currently, agriculture and forestry are cornerstones of the regional economy[36], but there still is a significant presence of industrial activities (almost 300 factories) including many chemical industrial plants for the production of polymeric yarns, synthetic tissues, nylon films, polymeric additives, and PVC bottles. Other industrial activities consist in the production of mechanical components, rolled iron, electrical motors, building materials and leather tanning. All these activities (industrial plants, commercial traffic, and agricultural practices), together

[35] Van Dijk, J.P., V. Affinito, R. Atena, A. Caputi, A. Cestari, S. D'Elia, N., & Giancipoli, M. Lanzellotti, M. Lazzari, N. Oriolo, & S. P. (2012). Cento Anni di Ricerca Petrolifera. L'Alta Val d'Agri (Basilicata, Italia meridionale). December. https://www.researchgate.net/publication/268130832_Cento_Anni_di_Ricerca_Petrolifera_l'Alta_Val_d'Agri_Basilicata_Italia_meridionale

[36] EURES (2019). Labour market information. URL: https://ec.europa.eu/eures/main.jsp?catId=394&acro=lmi&lang=en&countryId=IT&regionId=ITF&nuts2Code=ITF5&nuts3Code=null&regionName=Basilicata

with the presence of landfills and waste dumps, may still cause heavy metal soil pollution[37]. As in the case of the previous case study in Italy, also the Val Basento industrial area is included in the list of SIN areas, as per the definition given by the National Law 179/2002, and enclosed according to the Ministerial Decree (DM) n°83/2003.

The nature of cropping terrains (type of soils) together with the climate dynamics (e.g. low precipitations – see Table 3) and deforestation necessary to make room for pastures and the growing of cereals, have brought several inner areas to desertification, due to the widespread forms of land degradation (badlands) including rills, gullies, debris flows and loss of soil fertility[38]. As of today, Basilicata is the second region in Italy, after Sardinia, with the highest percentage of marginal agricultural lands in the country (50.9 %) out of the total agricultural land[39].

Table 3. Annual total rainfall for six pluviometric stations included in the case study area. Mean precipitation values (mm) for the period 1923–2000 and climate normals from 1931 to 2000[40].

Pluviometric station	Mean precipitation for 1923–2000 (mm)	Normal 1931–60	Normal 1941–70	Normal 1951–80	Normal 1961–90	Normal 1971–2000
Ferrandina	568.98	638.16	569.07	570.01	519.34	513.90
Grottole	572.54	647.38	616.03	619.43	513.78	521.29
Matera	543.50	570.67	555.50	596.92	533.71	503.93
Pisticci	644.76	738.18	720.47	661.21	569.52	540.94
Pomarico	601.43	762.86	729.61	669.81	513.41	418.38
Salandra	692.95	758.65	739.31	773.30	654.56	625.66

According to the last census of the Italian population, the selected area hosted in 2011 around 109,000 inhabitants[41].

In 2013, the region's economic activity remained on a downward course. The decline in industrial production, for the sixth consecutive year of crisis, eased compared to 2012 in almost all sectors except for textiles, clothing, and mechanical production. Exports declined more than in the rest of Southern Italy and the country as a whole. All economic sectors (e.g. industrial

[37] Chianese, D., D'Emilio, M., Bavusi, M., Lapenna, V., & Macchiato, M. (2006). Magnetic and ground probing radar measurements for soil pollution mapping in the industrial area of Val Basento (Basilicata Region, Southern Italy): A case study. Environmental Geology, 49(3), 389–404. https://doi.org/10.1007/s00254-005-0082-3

[38] Piccarreta, M., Pasini, A., Capolongo, D., & Lazzari, M. (2013). Changes in daily precipitation extremes in the Mediterranean from 1951 to 2010: The Basilicata region, southern Italy. International Journal of Climatology, 33(15), 3229–3248. https://doi.org/10.1002/joc.3670

[39] Sallustio, L., Pettenella, D., Merlini, P., Romano, R., Salvati, L., Marchetti, M., & Corona, P. (2018). Assessing the economic marginality of agricultural lands in Italy to support land use planning. Land Use Policy, 76(March), 526–534. https://doi.org/10.1016/j.landusepol.2018.02.033

[40] Piccarreta, Marco, Capolongo, D., & Boenzi, F. (2004). Trend analysis of precipitation and drought in Basilicata from 1923 to 2000 within a southern Italy context. International Journal of Climatology, 24(7), 907–922. https://doi.org/10.1002/joc.1038

[41] ISTAT, 2019. Available at: http://dati.istat.it/Index.aspx?QueryId=18564. Accessed on 03 April 2020

enterprises; construction) were affected by the real estate market crisis, except for tourism where the number of tourists, including foreign tourists, increased.

The region's labour market remains affected by an overall weak economy, and employment is declining alongside with the general economic situation of this area. As a consequence, young emigration occurs and the remaining population's average age increases, contributing to restricting workforce supply and a push towards growth necessary in this part of Italy.

Between 2001 and 2011, the region lost 3.3% of its population. This figure is worse than those coming from the other Italian regions for the same period. In some areas of the region, employment declined by more than 10%, and population ageing has been especially rapid[42].

In 2016, employment in the entire Basilicata region accounted to 192,502 people, with 118,993 males and 73,509 females[43]. Clearly, the region low population density and current socio-economic situation points strongly towards policies that could make best use of the vast underutilized agricultural land available in the region to create economic and social benefits.

The main economic activities of Basilicata are agriculture and forestry, industry, construction, commerce, hotels and restaurants, transport and communications, financial brokerage, real estate and other business activities. The region focuses also on research and technology transfer, key strategic sectors which have generated strong cooperation between universities.

A structured survey was prepared and circulated amongst the 20 local offices of CREA-PB across Italy. Survey outcomes gave an overview about existing MUC lands and Bioenergy Processing Plants (BPPs) already established across the Country.

The survey was followed by further dialogues, on a one-to-one basis, amongst CREA-PB experts and various bioenergy stakeholders both at national and local level. Examples of national stakeholders interviewed are: the Italian Consortium for Biogas and the Italian association for agro-forestry energy (AIEL). This exchange of information was useful to better understand key aspects related to the actual potential of developing a sound bioenergy sector at local level such as the availability of suitable biomass to be used as bioenergy feedstock, availability of data useful to assess the sustainability of bioenergy value chains, past and still on-going experience(s) in establishing bioenergy value chains, and the actual level of buy-in of local stakeholders to be involved in activities aiming at strengthening a sustainable bioenergy sector.

The survey provided a preliminary selection of 8 potential case study areas that were presented at the 2nd BIOPLAT-EU progress meeting held in Kyiv in September 2019 and discussed in a plenary with all project partners. Afterwards, the CREA team focused its attention and further analysis on 4 case study areas (i.e. Sardinia, Basilicata, Sicily and Umbria).

With the aim to finalize the selection procedure, CREA-PB staff conducted a field visit to the industrial plant of Greenswitch, a biorefinery established in Ferrandina (Matera province – see Figure 40). The visit was the opportunity to meet the company's manager and a few

[42] EURES (2019). Labour market information. URL: https://ec.europa.eu/eures/main.jsp?catId=394&acro=lmi&lang=en&countryId=IT&regionId=ITF&nuts2Code=ITF5&nuts3Code=null&regionName=Basilicata

[43] Regione Basilicata. (2017). URL http://basilicatadati.regione.basilicata.it/studi-e-reportistica/lavoro/. Accessed on 20 April 2020

components of the staff, to exchange information and raising their awareness on the main task of the BIOPLAT-EU project. The field visit was very productive and the dialogue with the staff served to understand the main barriers and opportunities characterizing the bioenergy sector. The industrial plant has been just acquired by a new investor (with a contribution of the regional government), who has also financed the full revamping of the site. The plant, which in the past was used for the production of biodiesel from palm oil, is currently used for the production of other biobased products through various processes, such as soybean oil epoxidation (capacity 15,000 tons per year) and purification and refining of vegetable glycerine (capacity 8,000 tons per year). The plant is ready to restart the production of biodiesel, but needs to face some constraints, such as the reduced availability of biomass to be used as feedstock and the reduction of available market.

Further to the field visit, a stakeholder meeting was organized and held in the CREA-PB premises in Rome on 4th February 2020. The meeting was the opportunity for the CREA-PB staff to meet 3 representatives of the Consortium for Industrial Development for the province of Matera (CSI) and to exchange with them information on the availability of existing data and on existing social barriers preventing the development of bioenergy sector in the specific area. Among other aspects, the members of the CSI delegation highlighted a general need for an awareness raising campaign on bioenergy, to be addressed to the wider public in Basilicata. Therefore, the CSI confirmed the interest of local authorities to be involved in the project also with the scope to overcome the existing barriers, also by organizing info-days and meetings with stakeholders at local level.

As a result of the selection process above described, CREA-PB has ultimately selected 2 case studies (among which Basilicata) and a backup case study site (Umbria).

For each selected case study, a local focal point was identified amongst the CREA-PB staff working in the local office.

The main reasons that brought to select Val Basento and its surrounding area as one of the two main case studies for the BIOPLAT-EU project are summarized below:

• presence of contaminated (included in the list of polluted Site of National Interest) and of underutilized lands, with a quite significant extension (more than 4,000 ha);

• availability and accessibility of data (mainly collected by the government of the region and by various existing local associations and consortia (e.g. CSI; Lucania Agency for development and innovation in agriculture -ALSIA; Lucania Cluster for Bio-economy - CLB));

• existence of already established bioenergy value chains (e.g. biogas plants) and of industrial infrastructures ready for the production of biodiesel (i.e. Greenswitch - ex Mythen: a decommissioned bio-refinery, recently revamped, that can count on a fuel tanks capacity of 16,000 m^3 having a biodiesel production capacity of 120,000 tonnes per year);

• interest of national and local stakeholders to support the development of local short bioenergy value chains in the area (e.g. CIB; oil company such as ENI; GREENSWITCH; regional government);

In general, challenges and opportunities have been pre-identified in the area. Among the opportunities, local policy support could foresee public financial instruments to incentivize the development of sustainable bioenergy value chains in the area in the next Regional Plan for

Rural Development (PSR) as well as in the Regional Funds for Industrial Development (FESR), which are both currently under definition. These would be informed by pre-existing experiences of cultivation of oilseeds crops in the area (e.g. sunflowers, cardum) and the presence of infrastructures and BPPs. However, this choice comes with some challenges as well, including the current lack of feedstock produced at local level and of parts of the infrastructures useful for the completion of the biodiesel value chain (e.g. mills for oil production from oil-crops) which have been dismantled over the years and the lack of a local market for biofuels in the area.

Figure 41. GREENSWITCH industrial plant ready to start the production of biodiesel in Ferrandina (Val Basento Industrial area). Pictures were taken by CREA-PB staff during the field visit conducted on 24 October 2019 in the context of project activities.

Figure 42. The recently revamped GREENSWITCH plant in the municipality of Ferrandina (Val Basento). Pictures were taken by CREA-PB staff during the field visit conducted on 24 October 2019 in the context of project activities.

2.3.3 Case study 3

Location: Conca Ternana and Pietrafitta Basin – Umbria region (Italy)

MUC status: Contaminated

BPS Approx surface: 650 ha and 250 ha, respectively

Potential crop(s): herbaceous/lignocellulosic crops (giant reed, miscanthus)

Potential bioenergy pathway(s): biogas and biomethane

Existing BPP: Yes

Selection Process

The backup case study selected for Italy embraces two areas within the Umbria region (Central Italy), namely the area of "Conca Ternana" in the province of Terni and the basin of Pietrafitta, in the province of Perugia. These areas have an extension of approximately 650 ha and 250 ha, respectively.

The name "Conca Ternana" is from the town of Terni, which is the main settlement in the Southern plains of Umbria. Further to Terni, the area embraces also the municipalities of Narni, San Gemini, Acquasparta, Amelia and Stroncone.

The area includes, in its oriental part, the industrial site of Terni-Papigno, which has been identified as a SIN, by DM n.°468/2001. The area includes both currently operational and decommissioned industrial activities. It hosts currently 14 plants subject to Integrated Environmental Authorization[44], amongst which one of the largest stainless steel production site in Europe (Thyssen Krupp AST), various power plants for waste treatment and one of the largest biomass gasifier in Italy (Terni Biomass).

The Conca Ternana alluvial plain is situated in an intramountain depression, delimited by the Apennine mountain range. The peculiar geomorphological and meteorological conditions of the area limit the dispersion and enhance the accumulation of the atmospheric pollutants produced by the industrial sources in the area[45] and by the presence of typical urban fine particles (particulate matter, PM) emission sources including vehicular traffic and domestic heating.

The area is characterized by calcareous sandy soils (83% of sand) that can be considered as representative of ancient fluvial-lacustrine deposits widely outcropping along alluvial plains and hillslopes in Umbria Region and in other places in Central Italy[46]. Soils are not plastic and the main mineralogical components are carbonates with subordinate minerals (muscovite, gypsum). The Pietrafitta basin (within the Valley of Nestore river) is located just south of the lake Trasimeno basin and comprises in the territory of the municipalities of Piegaro and

[44] Stranieri Paolo. (2016). Le attività di ARPA Umbria nel contesto ambientale della Conca Ternana.

[45] Massimi, L., Ristorini, M., Eusebio, M., Florendo, D., Adeyemo, A., Brugnoli, D., & Canepari, S. (2017). Monitoring and evaluation of Terni (Central Italy) air quality through spatially resolved analyses. Atmosphere, 8(10), 1–14. https://doi.org/10.3390/atmos8100200

[46] Ercoli, M., Di Matteo, L., & Pauselli, C. (2018, August 20). Comparison of GPR and Capacitance Probe laboratory experiments in sandy soils. 2018 17th International Conference on Ground Penetrating Radar, GPR 2018. https://doi.org/10.1109/ICGPR.2018.8441567

Panicale, both in the province of Perugia, about 30 km South-West of the main city. The industrial development of the area is connected to the beginning of the exploitation of local lignite deposits. From the mid-1950s to the mid-1980s, the area hosted a lignite-fired thermoelectric power plant and a landfill for ashes produced by Pietrafitta's and other coal fired power plants across Italy. The lignite deposits expanded in the years of excavations and, after the exhaustion of mine, this has been turned into an artificial lake which now has a circumference of more than 6 km.

Analysis recently carried out in the territory have evidenced significant exceedances of the national contamination thresholds (CSC) for heavy metals including lead, titanium and chrome. The situation of the latter is rather serious, both for the known danger to human health and for the low carbonate content in the soils concerned, which cause poor mobility of this metal in the matrix. Furthermore, significant exceedances have been detected for arsenic, iron, sulfates and manganese in the water taken from wells located in the municipalities of Panicale and Piegaro.

In May 2019 the regional government of Umbria, the interested municipalities and Enel (Italian energy company) reached an agreement on the recovery of the decommissioned power plant in Pietrafitta, according to which a project competition will be launched by March 2020 to select stakeholders interested in purchasing the area to carry out recovery and requalification projects. Among the hypothesis considered, Enel highlighted the possibility to realize energy production plants from renewable sources or storage systems[47].

The reference climatic station for the area of Pietrafitta is settled in Perugia. Data related to the period 1971-2000, show that January is the coldest month, with an average temperature of +4,8 ºC, while the hottest month is August, with an average temperature of +22,8 ºC. The average annual precipitation is 805 mm, on average distributed over 86 days, with relative minimum in summer, peak in autumn and secondary peak in spring. The annual average relative humidity recorded the value of 74.7%. On average 49 days of frost per year and 41 days per year with a maximum temperature equal to or greater than 30 ºC are recorded.

In Italy, the Cadaster is the land registry which contains graphical, census and administrative data on properties throughout most of the country. The Cadaster is divided into two parts: one covers urban properties, the other covers rural land. The reference law for land and building properties are: Royal decree n. 2153 of 8 December 1938 on Cadaster of Lands; Presidential Decree n. 1142 of 1 Dec. 1949 on Catasto Edilizio and Law Decree n. 557 of 30 Dec. 1993 on Cadaster of Buildings[48].

The industrial site of Terni-Papigno has been identified as one of the polluted SIN by the DM 468/2001. A subsequent Decree of the Minister of the Environment (DMA) released on 8th July 2002 has defined the perimeter of the site. The SIN is divided into areas at risk of passive contamination (agricultural vocational areas) and productive areas for potentially polluting activities[49]. In the former dump of Papigno (in the municipality of Terni) the whole area is

[47] Quotidiano dell'Umbria. (2019). Centrale di Pietrafitta, accordo fra Istituzioni ed Enel sul recupero area. Available at: https://www.quotidianodellumbria.it/quotidiano/piegaro/centrale-pietrafitta/centrale-di-pietrafitta-accordo-fra-istituzioni-ed-enel-sul-recupero. Accessed on 3 April 2020.

[48] ICGL. (2020). Italy: Real Estate 2020. Available at: https://iclg.com/practice-areas/real-estate-laws-and-regulations/italy. Accessed on: 29 April 2020

[49] Petralla, R. (2018). Lo stato della contaminazione delle matrici acqua e suolo nel SIN e nelle aree in bonifica. URL: https://www.comune.terni.it/system/files/petralla_def.pdf

interdicted to public use since 2005 to safeguard health. Intervention of phytoremediation have been considered but never put in place.

The area in the Pietrafitta basin is under seizure starting from 15 June 2016 and every type of activity is forbidden starting from November 2016.

Umbria is a landlocked Region, mainly hilly and mountainous, located in Central Italy. The region covers an area of about 8,500 km^2 and, as of January 2019, registered a population of 882,015 inhabitants, of which almost 26% living in the province of Terni and the rest in the province of Perugia.

The six municipalities considered in the study area of the Conca Ternana cover a territory of 650 km^2 and in 2019 hosted a population of 156,000 inhabitants, of which approximately 111,000 in Terni[50]. In these municipalities, in 2019 the average annual income per-capita was around € 19,000 per year[51].

On the other hand, the municipalities of Piegaro and Panicale in the Pietrafitta basin study area have a total population of 9,000 inhabitants, distributed across 178 km^2 [50]. The average annual income per-capita declared for the year 2019 in these municipalities is around € 18,000[51].

The economy of the region is based on services, industry and agriculture, which represented 73.2%, 24.4% and 2.4% of value added in 2018, respectively. Agriculture represented 6.3% of work units in Umbria, thus having an incidence on the economy above the Italian average[52]. At the end of 2018, there were 94,358 registered enterprises in the region, but only 85% of them were active. 56% of the existing companies are operating in services, 19% in agriculture, 14% in construction and 11% in the industry and manufacturing sector[53]. In 2018, the employment rate of the region (63%) was higher than the national average (58.8%) though still below the European average (72.4%), with a slight increasing trend between 2017 and 2018 (+0.1%). The unemployment rate drops to 9.2% in 2018 [52]. In 2017, in the province of Terni, the employment rate was higher than the national average, 59.5% against 58%, but lower than the regional figure, 62.9%. The unemployment rate is equal to 11.8 percent, compared to 9.8 percent in 2016.

As in the case of the other sites identified in Italy, the selection process started with a structured survey circulated amongst the 20 local offices of CREA-PB across Italy, further dialogues on a one-to-one basis, amongst CREA-PB experts and various bioenergy stakeholders, both at national and local level.

The main reasons that brought to the selection of the two areas in Umbria (i.e. Conca Ternana and Pietrafitta's Basin) as backup case studies for the scope of the BIOPLAT-EU project are summarized below:

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[50] ISTAT. (2020). Available at: http://dati.istat.it/Index.aspx?DataSetCode=DCIS_POPRES1. Accessed on: 29 April 2020

[51] Umbria24.it. Available at: http://www.umbria24.it/economia/umbria-cresce-il-reddito-medio-ma-si-allarga-la-forbice-tra-ricchi-e-poveri. Accessed on: 30 April 2020

[52] Banca d'Italia. (2019). Economie regionali. L'economia dell'Umbria. In Statistica (Vol. 10).

[53] EC. (2020). Available at: https://ec.europa.eu/growth/tools-databases/regional-innovation-monitor/base-profile/umbria-0. Accessed on: 29 April 2020

• presence of underutilized and/or contaminated lands. Amongst the latest, two areas have been considered. The first area (Conca Ternana) has been included since 2001 in the list of polluted Site of National Interest (SIN of Terni-Papigno – 650 ha), whilst the second one has been recently sequestered as contaminated (Basin of Pietrafitta – 250 ha). This last area hosted for years a lignite-fired power plant, opened in the fifties, and a landfill for ashes produced by other power plants operating in the surrounding areas. Furthermore, it includes exhausted lignite basins which have been then turned into an artificial lake;

• availability and accessibility of data. Umbria hosts numerous research centers actively working on bioenergy sustainability subjects. Noteworthy among these, the Research Center on Biomass (CRB), established by the Ministry of Environment and Land Protection at the University of Perugia, which is the Italian reference center for research on biofuels and biomass for energy use. This center has carried out numerous projects in the last two decades with a focus on the development of a sustainable bioenergy sector in the region some of which strictly related to the thematic framework of BIOPLAT-EU. It is the case of the "Agroenergy" project (2013-2015) which assessed the sustainability of the cultivation of low input plant species grown on poor, marginal, degraded soils addressed to bioenergy production as of the "Biomass energy register for sustainable site development for European Regions" project (BEN - 2011).

Among the relevant factors for the selection of Umbria as a potentially interesting case study for the market uptake of bioenergy on MUC lands is the existence of relevant financial opportunities in the area. In the financial framework of PSR 2014-2020 in fact, Umbria allocated to the development of the bioenergy sector the highest share of total funds foreseen in the PSR, compared to the rest of Italian regions: 49.02% with 420 Million euros. The other regions with the highest share of total financial funds in the context of the PSR plan were: Marche (40.46% with 220 Million Euro); Veneto (39.61% with 470 Million Euro) and Friuli Venezia Giulia (34.27% with 100 Million Euro)[54].

Moreover, through stakeholder consultations it emerged a high interest of local authorities to support the development of local short bioenergy value chains in the area. As mentioned above, some plans are already being developed to integrate renewables and thus likely also bioenergy in these areas.

Last but not least, it should be considered that in the areas surrounding the case study sites there are pre-existing experiences of cultivation of oilseed (and other) crops in the area. A study conducted in 2007, identified the most suitable areas for the cultivation of certain herbaceous energy crops in the territory of Umbria. The study considered, among the others, also the cultivation of sunflowers and cardoon[55]. The suitability of tobacco varieties (i.e. Solaris) for seed oil production have been assessed in the province of Perugia, where flue-cured tobacco is traditionally cultivated. The Umbria region accounts, in fact, for about 30 % of the national tobacco leaf production, which in 2014 was around 54,000 t, with a crop extension of 18,000 ha, ranking first among regions in Europe.

[54] Porcu, F. (2016). Il Piano di Settore per le Bioenergie e i Piani di Sviluppo Rurale 2014-2020. Analisi critica delle politiche di settore ed indirizzi strategici.URL

[55] Bidini Gianni, Fantozzi Francesco, Buratti Cinzia, B. Pietro. (2007). Most Suitable Areas for the Cultivation of Herbaceous Energy Crops in Umbria. 15th European Biomass Conference & Exhibition, 7-11 May 2007, Berlin, Germany MOST, May, 7–11.

In the area of the Conca Ternana, there are several biogas plants (using manure mixed with agricultural residues) and a gasification plant that uses woodchips. Several other biogas plants are found within a 100 km radius from the center of gravity of the case study site.

2.4 Romania

2.4.1 Case study 1[56]

Location: Bacău County, Strugari and Blăgești sites

MUC status: Underutilized

BPS Approx surface: 94.7 ha and 141.5 ha, respectively

Potential crop(s): Mischantus, sorghum

Potential bioenergy pathway(s): Solid biofuels, Lignocellulosic ethanol, biogas

Existing BPP: Yes

Selection process

Bacău is one of the 41 counties of Romania. It has an area of 662,100 ha and a population of some 750,000 people. It is located in the East side of Romania. Almost half of the area is agricultural land.

Table 4. Use of lands in Bacau County, 2019

Category of use	Area	
	ha	% of total county
Agricultural land of which	320,756	48.45
Arable lands	186,332	28.14
Pasture s	86,323	13.04
Meadows	39,503	5.97
Vineyards	5,930	0.90
Orchards and nurseries	2,668	0.40
Non-agricultural land of which	341,296	51.55
Forests	280,918	42.43
Waters	14,955	2.26
Constructions	21,719	3.28
Communications	10,244	1.55
Degraded and non-productive	13,460	2.03

[56] National statistics https://insse.ro/cms/sites/default/files/field/publicatii/asr_2019_romana.pdf
Bacau county statistical yearbook 2020
Environment Protection Agency Bacau, Annual Report, http://apmbc.anpm.ro/rapoarte-anuale1
Blagesti Environment Report 2017 http://files.primaria-blagesti.webnode.ro/200002108-ecfefedf82/RM%20PUG%20Blagesti.pdf
Strategy for sustainable development of Bacau county 2016
Blagesti commune website https://www.primaria-blagesti.net/products/primaria/
Strugari commune development strategy 2015 https://primariastrugari.ro/fisiere/pagini_fisiere/Strategie_Strugari_1.PDF._pdf.pdf
Valentin-Mihai BOHATEREȚ, Ioan Sebastian BRUMĂ, Lucian TANASĂ, Comparative study on the profile of agricultural holdings without legal status in the development regions north-east and south-east of romania http://www.fao.org/family-farming/detail/fr/c/1171853/

The Site selection process took off starting from the initial feedback received via the remote sensing analysis, based on satellite imageries techniques provided by JR in the context of the WP2. Subsequently, an expert discussion among the members of ENERO focused the assessment and allowed to identify areas that could offer a potential in terms of MUC lands in Romania. The analysis identified two communes with large underutilized areas which consequently were pre-selected for the case study: Blăgești and Strugari.

In the municipality of Blăgești there are two underutilized large surfaces of land in the locations Țârdenii Mari and NE Blăgești. The selected sites are located in the Central-Northern part of the Bacău County, a hilly region. The MUC lands in the sites of Strugari and Țârdenii Mari, were also flagged by the TIER-2 assessment and are characterized by an irregular and ramified shape. The climate of this region of Romania is temperate continental, average annual temperatures range between 8 and 9 deg Celsius, with monthly averages from -3°C in January to 19.5°C in July. The average humidity is 77% and the rainfall is comprised between 600-700 mm/year. No information was retrieved about the sites' soil type. Nevertheless, a study on the pastures soils in a neighboring area may suggest, by similitude, a luvisol soil group.

The case study site of Blăgești site used to be a lake, the Racova lake, part of the Bistrița river hydrographic course. Over time, the lake was silted up with deposits brought by the Bistrita river. In 1975, the Racova lake appeared on official soviet maps but today the sandy deposits have covered the area, the course of the river is now more confined, and the former lake has become a dry land covered by spontaneous vegetation.

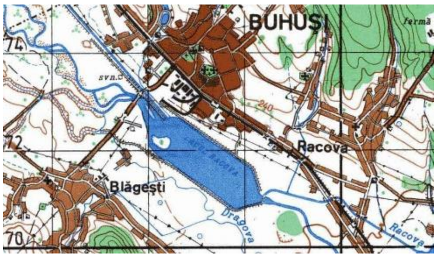


Figure 43a. The case study area in a military map from 1975 where lake Racova is clearly visible.

Figure 43b. The same area in an image from 2020 where former lake Racova is no longer visible and only a flat plain crossed by the river is shown.

Statistics report that within the Bacău County the agricultural land is for the vast majority privately owned whereas specifically to Blăgești and Strugari, lands are partially public-private (ownership of the local authority) or private (local individuals own fragmented land).

A more efficient use of the land is challenged by:

- fragmentation of the land properties
- poor strategies to overcome natural risks in agriculture
- difficulties in the marketing of agricultural and wood products or by-products such as wood waste
- many properties are not registered in the Cadastre property register.
- underdeveloped entrepreneurial culture, there is a reduced number of rural SMEs;

The Blăgești site is partially within the municipality of Blăgești (some 30 ha), while the remaining part of the underutilized land in this case study site (60 ha) are within the Buhuși city administrative limits. The ownership status of the land within the Buhuși city limits is unclear as the Water Administration Agency, the former owner of the Racova lake, is still involved in the property but during the extent of this project it was impossible to assess the actual role of the Agency.

Bacău county is a poor region (GDP per inhabitant is 38% lower than national average) with a higher unemployment rate. Predominantly, economic activities in the region are linked to agriculture and exploitation of natural resources at a higher rate than the national average. The migration of young people from the village to urban areas or abroad, is responsible for the over-aging of the population. County unemployment rate was 2.7% (2018). Net average monthly salary for employees was 2,270 RON in 2018 (493 Euro), lower than the national average 2,642 Ron.

In both municipalities economic activities focus predominantly on agriculture and animal husbandry. Maize cultivation in the area is the most common agricultural activity (farmers in Blăgești produce about 1,000 tones grain/year), and there are some 1,200 cattle farms and 7,000 farms engaged in poultry production, which could also be considered an additional resource for mixing raw materials for biogas production. Households have a reduced economic potential in this area of Romania: mechanical equipment for agriculture is poor and outdated, as a consequence, practiced agriculture is underperforming, where predominates small agricultural exploitations, without the adequate equipment, that provide only enough subsistence income to the family.

The subsistence and semi-subsistence agricultural holdings obtain crop and livestock production mainly for self-consumption. In Blăgești, which is bigger and more economically developed than Strugari, there are also mill/bakery units and carpentry and leather goods workshops. There is no connection to the natural gas network in this area and the residential heating is provided by individual stoves using solid biomass. The traditional rural lifestyle is well preserved in this part of Romania, including the diffused presence of handicraft activities in households. The development of further and modern services, especially tourism, represents one of the alternatives for economic development of these areas when considering the beauty of the landscape but lack of touristic infrastructures and promotional activities hinder this opportunity for the time being.

The statistical study on the composition of MUC parcels identified by the TIER-2 analysis in the area returned interesting results on the composition of these parcels. In total, 2,099 land parcels have been identified, ranging from 0.5 ha to 94.73 ha, totaling 5,332 ha. The average size of the parcels is 2.54 ha with a vast majority of parcels under 1.5 ha of total surface (1,318 sites, or 63% of total) and only a handful of parcels (13 sites) larger than 30 ha, covering 12.1 % of the total identified areas.

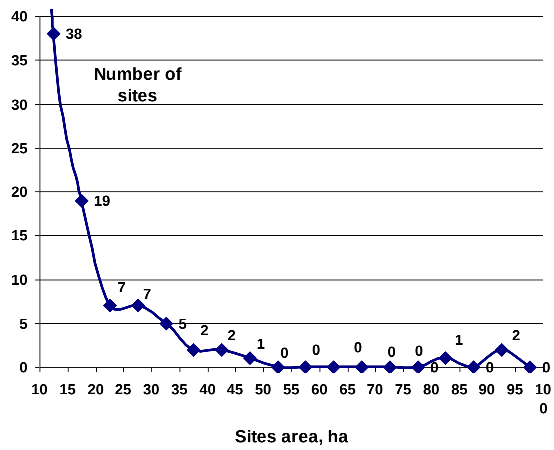


Figure 44. The size density distribution of the MUC sites over 10 ha of surface.

The main selection criterion was to focus on large parcels, thus giving more relevance to a potential investment projects at first, because as highlighted in the analysis of the structure of the farms and the economic assessment of the area, small farms are subsistence agriculture and although diversification of outputs would be an asset, the underutilized land percentage for small farmers is negligible. A further selection criterion was the sites' distance from main cities and therefore markets for the products of these lands. Last but not least, MUC lands in this territory which were within a 100 km radius from existing biomass plants were available and received due attention. This is the case of MUC parcels found near the existing biomass power plants Pângărați and Tarcău (some 55 km radius from these).

A field visit was not performed due to the evolution of the Covid pandemic in the country which has imposed limitations on regional travel.

Firewood and woody residues are the most significant source of heating in rural Romania and the majority of the people use it for heating and cooking. Almost all the households in Blăgești and Strugari rely on outdated traditional wood stoves with a low heating efficiency, (15-20%) and characteristic indoor smoke generation due to the low level of engineering of these stoves. Part of the woody biomass residues comes from the farms or from public forests but often on an informal market. The use of pellets and briquettes is becoming more and more common in the area though to date it still represents a minuscule share of the total net primary energy supply of this region.

Within a radius of 100 km from the case study sites, there are the following units using biomass for fuel or for energy production purposes:

Table 5. Units using biomass for energy purposes within a radius of 100 km around Strugari and Blăgești

Type of installation	Location	Capacity	Straight line distance from sites, km	Other information
Briquettes producer	Bacau	Small	15	
Briquettes producer	Traian	Small	24	
Briquettes producer	Comănești	Large	28	Large timber processing company using own residues
Briquettes producer	Darmanesti	Medium	34	
Briquettes producer	Onesti	Medium	39	
Solid biomass cogeneration	Tarcau	Small	51	
Solid biomass cogeneration	Pângărați	Medium	55	
Biogas cogeneration	Muntenii de Jos	Small	79	
Briquettes producer	Joseni	Small	84	

On the Romanian market the cost of woody biofuels is approximately 200 – 240 EUR/tonne for pellets, between 180 and 260 EUR/tonne for briquettes and about 80 EUR/tonne for dry woodchips. In Romania, biomass power plants benefit from subsidies based on green certificates paid on bills by all energy consumers. The power producer receives 3 green certificates for each MWh produced and delivered, with a minimum transaction value of almost 30 euros in 2019.

The Regulatory Body data show that, at the end of last year, the biomass power plants had a very low share in the total gross installed capacity in the energy production units, totaling only 124.16 MW.

2.4.2 Case study 2

Location: Oltenia mining area, Gorj County, Pesteana querry (Pesteana South and North closed spoil heaps)

MUC status: Underutilized

BPS Approx surface: 176 ha

Potential crop(s): Miscanthus, Lucerne, Sorghum, Camelina

Potential bioenergy pathway(s): Solid biofuels, Lignocellulosic ethanol, biogas

Existing BPP: No

Selection process

Gorj County is located in the southwestern part of Romania with an area of 5,602 km^2, (2.34 % of the country's territory). The region is characterized by a temperate-continental climate with Mediterranean influences. The average yearly temperature is +10.2 degrees Celsius while average multiannual amount of precipitation differs depending on the area, being lower in the plains (500-600 mm), and higher in mountainous areas, with over 1,500 mm of rain and snow every year. Within the Oltenia Mining Basin, the natural conditions favored the evolution over time of the soils from the Luvisols Class: from the total surface of 17,257 ha affected by mining, Luvisol occupy the largest surface (10,885 ha) followed by soils from the Cambisols Class - 3,059 ha, the Pelisols Class - 2,151 ha and the Protisols Class - 1,162 ha (Source: Craioveanu Gh, Carigoiu V, Sarbu L, 2010).

Most of the geological materials brought up to date by excavation and scaffolding have a medium texture, with good and very good suitability for agricultural and forestry activities. The rest is material with low suitability or unsuitable.

The exterior waste heaps resemble an artificial mound formed on an initially flat land or, in other cases they fill completely or partially valleys and creeks, perhaps situated outside the exploitation perimeter. More recent waste heaps have a structure that is primordial and not developed into proper soils yet but rather resemble waste deposits that form the edaphic support for the vegetation. They evolve very slowly in the direction of forming proper soils since the accumulation of organic matter and the intensification of the specific microbiological activity is slow in this area due to its climatic conditions as well as to the composition of the substrate. The reaction of the materials from waste heaps is mild alkaline to average alkaline due to the heterogeneous mixture of bedrock, clay, dust and sand. In the waste heaps without or recently planted forest vegetation, the humus content is very low on the entire section due to the very heterogeneous material that resulted after the excavations and the unselective sedimentation of soil horizons. The granulometric composition of the material from the waste heaps differs from an area to another so that the texture varies at small distances from loamy-sandy to clayey. (SOURCE: ICAS BRASOV)

According to the Romanian legislation, mining companies have the obligation to perform and secure the costs of the ecological rehabilitation of the lands affected by mining operations. The user of the Pesteana site is now Energy Complex Oltenia (Complexul Energetic Oltenia - CEO), but in many cases the ownership situation is not entirely clear between CEO, municipalities and local private farmers. For the same reason the cadaster registration is not performed yet, but probably this will be clarified in the near future.

The larger part of the two selected sites are situated within the municipality of Urdari, which has a surface of 3,114 ha and about 3,000 inhabitants. The current unemployment rate (as of July 2020) was 3.7% and the average monthly salary is EUR 630, but there are concerns that the restructuring of the mining company CEO, the most important employer in the county, will lead to the release of relatively skilled labor.

The main industrial centers in Gorj county are the lignite extraction in two large basins, Motru and Rovinari, the electricity production in two large thermal power plants, Turceni and Rovinari, and the hydropower plants in the area. A significant part of the economy of Gorj County is based on the Energy Complex OLTENIA, which comprises the lignite extraction quarries and the aforementioned thermal power plants.

The selection of the former mining areas as case study sites has its origin in a preliminary analysis regarding the suitability of using former mining areas for biomass for energy projects which was developed by ENERO within the FORBIO project. The present BIOPLAT-EU project offered the opportunity to go further with this analysis. A first on site visit was carried out in July 2019 in Oltenia lignite region when the fate of the land affected by the lignite extraction in the region after the mining operations end was discussed with the owners of the company and other local stakeholders. From this discussion it emerged that on these highly degraded lands, on large surfaces of land only spontaneous vegetation has grown, predominantly sparse weeds and grasses. When rehabilitation was instead performed, black locust plantations were established. There have been also some small trials using other crops. In 2011, two 0.5 ha trials with Miscanthus on the Rovinari dumps were performed. The first was established on the slag and ash dump from the thermal power plant whereas the other trial interested the raw tailings dump from the surface exploitation of the actual lignite mine. This experiment showed that Miscanthus has a good suitability to be used on such terrains, with a production of about 15 t dm/ha per year. The statistical study on the composition of MUC parcels identified by the TIER-2 analyze in the area returned interesting results on the composition of these parcels. In total, 2,099 land parcels have been identified, ranging from 0.5 ha to 94.73 ha, totaling 5,332 ha. The average size of the parcels is 2.54 ha with a vast majority of parcels under 1.5 ha of total surface (1318 sites, or 63% of total) and only a handful of parcels (13 sites) larger than 30 ha, covering 12.1 % of the total identified areas.

After the first visit on site, our attention was directed to a plot belonging to the closed Garla quarry, where over 100 ha of unused land were available. During the course of 2020, other three missions were carried out in Gorj, two of them including sites visits. These new visits revealed that the plot initially selected was not actually available because the CEO company would use it for a new slag and ash dump. Also other former mining areas owned by CEO that looked suitable for energy crops has in the meantime been reserved by the CEO to Photovoltaic parks in the context of a project totaling 700 MW of installed electrical generation capacity. The local BIOPLAT-EU partner ENERO discussed about the available lands during the working group meeting hold in July 2020. The Working Group confirmed that there are significant additional areas available today or starting 2021 for energy crops, areas coming also from closed spoil heaps of lignite mines.

Within the context of the TIER-2 analysis, 12 parcels of MUC land with an individual surface of over 10 ha were identified. The cumulated area of these first 12 large polygons stands for some 15% of the total area of the total 1.414 MUC land patches detected in the area. All large polygons are confirmed to be within former mining areas, more precisely closed mine spoil heaps, available for ecological restoration

Consequently to this exercise, two available sites belonging to the closed quarry Pesteana have been identified as testing sites for the BIOPLAT-EU project. One of them is in Pesteana North and has a total surface of 151 ha, and the second site of this case study is in Pesteana South and covers about 121 ha.

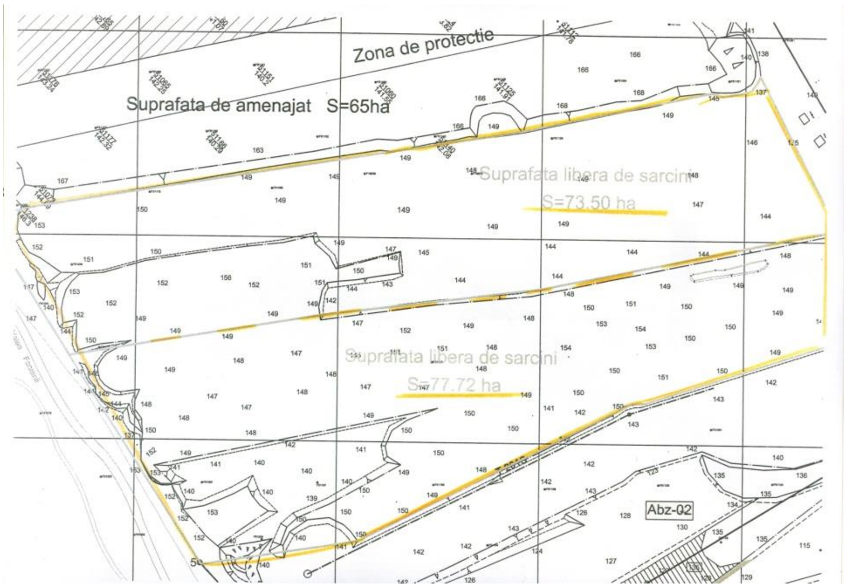


Figure 45. Map of Pesteana North identified site (yellow contour). Source: CEO

Figure 46. Image taken during the Pesteana North on site visit. The spontaneous vegetation is visible.

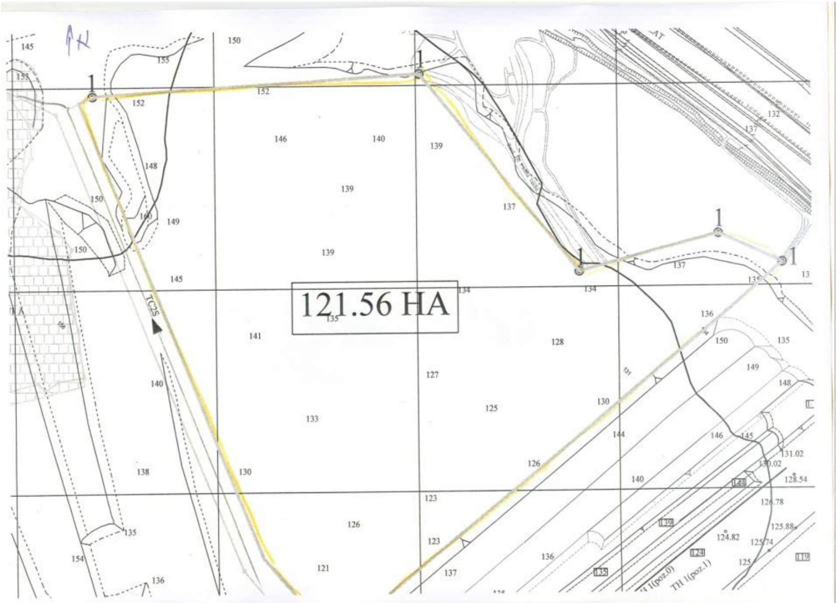


Figure 47. Map of Pesteana South case study site (yellow contour). Source: CEO

Figure 48. An image of the landscape of the Pesteana South site with underutilized spontaneous grasses.

There is no operating BPP at a reasonable distance from the selected plots. In Gorj County there are only some pellets and briquettes manufacturers (e.g. in Balanesti and Telesti). However, about 90 km away from the case study area, in Podari, Dolj County, a lignocellulosic bioethanol plant is under construction, co-financed by the BBI-JU programme. The feedstock envisaged to be used is agricultural waste. But the owner demonstrated the same technology using Miscanthus as feedstock. If in the future the agricultural waste feedstock will prove to be insufficient, the solution of using Miscanthus instead could be considered.

2.5 Spain

2.5.1 Case study 1

Location: Albacete

MUC status: Underutilized and Contaminated

BPS Approx surface: >1,000

Potential crop(s): Wheat, Sunflower, Camelina

Potential bioenergy pathway(s): Solid biofuels, SVO, HVO, Biodiesel

Existing BPP: Yes

Selection process

The province of Albacete is located in the Southeast of the Iberian Peninsula, as shown in Figure 49, and extends over part of the southern plateau, at about 700 meters above sea level, with a surface area of 1,429,105 ha, of which 719,811 ha are farmland (Statistical Yearbook, 2019). The climate is semi-arid continental Mediterranean with cool winters, with frequent frosts from December to March, and hot summers. Precipitation is scarce, around 350-400 mm per year, to which is added the low fertility of the soils characterized by a predominant shallow limestone layer. The information above is common and defines also several other areas of Spain.

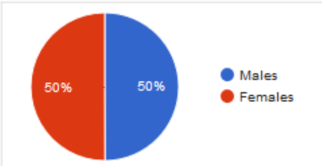
Figure 49. Location of the area of Case Study in the Albacete Province

Private land ownership is dominant with common grazing land. Mixed arable land operation and animal husbandry (sheep herding), where existing, are carried out on the same land units (grazing allotments or *"polígonos de pastos"),* under private ownership of arable land and public grazing rights. The land ownership structure exhibits a common size of useful agricultural surface of about 18-30 ha, although it remains often polarized into small holdings of less than 5 ha each, and a few estates exceeding in size 200 ha.

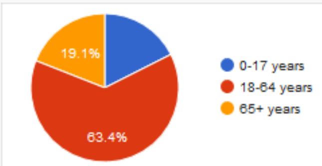
The traditional annual crops in these dry lands are cereals, wheat and barley, together with legumes such as peas, lentils, among others, and in some areas sunflower. Typical crop rotation is a cycle of three-year, cereal-cereal-legume, although the alternance of a one-year fallow is also common practice. Permanent crops such as vineyards and almonds occupy an important part of agricultural soils.

The main limiting factor in the production of rainfed agriculture is the low rainfall and its high interannual variability, which is typical of Mediterranean climate. For most common cereals such as wheat and barley, the average total biomass production is around 5-6 ton/ha, of which 2-3 ton/ha in grain, and the rest in the form of straw. This low production is coupled with low prices, bringing the profitability of rainfed agriculture very close to survival levels. In fact, in this part of Spain, the subsidies from the Common Agricultural Policy are vital for the maintenance of productive activity in many areas.

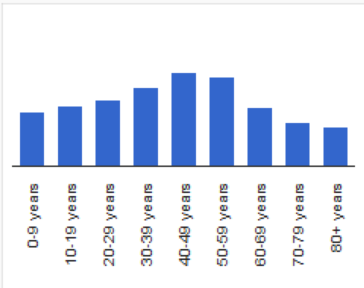
The population of the Province of Albacete counts 389,000 inhabitants (2019 census), concentrated on the province capital, the city of Albacete, with a population of 173,329 living within the administrative borders of the city itself, and additional 219,121 people living in the larger metropolitan area. Albacete is the largest city in both the province and the administrative region of Castilla La Mancha.



Gender (E 2019)	
Males	193,911
Females	194,256



Age Groups (E 2018)	
0-17 years	68,331
18-64 years	246,375
65+ years	74,080



Age Distribution (E 2018)	
0-9 years	36,394
10-19 years	40,179
20-29 years	43,738
30-39 years	52,418
40-49 years	62,045
50-59 years	58,910
60-69 years	39,300
70-79 years	29,410
80+ years	26,392

Figure 50. Population structure of Albacete province, source INE, Instituto Nacional de Estadística, censo 2019.

The region's development is rather behind that of the rest of Spain and Albacete province shares the main economic regional characteristics. In 2017, GDP per capita in purchasing power standards (PPS) was 21,800 EUR, below the national figure of EUR 27,600/year and the EU average (30,000 EUR/year) (Eurostat, 2019). The gross value added (GVA) components in Castilla-La Mancha's economy in 2017 were distributed as follows:

- primary sector was responsible for 9.1% of total GDP;
- industry covered 29.4% of which building represented 7.3%, and services had a share of 61.6% (Eurostat, 2019).

As observed in all developed countries, the economy is moving towards the service sector, nonetheless the primary sector still holds a significant weight in the region's economy. In fact, agriculture's economic performances in Castilla-La Mancha is the only sector above the national average due to the production of olives, arable crops and high-quality wines (Servicio de Estadística de Castilla-La Mancha). Traditionally Castilla-La Mancha fosters a small industry. Due to the economic crisis, the industrial production of Castilla-La Mancha decreased dramatically from 2010 to 2015. As it could be expected given the importance of the primary sector, food processing and agroindustry compose the main industrial activities in the region as well as main exports manufacturing activity. In this context, it is important to note the relevance of the wine sector in Castilla-La Mancha, which hosts almost half of the surface cultivated with vineyards in Spain and is one of the largest vineyard regions in the world. The unemployment rate in 2017 was 18.2% (Eurostat, 2019), above the national (15.3%) and EU average (6.9%).

The selection process of the pilot area has been carried out according to the criteria of physical proximity, consultation with possible users and knowledge of the territory and availability of information, such as the detailed cartography describing Land Parcel Identification System (SIGPAC, in Spanish).

Within a 100 km radius of the case study, there is a biomass power plant that generates electricity burning wood and forest residues. The burning of crop residues in the plant, such as vine shoots, is very marginal despite several trials, due to the difficulty both in collecting these residues and in transporting them to the plant.

2.5.2 Case study 2

Location: Cuenca

MUC status: Underutilized

BPS Approx surface: 500

Potential crop(s): Camelina

Potential bioenergy pathway(s): SVO, HVO, Biodiesel

Existing BPP: Yes

Selection process

In mainland Spain, rainfall is low in many regions, with values between 300 and 450 mm per year, which are distributed irregularly, with dry summer as corresponds to the Mediterranean climate, with high variability from one year to another and frequent droughts. As a consequence, large agricultural areas exhibit low yield without irrigation, which places them close to being marginal and underutilized.

Camelina is a new oilseed crop that has been garnering a lot of attention in the past few years[57]. This is partly due to a worldwide interest in bio-fuels. Other possible bio-based products from camelina include fish feed, bio-lubricants and healthy dietary oil. Most recently, the jet fuel market has emerged as a potential business opportunity for camelina oil and, therefore, for camelina producers.

Camelina is an oilseed alternative for rainfed areas in semi-arid regions. Camelina would insert into the typical crop rotation for Spanish rainfed areas, like cereal, cereal, camelina, or alternating with fallow. Main characteristics of Camelina crop match with semiarid continental Mediterranean climate and with current used machinery and farmer knowledge. Camelina is drought and frost tolerant, requires cereal-like fertilization, it has a cereal-like growing cycle and uses conventional machinery used for grain seeding and harvesting.

Figure 51. Typical root structure of Camelina and field pictures.

[57] Moser, B.R., 2010. Camelina (Camelina SativaL.) oil as a biofuel stock: Golden opportunity or false hope?. 270, December 2010, Vol. 22, No. 12, Lipid Technology. DOI 10.1002/lite.201000068.

According to data supplied by A. Capuano, (2020)[58], figure 52 shows the expected yield for Camelina in Spain under rainfed conditions, ranging among 1,000 and 2,000 kg/ha, depending on the precipitation regime. The area sown in the 2019-2020 campaign was around 4,200 hectares (30% in No-Tillage, 70% in Conventional land management). Organic farming (around 400 ha) rise slightly in the last years. The Oil Extraction Rate is around 35% and the plant produces by-products including a protein cake to be used as animal feed. The nutritional properties of camelina's protein is similar to those of rapeseed and soy.

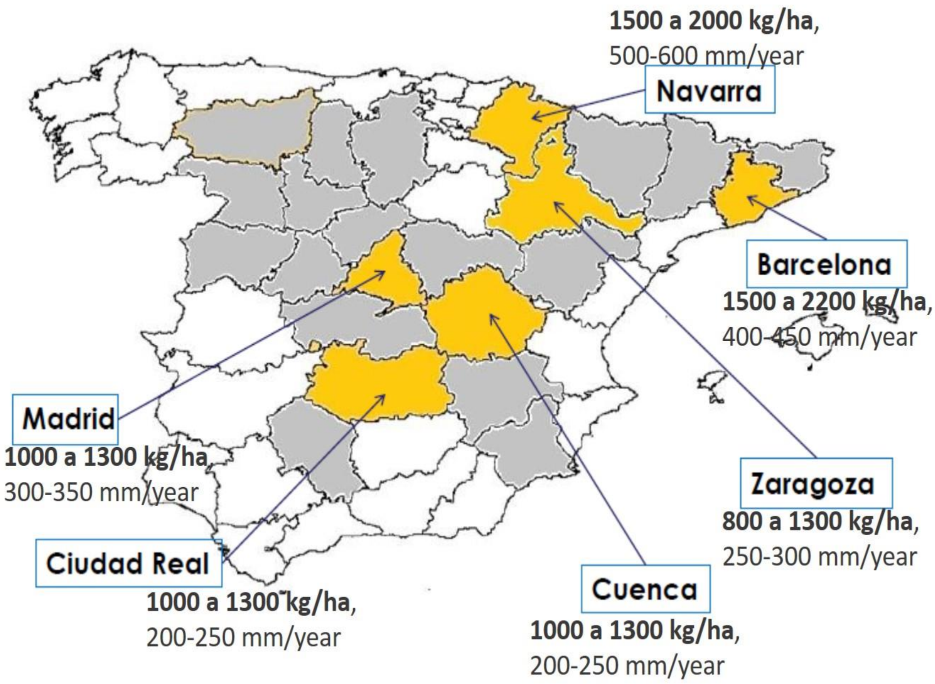


Figure 52. Camelina yield in rainfed areas of Spain

Within a 100 km radius of the case study, there is an oil extraction plant for Camelina, operated by Camelina Spain Company[59]. Taking all this into account, a pilot zone has been selected (Figure 53) where we can know the fields in which this crop is planted and managed, as well as the data concerning the crop cycle. The selection process of the pilot area has been carried out according to the criteria of physical proximity, consultation with possible users and knowledge of the territory and availability of information, such as the detailed cartograbout about Land Parcel Identification System (SIGPAC, in Spanish).

The selected case study site is an area belonging to the Cuenca province, located in the center of the Iberian Peninsula, as shown in Figure 53, and it extends over part of the southern plateau, at about 700 meters above sea level. The climate is semi-arid continental Mediterranean; winter is cold, with frequent frosts from December to March, and hot summers. Precipitation is scarce, at around 350-400 mm per year, to which is added the low fertility of the soils.

[58] Capuano, Anibal (2020) Personal communication.
[59] https://camelinacompany.es/

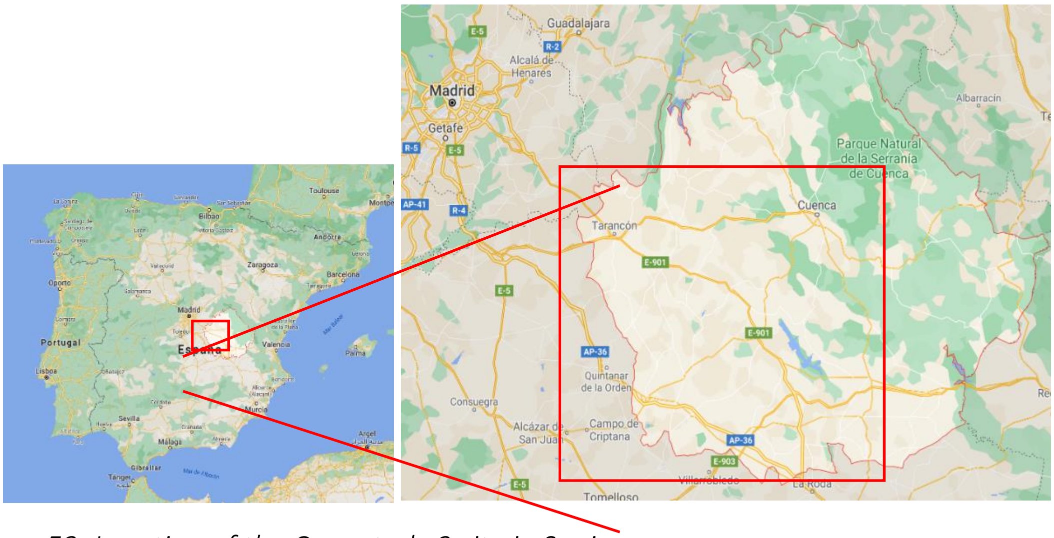


Figure 53. Location of the Case study 2 site in Spain.

Private land ownership is dominant with common grazing land in the selected area. Mixed arable and sheep operation, where existing, are carried out on the same land units (grazing allotments or "polígonos de pastos"), under private ownership of arable land and public grazing rights. The land ownership structure exhibits a size of useful agrarian surface of about 18-30 ha per parcel, although remains polarized into small holdings of less than 5 ha, as well as estates exceeding in size 200 ha.

The traditional annual crops in dry land are cereals, wheat and barley, together legumes such as peas, lentils, among others, and in some areas sunflower. Typical crop rotation is a cycle of three year, like cereal-cereal-legume, although one-year fallow also is a usual practice.

The population of the province of Cuenca is about 196,329 inhabitants (2019 census), concentrated on the province capital of the same name, Cuenca, with a population of 54,690 inhabitants. The region's development is rather behind that of the rest of Spain. In 2017, the per capita GDP in purchasing power standards (PPS) was 21,800 €, below the national (27,600 €) and the EU averages (30,000 €) (Eurostat, 2019). The gross value added (GVA) components in Cuenca economy were distributed as follows in 2017: primary sector was responsible for 9.1%, industry covered 29.4% of which building represented 7.3%, and services had a share of 61.6% (Eurostat, 2019). As observed in all developed countries, the economy is moving towards the service sector; nonetheless the primary sector still holds a significant weight in the region's economy and accounts for over 10% of the agricultural companies in Spain.

2.6 Ukraine

2.6.1 Case study 1

Location: Khmelnytskyi and Ternopil regions

MUC status: Underutilized

BPS Approx surface: > 30,000 ha

Potential crop(s): Miscanthus, switchgrass

Potential bioenergy pathway(s): Solid biofuels

Existing BPP: Yes

Selection process

Ukraine is a large country that hosts some of the most fertile soils in the world and leads in terms of yields and production quantity with respect to many agricultural commodities and yet it has an impressive 4 million hectares of agricultural land which are currently underutilized. The selected case study area follows the same trend for large surfaces and it interests a cumulative area of 575,000 ha inside which more than 30,000 ha of underutilized land are found. The case study touches upon two neighboring regions – Ternopil and Khmelnytskyi – located in the Eastern side of Ukraine. The area includes eight districts of the Ternopil region (Husyatynskyi and parts of Ternopilskyi, Zbarazkyi, Pidvolochyskyi, Terebovlyanskyi, Chortkivskyi, Zalishchytskyi, Borshchivskyi) and ten districts of the Khmelnytsky region (Horodotskyi, Chemerovetskyi and parts of Dunajevetskyi, Khmelnytskyi, Volochyskyi, Yarmolynetskyi, Kamyanets-Podilskyi, Vinkovetskyi, Krasylivskyi, Novoushytskyi). The cumulative surface of all districts in this region sums up to 1,202,200 hectares whereas the total surface of MUC lands found in these two Regions of interest is in excess of 30.000 ha.

Table 5. Case Study area 1, total surface (in thousand ha) including but not limited to MUC lands

Khmelnytskyi		Ternopil	
Horodotskyi	111.1 (ha)	Husyatynskyi	101.6
Chemerovetskyi	92.8	Ternopilskyi	37.4
Dunajevetskyi	118.2	Zbarazkyi	17.0
Khmelnytskyi	102.0	Pidvolochyskyi	69.6
Volochyskyi	96.0	Terebovlyanskyi	52.0
Yarmolynetskyi	83.1	Chortkivskyi	74.2
Kamyanets-Podilskyi	77.3	Zalishchytskyi	42.0
Vinkovetskyi	14.6	Borshchivskyi	72.2
Krasylivskyi	31.5		
Novoushytskyi	9.6		

Subtotal	736.2	Subtotal	466.0
Total	**1,202.2**		

These two regions are located at the south-west of the East European Plain in the zones of forest steppe and mixed forests called Polissia. Soils of these areas are mostly grey podzolized and chernozems. Climate is temperate continental with warm humid summers, mild winters and sufficient rainfall. Case study area 1 lays in the central and southern agro-climatic zones of both regions with average annual temperature of 7.3 - 9.8°C and average annual precipitation of 510 - 650 mm. Rivers of the area belong predominantly to the Dniester river basin. Based on the available statistics for the two regions, forests cover about 13% of the selected territory. Natural reserves and parks in this area include botanical, landscape and forest reserves with a total area of 10,422 ha (6 reserves with total area of 5,777 ha in Ternopil Region and 13 reserves with total area of 4,645 ha in the Khmelnytskyi's part of the Case study area). Agricultural lands represent about 76% of the total area of these regions. Of these several small patches are underutilized.

The ownership structure of agricultural lands in Ukraine is subdivided into private, communal and state-owned parcels. Private owners can be citizens of Ukraine and legal entities. Communal ownership refer to agricultural lands owned by territorial communities of villages, settlements, cities whereas State owned agricultural lands are belonging to the Government of Ukraine and are public lands to access, use or exploit which users may require e permit.

In identifying the lands suitable for the purpose of the BIOPLAT-EU project, local partner SECB carried out a comparative analysis of several policy and statistical methods employed in Europe and Ukraine to align their feature with a view to harmonize the outcomes of the analysis. According to the Land Code of Ukraine MUC lands defined as degraded, low-productivity and contaminated are subject to rehabilitation actions. **Degraded lands** include: a) land plots, the surface of which is disturbed due to earthquakes, landslides, karst formation, floods, mining, etc.; b) land plots with eroded, overwetted, with high acidity or salinity, and soil contaminated with chemicals of natural origin and occurrence. **Low-productivity lands** include agricultural land, the soils of which are characterized by low fertility, and their economic use is intended as economically inefficient. **Contaminated lands** are a category of lands which shows concentrations of chemicals that exceed national thresholds as a result of human activities, which led to land degradation and its negative impact on the environment and human health. These lands include radioactively contaminated lands, as well as lands contaminated with heavy metals, other chemical elements, and the like. When using contaminated lands, the features of their use regime are taken into account. According to the Land Code of Ukraine, land restoration and rehabilitation actions are carried out by terminating their current use for a specified period and by putting in place afforestation campaigns[60]. These lands are transferred to the category "stock land". Stock lands belong to communal and state ownership type. Usually, these lands include old orchards and territories of former collective farms with unused and partly ruined buildings, and territories covered with grassland with rare bushes located in-

[60] Land Code of Ukraine https://zakon.rada.gov.ua/laws/show/2768-14

between the utilized agricultural lands. Several degraded lands exist within the case study area but their contiguous surface is limited to less than 50 hectares[61].

Population of the Case Study area including big cities and constituent districts is 1,505,388 people (Table 6). Employment rate in both regions is higher than 60%, but is higher for the Khmelnytskyi region (66.1% in 2019), than for Ternopil region (62.3% in 2019). The average salary per year amounted to the equivalent of 3,432 EUR in Ternopil region and 3.597 EUR in Khmelnytskyi region in 2019. Predominant economic activity in both regions is agriculture, forestry and fishing, followed by wholesale and retail trade; and lastly the industry sector.

Table 6. Population of the Case Study area

Khmelnytsky		Ternopil	
Cities	Population	*Cities*	Population
Khmelnytskyi	271,263	Ternopil	221,820
Kamyanets-Podilskyi	99,755	Chortkiv	28,858
Districts		***Districts***	
Horodotskyi	46,139	Husyatynskyi	58,502
Chemerovetskyi	39,320	Ternopilskyi	67,077
Dunajevetskyi	60,410	Zbarazkyi	56,376
Khmelnytskyi	53,228	Pidvolochyskyi	41,320
Volochyskyi	49,595	Terebovlyanskyi	63,865
Yarmolynetskyi	28,322	Chortkivskyi	43,416
Kamyanets-Podilskyi	64,072	Zalishchytskyi	45,541
Vinkovetskyi	23,173	Borshchivskyi	65,731
Krasylivskyi	50,145		
Novoushytskyi	27,460		

The selection of the Case Study sites started with identification of MUC lands using data from State statistics service of Ukraine. A first assessment reported some 3.97 million ha of free agricultural lands were identified in Ukraine. Regions with the largest share of unused agricultural lands are Donetsk, Luhansk, Kherson, Odesa, Chernihiv and AR Crimea, which together represent more than a half of these lands. Additionally, regions with more than 100,000 ha of unused agricultural lands are Kyiv, Zhytomyr, Khmelnytskyi, Vinnytsya, Dnipropetrovsk, Kharkiv, Mykolaiv, Zaporizhzhya, which together represent almost 1 million ha of underutilized agricultural land in Ukraine.

Following this preliminary assessment, local authorities of the regions and their districts and amalgamated territorial communities were contacted by e-mail to survey their knowledge of the issue of MUC lands in their territory. According to the answers received, 4,997 hectares of

[61] According to the data from the State Service of Ukraine for Geodesy, Cartography & Cadastre, checked on the Public cadastral map https://map.land.gov.ua/

marginal and underutilised lands were identified with strong emphasis on the regions of Lvivska and Khmelnytska (Table 6).

Table 7. Marginal and underutilized lands identified in Ukraine from a survey of regional and local authorities.

Region	Land area, ha		
	Marginal	Underutilized	TOTAL
Vinnytska	-	476.43	**476.43**
Volynska	184.94	8	**192.94**
Zhytomyrska	-	378.01	**378.01**
Kyivska	-	121.06	**121.06**
Lvivska	928.95	320.73	**1,249.68**
Rivnenska	486.56	181.72	**668.28**
Khersonska	581.9	180.76	**762.66**
Khmelnytska	50	955.89	**1,005.89**
Cherkaska	-	142.65	**142.65**
TOTAL	**2,232.35**	**2,765.25**	**4,.997.6**

Along with the identification of MUC lands, the search for stakeholders was launched. About 200 stakeholders were identified in 21 regions of Ukraine, among which investors, interested in construction of bioenergy objects in the regions (Table 7).

Table 8. Identification of stakeholders and potential bioenergy pathways

Region	**Bioenergy pathway**	**Energy crop**	**Plantation (considered)**	**Data availability (maps, statistics)**	**Local stakeholder engagement existing**
Kmelnytska	TPP	Miscanthus, switchgrass	1000 ha	available	Investors, farmers
Kharkivska	CHO	Willow, Miscanthus	8,00 ha	Maps – no, Statistics – yes	Municipality, farmer, Boilers manufacture
Kyivska	TPP	willow	1,000 ha	available	Municipality
Lvivska	Biomass production for a Heating plant	willow	60 ha	available	Utility company
Khersonska	Biomass production, Briquettes production	Miscanthus, willow	21 ha 20 ha	available	Municipalities, private landowner, SME, farmers, utility company
Dnipropetrovska	CHP	Willow	200 ha	available	Investor

The 1st Case Study area was selected based on:

- availability of large areas of MUC lands in the region,
- potential large scale investors (e.g. the Khmelnytsky Biomass Power Plant under construction),
- interested regional authorities (Khmelnytska and Ternopilska regional administrations),
- interested local authorities (Novoushytskyi village council, Sataniv village council),
- interested stakeholders (Sudylkiv Agrarian Company, PU "Khmelnytskyi Energy Cluster", "Zodchyi" LLC, Krai LLC, PO "NTC Bioenergija").

Last but not least, these areas have been screened by the Johanneum Research Institute with the TIER-2 approach to verify the vast surfaces of land identified in the previous two tasks as effectively underutilized. The results of this TIER-2 assessment validated in a number of cases the guidance received from statistics and local authorities and stakeholders and allowed to define a map of the sites within the case study quadrant that will be tested in the context of the BIOPLAT-EU project (Figure 54).

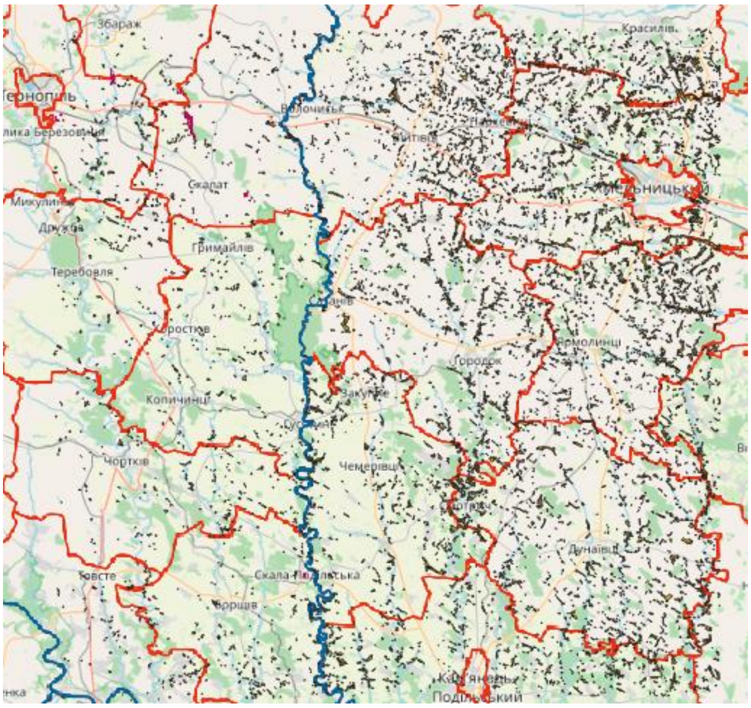


Figure 54. TIER-2 Map of the case study area 1 of Ukraine. The areas preliminarily identified have been scanned through the TIER-2 approach to highlight the MUC lands within the contour of the case study area. The black parcels are the underutilized lands that compose case study 1.

The areas identified via the satellite imagery's interpretation have been verified on the ground by local stakeholders involved in a working group created by the national BIOPLAT-EU partner. The result of this field visit is displayed below.

Figure 55. Abandoned orchard in the Novoushytskyi district

Figure 56. Underutilized land in the Novoushytskyi district

Several bioenergy facilities are located in a 100 km radius from the 1st Case study site. The 10.5 MWel biogas plant of the Theophipol Energy Company LLC is located at 80 km distance from the Case study site. The predominant feedstock used in the plant is agricultural residues. The plant generates electricity that is sold at a "green" tariff (EUR 123.9 per MWh according to the Law of Ukraine No. 555-IV on Alternative Energy Sources with amendments from 09.08.2019[62], set in October 2017). Within the same radius there is also a bioethanol plant at Teofiopolskyi sugar plant (capacity: 25,000 t/year) and a vegetable oil extraction plant located in Starokostiantyniv (capacity 1000 thousand tons of oil/year). A CHP plant fueled with wood chips that has a capacity of 1.8 MWel is located at 118 km from the borders of the 1st Case study site.

[62] https://zakon.rada.gov.ua/laws/show/555-15

2.6.2 Case study 2

Location: Kyiv and Chernihiv regions

MUC status: Underutilized

BPS Approx surface: > 40.000 ha

Potential crop(s): Willow

Potential bioenergy pathway(s): Solid biofuels

Existing BPP: Yes

Selection process

The selected area is located in the northwestern part of the Chernihiv region. The area includes six districts of Chernihiv region (Ripkynskyi and parts of Chernihivskyi, Gorodnianskyi, Snovskyi, Menskyi, and Kulykivskyi districts) and Slavutych city which is found within the Kyiv region (Table 7). The cumulated surface of all the aforementioned municipalities amounts to some 575 thousand hectares.

Table 9. Case Study area 2, thousand ha

Chernihiv region		**Kyiv region**	
Chernihivskyi	186.4	Slavutych city	2.08
Ripkynskyi	208.52		
Gorodnianskyi	137.74		
Snovskyi	2.66		
Menskyi	7.9		
Kulykivskyi	30.13		
Subtotal	573.35	Subtotal	2.08
Total	**575.43**		

The case study area is part of the Dnipro lowlands in the zone of Chernihivske Polissia. It lies in the zone of mixed forests (pine, oak, birch, aspen, black alder, hornbeam). The climate is moderately continental. The average temperature in July is from 18.4 to 19.9 °C, in January from minus 6 °C to minus 8 °C. The period with an average daily temperature above 10 °C is 150-160 days per year. Annual precipitation is 500-600 mm. Soils in the northern part of Chernihiv lands (Polissia) are mainly sod-podzolic, as well as gray and light gray podzolic, and peat-bog.

The hydrographic network of the region belongs to the basins of the great rivers Desna and Dnipro. The main water artery of the region is the Desna River, which is a left-bank tributary of the first order of the Dnipro river. There is a significant area of flood-plains of the rivers that belong to the Dnipro river basin. According to available statistics, forests cover about 30% of the Case Study area. Site of naturalistic relevance in the area include different types of environmentally protected sites with total area of 29,775 ha (97 sites). Agricultural lands represent about 65% of the total area of the region.

Districts that are covered by the 2nd Case study area have abundance of land plots cathegorized as “stock land” (see Ukraine case study 1 for a detailed description. The stock lands in this case study area are sometimes subjects to unregulated agricultural activity. At the same time, a number of identified underutilized land plots of communal and state property have been transferred to the category “for agriculture” and are planned to be leased through land auctions. The vast majority of these underutilized patches has an extension of less than 5 hectares and there are only about 10 land plots with a surface of more than 100 ha and only 1 with contiguous MUC patch measuring more than 200 ha.

Within the Case Study area near the urban village Zamglai of the Ripkynskyi district there is an abandoned peat bog of about 2,900 ha, where one of the biggest in Europe Zamglaiskyi peat plant was located. Now energy generation at the plant has been discontinued without prospects for further work.

The population of the Case Study area includes cities and constituent districts and accounts for some 416,000 people. In 2019, the employment rate of the population in the selected area aged 15 and over was 50.8%. Unemployment rate among the labor force aged 15 and older was 10.1%. Average salary per year amounted to 3,404 EUR in Chernihiv region and to 4,563 EUR in Kyiv region in 2019. The average nominal monthly salary of a full-time employee of enterprises and institutions and organizations in Chernihiv region in April 2020 amounted to 8,697 UAH (294 EUR), which is 1.8 times higher than the level of the minimum wage (4,723 UAH or 160 EUR). In Kyiv region, the average nominal salary of a full-time employee of enterprises and institutions and organizations in April 2020 amounted to 10,797 UAH (365 EUR), which is 2.3 times higher than the level of the minimum wage.

In 2017, the largest share to the local GDP was represented by agriculture, forestry and fishing (28.2%) followed by the industry sector (20.5%).

The selection of this Case Study site was initially linked to the Kyiv region, based on the experience from the FORBIO project. In the FORBIO project, the underutilized and marginal lands of Ivankiv district of Kyiv region were analysed, based on statistical data and vast exchanges with local stakeholders. As there is already an operational Biomass Power plant of 18 MWel in the Ivankiv region, further analysis of the underutilized lands of Kyiv region was accompanied by an enlarged stakeholders search with a focus on investors interested in implementing bioenergy projects in the area. The search resulted in the identification of a potential investor, the UKRTEPLO group of companies, which deposited plans for the construction of a CHP plant with a capacity of 12.5 MWe for in the city of Slavutych within the Kyiv region. The company already has a 10.5 MW heating plant in Slavutych that covers up to 40% of the heat demand of the city. With the new CHP UKRTEPLO plans to help the municipality to completely abandon the use of natural gas in district heating. Although Slavutych city belongs to the Kyiv region, in fact, it is located on the north-west of the Chernihiv region in the 12 km distance from the border with Belarus. Therefore, further identification of the underutilised and marginal lands was linked mainly to Chernihiv region as the feedstock catchment area is more likely to be within the latter.

According to the data of the State statistics committee of Ukraine, the Chernihiv region takes the second place in the ranking of the lowest share of sown agricultural land in Ukraine. There are more than 200,000 ha of unused arable land in Chernihiv region (Fig. 54).

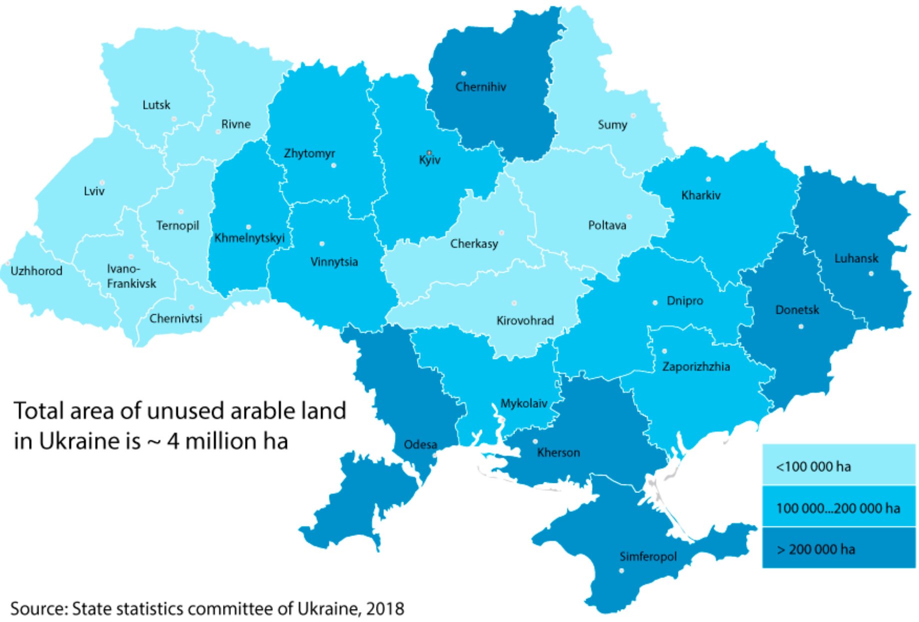


Figure 57. Unused arable land in Ukraine in 2018

According to data of the Department of Ecology and Natural Resources of the Chernihiv Regional State Administration[63], there are more than 8,.000 ha of degraded and low-productive lands in Chernihiv region, but the analysis of the TIER-2 maps carried out in the context of this project revealed a potential of more than 40,000 ha.

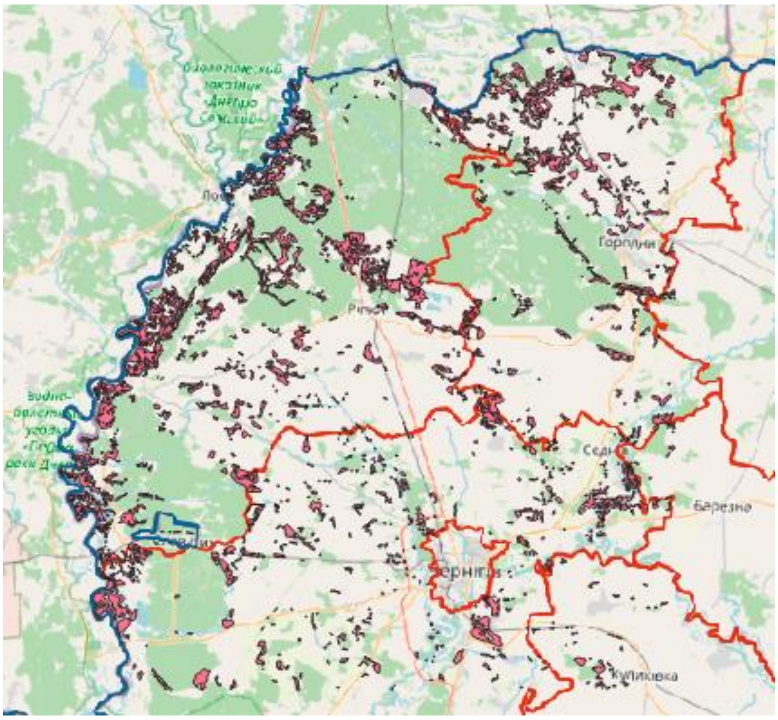


Figure 58. TIER-2 Map of the case study area 2 of Ukraine. The areas preliminarily identified have been scanned through the TIER-2 approach to highlight the MUC lands within the contour of the case study area. The pink parcels are the underutilized lands that compose case study 2.

[63] Department of Ecology and Natural Resources of the Chernihiv Regional State Administration http://eco.cg.gov.ua/index.php?id=15800&tp=1&pg=

About 200 stakeholders in Kyiv and Chernihiv regions were identified, including 14 representatives of national, regional and local authorities, 19 representatives of farmers and agrarian companies, 12 representatives of industry, 12 representatives of SMEs and 33 researchers interested in being involved in the project and to be informed about project's results.

In addition to the biomass heating plant of 10.5 MW on wood chips in Slavutych, in a 100 km radius from the Case study area, mostly biomass heat production plants are located with individual capacities up to 1 MW, which use wood chips, logs, pellets and straw bales as feedstock. Two biogas plants of Gorodishche-Pustovarivska Agrarian Company LLC are located in the Chernihiv region, but more than 235 km away from the borders of the case study site, near Lynovytsia (2.4 MWel) and Zhuravka (1.2 MWel) villages. Predominant feedstock of the Lynovytsia biogas plant is bagasse and molasses, and for the Zhuravka biogas plant pig manure and maize silage.