




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

D3.6

Operational webGIS tool



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List of Acronyms

BPP	Biomass Processing Plant
BPS	Biomass Production Site
EU	European Union

FAO	Food and Agriculture Organization of the United Nations
GAEZ	Global Bioenergy Partnership
GIS	Geographic Information System
JR	Joanneum Research
LUC	Land Use Change
MUC	Marginal, Underutilized and Contaminated
NUTS	Nomenclature of Territorial Units for Statistics
STEN	Sustainability Tool for Europe and Neighbouring Countries
TABL	Target Area Base Layer
UCLM	University of Castilla-La Mancha

Executive Summary

This document presents the functional and operational version of the BIOPLAT-EU webGIS v1.0 tool. The tool works according to the requirements of users interested in the generation of biomass for its use as bioenergy. The conceptual design gathered these requirements, which deliverable D3.4 described in detail. The tool also incorporates the usability characteristics, implemented in the precursor prototype and described in deliverable D3.5.

In its current state, the BIOPLAT-EU webGIS v1.0 system is capable of operating on the complete set of ten socio-economic and environmental indicators that make up the STEN tool, developed by FAO. The numerical outputs associated with these indicators will allow decision-making for the exploitation and sustainability of bioenergy value chains on those Marginal, Underutilized and Contaminated (MUC) areas, not suitable for food production, in Europe and neighboring countries.

The BIOPLAT-EU webGIS v1.0 system provides users with access to simulations that incorporate the socio-economic and environmental value chain for decision-making in the use of MUC areas for bioenergy production. In addition, it responds to the objective of having a tool that is easy to use, accessible, and with sufficient computing power for the described user requirements, in accordance with the project objectives.

The tool computes the set of variables that make up the ten socio-economic and environmental indicators. The process starts from the selection by the user of the zone of interest in a MUC area, which is done graphically and intuitively. It is in this well-defined area, named Biomass Production Site (BPS) where the potential for the production of bioenergy crops will be analyzed. Next, and interactively, the crop and the energy pathway in which the produced biomass transforms into energy are selected; this step incorporates the physical location of the processing plant in which the useful biomass produces bioenergy; this processing plant is called Biomass Production Plant (BPP). Furthermore, the system calculates basic data corresponding to the distance of the raw materials transportation from the production site to the processing plant.

The set of municipalities in which the BPS and the BPP are located constitute the Target Area. The definition of the municipalities that are part of the target area allows the system to access the set of socio-economic data (population, employment, etc.) necessary to carry out the analysis of the impact that the entry into production of the MUC area can produce. These data, associated with the municipalities, are in the Target Area Base Layer, TABL. The TABL layer has been previously uploaded in the system. The TABL, MUC, and BPP layers have been elaborated by partner JR, as described in Deliverable D2.3. All the data of these layers are accessible graphically and numerically from the main screen of the system.

The selection of the BPS geographic area, as well as that of the crop and its management, allow the system to estimate the expected average yield in that area and for that crop. This is done through the GIS operations that extract the yield value for that area and crop from previously uploaded layers, which estimate the yield of the crop and its suitability for that area, based on its management. The GIS layers about expected crop yield and suitability have been adapted

by FAO from the so-called GAEZ (Global AgroEcological Zones) maps. These uploaded layers are equally accessible graphically and numerically from the main menu.

Finally, the STEN simulation is ready for launching. The simulation processes the values of the socio-economic and environmental indicators, calculated over a 20-year life cycle, in which the evolution of these indicators is compared in two scenarios: the Target scenario (commonly known as With Project scenario) where the impact of the data inserted is measured, against the Baseline scenario, which consists in evolution of initial situation (the land without biomass production) in the planned lifecycle. It is noteworthy that the "advanced" user can modify the values of the input parameters, and replace them with more adjusted ones, the result of his own knowledge, with which he can produce his own analysis.

This document describes the BIOPLAT-EU webGIS v1.0 tool from the point of view of its construction as a web platform, accessible in a simple and intuitive way to the user. The system has been built on a classic client-server architecture, as it is considered the most efficient to satisfy user requirements.

The client part is the interface with the user that constitutes the front-end, together with the communication with the server or back-end part. The back-end part is made up of the indicators computation core, STEN_Engine, the set of web services, the data model and the input-output data set of the system. The front-end design includes the graphical representation of vector data to improve the usability and interaction with the user in a webGIS environment.

The Interface section describes the handling of the tool and the interaction of the webGIS with STEN for the analysis of indicators in a Target Area. The computational core of the socioeconomic and environmental indicators has been implemented in the part called STEN_Engine, which is a processor equipped with its own computer language to give flexibility to the definition of new indicators or the modification of the current ones without requiring the source code, only the list of required formulas. It also has the flexibility to easily incorporate developments made in Excel spreadsheets, widely used in this type of analysis.

The representation of the output data has been similar to that defined in the Excel version of STEN Tool, on which the STEN_Engine computing core has been built. In addition to the numerical values of indicators, the output also includes the map that describes the Target Area and their basic numerical data. Finally, the complete output can be downloaded in pdf format.

The two-tier data model allows the internal management of the different layers with regard to the information associated with the geographic location, such as that not associated. It gives advanced users the ability to easily modify the system input data.

The implemented web services allow accessing to the computation of the variables that constitute the input of the STEN indicators. They allow also access to the spatial representation in the form of maps of the basic layers of the system, and to the numerical data of these layers. These basic layers are: (1) Target Area Base Layer, TABL, (2) Marginal Underutilized and Contaminated lands, MUC, (3) BPP, and (4) a set of layers that define the suitability of the crop and the expected yield Crops Suitability and Yield.

Access to the system is provided at the URL <https://webgis.bioplat.eu>

1 Introduction

This document is a status report of the work carried out in the implementation of the operational webGIS Tool. The construction of the operational webGIS has been carried out like the previous prototype using agile management processes based on incremental life cycles to achieve a progressive growth of the functionality. The webGIS is based on the 1) requirements analysis elaborated in the conceptual design D3.4, 2) the collection of information and elaboration of basic layers by JR, 3) the development and functionality of the prototype elaborated in D3.5 and 4) the design of the STEN Tool for the calculation of indicators by FAO in Excel format.

The construction of the operational webGIS Tool responds to user requirements, following the workflow structure according to the user's perspective, as shown in Figure 1. This figure depicts the steps required for users, standard and advanced, to obtain the results of the socio-economic and environmental analysis. Standard user can run the tool with the only requirements of selecting the site, selecting the crop and selecting the plant and the bioenergy pathway. The input parameters are deployed from the layers and tables previously stored in the database of the system. Advanced users can introduce their own updated data into the system.

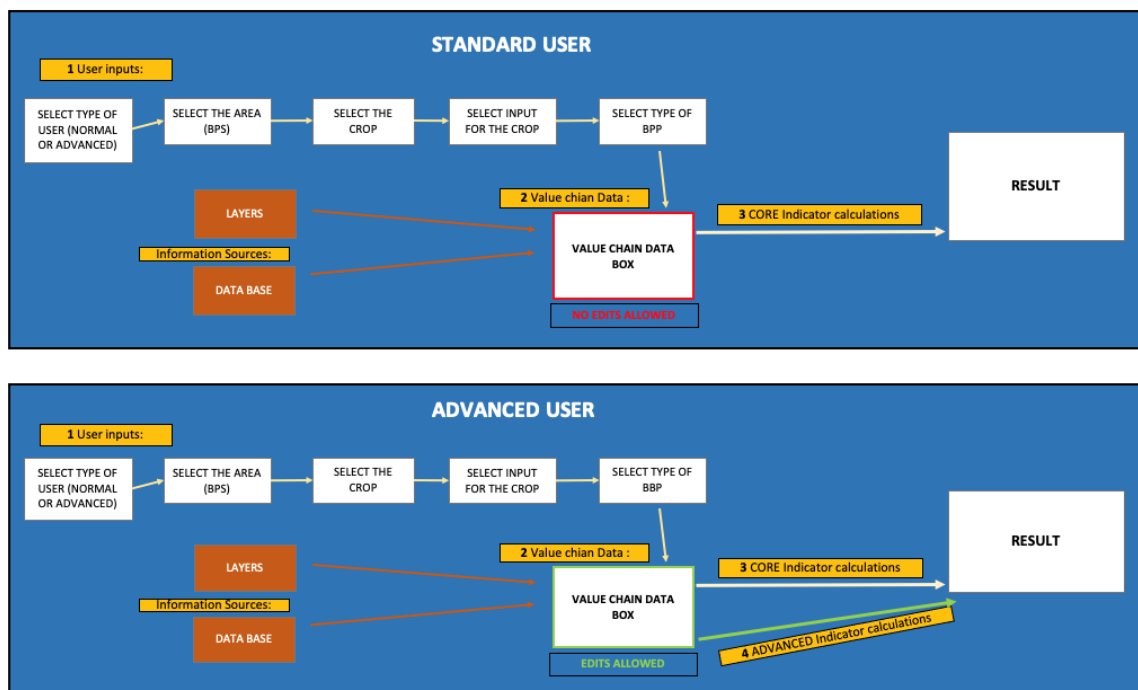


Figure 1 - STEN Tool data flow for Standard and Advanced Users

The prototype reflects the flow of user interaction within the webGIS + STEN tool, obtaining CORE and Advanced indicators results from user inputs, information sources and value chain data obtained and / or edited by advanced users.

The interaction with the STEN Tool begins with the selection on the map of a marginal, underutilized or contaminated land (MUC). MUC areas are those zones recognized as potential

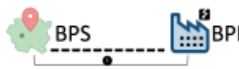
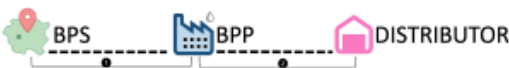

resources of raw materials for bioenergy production. This selection can be done through the information tool and / or with the search for a location (coordinates, names or GPS). The STEN Tool requires minimal information to start the process; 1) Delimitation of the BPS, 2) crop and management selection and 3) information on the BPP.

The webGIS tool provides a set of functionalities that allows the data box to be more user input friendly. The selected BPS could be the whole MUC or only a part of it. A part of the MUC is defined by drawing it using an editing tool. Once the BPS is defined, the Web Services calculates the appropriate crops for the BPS based on the suitability criteria of the GAEZ layers for those agronomic characteristics.

The choice of crop determines the compatible bioenergy pathways, necessary to define the distance and / or location to the different feedstock sites. The webGIS allows the reverse process to be carried out, where the user previously selects a bioenergy pathway and subsequently the crop based on the compatibility criteria. Crop and bioenergy pathway selection performs interactively.

The webGIS calculates by default the route to the nearest BPP for the selected bioenergy pathway, according to the bioenergy pathway as Table 1 outlines. The user can modify the distance manually or through the map to specify the location of the processing plants.

Table 1 - Summary table of distance calculation estimated by STEN according to bioenergy pathway

Bioenergy pathways	Trail	Transport feedstock
CHP, Straight Vegetable Oil	1	
1G Ethanol, 2G Ethanol	2	
Biodiesel & HVO	3	

With these simple steps, the target area is determined. The Target area are those municipalities that intersect with the BPS polygon and BPP location. The webGIS Tool is capable of retrieving attributes of the Target Area, BPS, suitable crop, precipitation, as well as BPP and populates a value chain data box which lists all raw data used by the system to assess the values of each of the sustainability indicators considered.

The STEN Services calculate the CORE Indicators from the data in the value chain data box. Advanced users can calculate the Advanced Indicators and edit the data entry of the value chain data sent to STEN Engine. **Fehler! Verweisquelle konnte nicht gefunden werden.** lists the set of indicators integrated in the operational webGIS.

Table 2 - List of BIOPLAT-EU CORE and Advanced sustainability indicators

BIOPLAT-EU sustainability indicators	
CORE indicators	Advanced Indicators
Air Quality	Income
Water Use and Efficiency	Energy Access
Land Use and Cover Change	
Employment in Bioenergy Sector	
Net Energy Balance	
Gross Value Added	
Infrastructure	
Capacity	

Note: The sustainability indicators have changes compared to those defined in chapter 1 of Deliverable 3.5 (Prototype BIOPLAT-EU webGIS Tool: beta version).

The operational webGIS Tool fulfills the following goals:

- It provides functionalities to visualize the base layers and map services
 - Contaminated Lands¹ (20 countries affected)
 - Underutilized lands² (26 countries affected)
 - BIOENERGY PROCESSING PLANTS (3205 Processing plants)
 - Administrative Limits
 - Countries (GADM data Level 1 - NUTS-1³)

¹ Please note that this map is the result of the application of EU thresholds for heavy metals in soils produced by JRC and available [here](#). BIOPLAT-EU has no authority on the production of such data nor on the actual presence of said levels of pollutants in any given specific area on the map. More information on the procedure for the creation of this map is available under chapter 2.2 (Contaminated Land Mapping) of Deliverable 2.3 (Report on Tier-1 Map) available at [this link](#).

² The layer of Underutilized lands in Europe and Ukraine was produced specifically in the context of BIOPLAT-EU and used an ad-hoc methodology. All details on the methodology are available under chapter 2.3 (Underutilized Land Mapping) of Deliverable 2.3 (Report on Tier-1 Map) available at [this link](#).

³ NUTS is a geocode standard for referencing the subdivisions of countries for statistical purposes. For each EU member country, a hierarchy of three NUTS levels is established by Eurostat in agreement with each member state; the subdivisions in some levels do not necessarily correspond to administrative divisions within the country.

- Groups of regions (GADM data Level 2 - NUTS-2)
- Regions (GADM data Level 3 - NUTS-3)
- Municipalities (Target Area Base Layer)
- Suitability Crops
 - GAEZ suitability crop layer
 - GAEZ yield crop layer
- Consulting and filtering of the main layers of information.
- Data model about the webGIS Tool and STEN Engine for all indicators.
- WebGIS + STEN data flow input form to obtain the value chain data box of a target area.
- STEN Engine computing services for all CORE & ADVANCED indicators.
- WebGIS + STEN data flow input form to obtain the value chain data box of a target area.
Forms for editing values of the value chain and output of indicator results in web and pdf format.

The Web services are operational and the workflow between webGIS Tool + STEN + WebServices are operational for all sustainability indicators defined by FAO.

The different parts of the construction of the operational webGIS tool are detailed in each of the two architecture blocks.

2.1 Interface

The webGIS Tool interface, shown in Figure 3, is part of the frontend. It is a Web application in charge of interacting with the backend services developed in Angular, a framework based on JavaScript + HTML + CSS. This serves as a tool for the analysis and visualization of Project data on a map viewer. The interface connects the STEN tool and displays the outputs of indicator variables in the evaluation of biomass production in MUC areas.

The interface of the operational webGIS Tool is divided into three blocks: webGIS, Authentication area and Web Manager. The main elements of the webGIS block have been kept as specified in Deliverable 3.5.

- Map Viewer: Full-screen map viewer located in the central area of the interface, which allows you to view all the spatial information.
- Main Tools – Management Layer & STEN: Left panel distributed in two tools that allows the management of layers and access to the STEN tool. In addition, the user can access the sign in and sign up.
 - The "Layers" tab contains the main tools, layer manager and base layer. From this tab the user can manage the spatial information of suitability crops, Contaminated lands, Underutilized lands, BPP, Administrative limits and base layers.
 - The STEN tab allows two actions: select the work area and interact with the user data box to define the target area for the calculation of the indicators.
- Map Tools: On the right side of the webGIS are the tools for interacting with the map:
 - Geographical location search engine based on the Google maps.
 - Information Tool - Allows you to view layer attributes at a location. The results are shown in the side panel for those active (check "i") and visible layers. Also from this tool you can select the working MUC.
 - Active and visible layer legend panel
 - STEN summary: Summary panel of STEN Highlights.

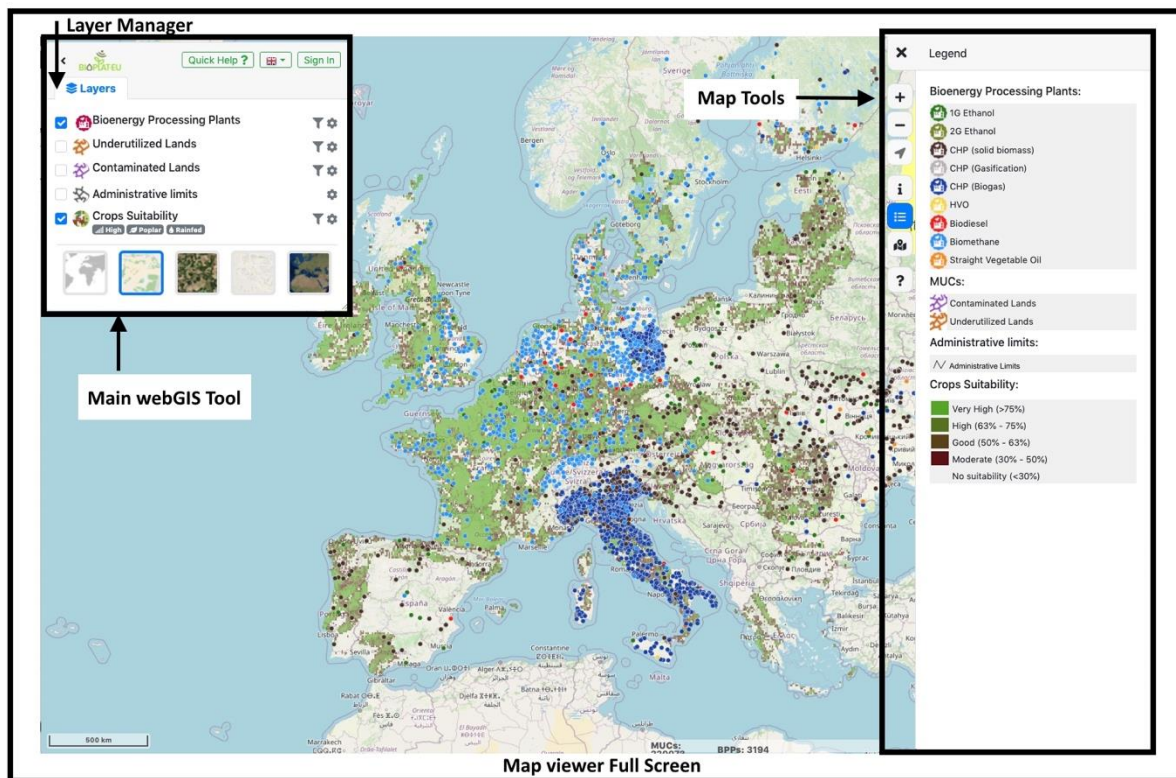


Figure 3 - Operational webGIS Tool interface

The distribution of the main blocks has been maintained with respect to deliverable D3.5. A first feedback was obtained in the mockup and it has been improved with the prototype until reaching the operational webGIS tool interface, which has allowed combining the functionality of a GIS with the STEN simulation tools.

In the operational webGIS Tool, some aspects have been improved such as the centralized panel for consulting information regarding the prototype and the simplification of elements in the STEN tab in order to improve user interaction. The visualization on the map using clustering has been discarded for the operational webGIS Tool.

Multi-language:

A relevant aspect is the internationalization and localization capacity of the webGIS tool. It is translated in different languages and regions without the need for code or engineering changes. This not only leads to translating a language, but also to consider the regional configuration (date format, measurements, time and currency).

The tool and the components use standard internationalization libraries (i18n) ⁴, which allows in a simple way, from a translation base file, to add new languages to the system compatible with i18n. Currently the application is available for the languages of the partners involved in the project (German, Austrian, Belgian, Dutch, Spanish, Finnish, Hungarian, Italian, Romanian and Ukrainian), being able to incorporate more in the future. A first version of the translation

⁴@ngx-translate/core: The internationalization (i18n) library for Angular.

has been carried out automatically for the aforementioned languages and we are working with the BIOPLAT-EU partners to review the translation strings to improve the user experience.

Map Viewer

The map viewer development uses the open source “Openlayer”⁵ library. This allows the visualization of vector and raster layers, both from own layers and from external sources in multiple projections following the Open Geospatial Consortium (OGC) standards.

The most outstanding aspect in the construction of the map viewer was the implementation of new layer structures for data management, as it already was proposed in D3.5. The management of groups of layers for crop suitability, routing layer for distance calculation allowing different waypoints, data structures for managing multiple layers at different scales, representation of vector elements at European level for MUC layer and BPP. This functionality allows represent different behaviors of spatial information at different scales, being an internally complex system but easy to handle for the user. The MUCs and / or BPP layers use these data structures for their representation.

One of the main bottlenecks of the project from the beginning has been not knowing exactly the indicators data model and the final volume of layers information. The tasks of gathering and crafting information in layers is complex and it have been finally completed between the months M24 - M29. To solve the problem of a representation on the map of a large number of polygons, different strategies and data structures between client and server already were developed in the prototype. This functionality has been improved and incorporated into the operational model.

The webGIS Tool prototype proved to be useful for making strategy management decisions in the representation of data and in achieving a better user experience in the operational webGIS. During the construction of the prototype, different strategies were implemented that can be combined in the representation of data in the viewer at different zoom levels. The operational webGIS Tool discarded the clustering strategy in the representation of the BPP and MUCs layers. The main reasons for not using clustering for visualizing were (a) the MUC layer has been divided into two layers (contaminated and underutilized), what causes overlapping on the balloons, and (b) the visualization of raw MUC lands at large scales is very intuitive in the map navigation for the user. In the case of the BPP layer, a WMS (Web Map Service) visualization system has also been chosen where the user can apply filters by BPP type. In this way, the main data layers apply the same operating strategy, homogenizing the behavior of the layers for the user. Annex D details the strategies supported by the map viewer core.

Finally, the used strategy consists of a large-scale representation of the Web Map Tile Services (WMTS) format of the MUCs and BPPs points, for representing the data in vector format on a municipal scale. This strategy allows to visualize the real zones since the beginning and the interaction with vector elements at municipality scales, improving the user experience, as shown in Figure 4.

⁵ Openlayers: <https://openlayers.org>. OpenLayers has been developed to further the use of geographic information of all kinds

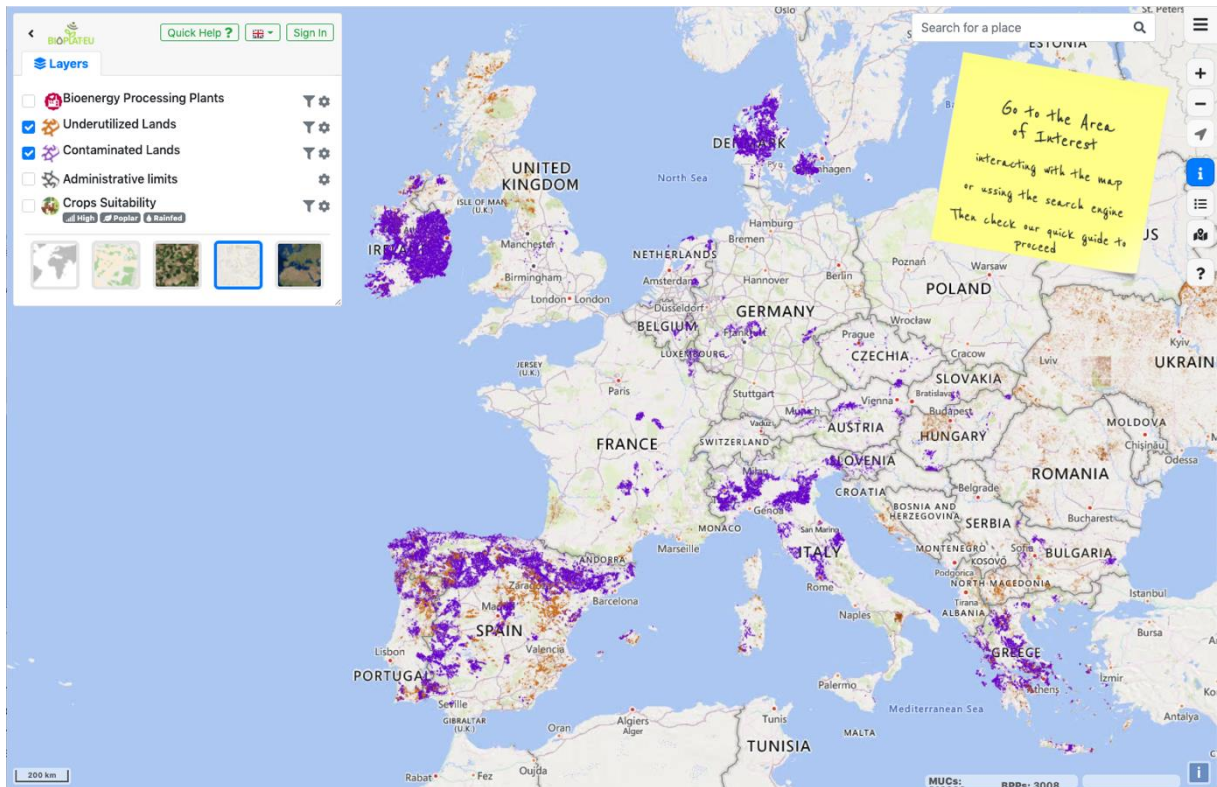


Figure 4 - Map viewer with Contaminated & Underutilized lands visualization in WMTS form

To guarantee the representation of geometries in the webGIS at the municipal level, a quality control of the cartography has been carried out and the number of vertices per polygon has been reduced to a maximum of 5000 vertices. The quality of the geometry and size improves the user experience when loading and handling it in the editing tool.

A key feature in the viewer is the point and polygon drawing tool for editing a BPS as a piece of a whole MUC area. In the case of editing MUCs, it allows drawing the BPS and its limitation within a MUC area. The editing tool allows you to freely draw a polygon on the map. The drawing tool adjusts the limits of the polygon drawn to the MUC through polygon intersection, ensuring that the BPS polygon is within the MUC.



Figure 5 - Example of editing polygons on the map

Beside to delimiting a BPS as a piece of a whole MUC, the drawing tool allows moving and editing processing plants in the route calculation, allowing for example to establish a Biomass Crushing Plant and distribution if the bioenergy pathway requires it. Figure 5 and Figure 6 show this functionality.

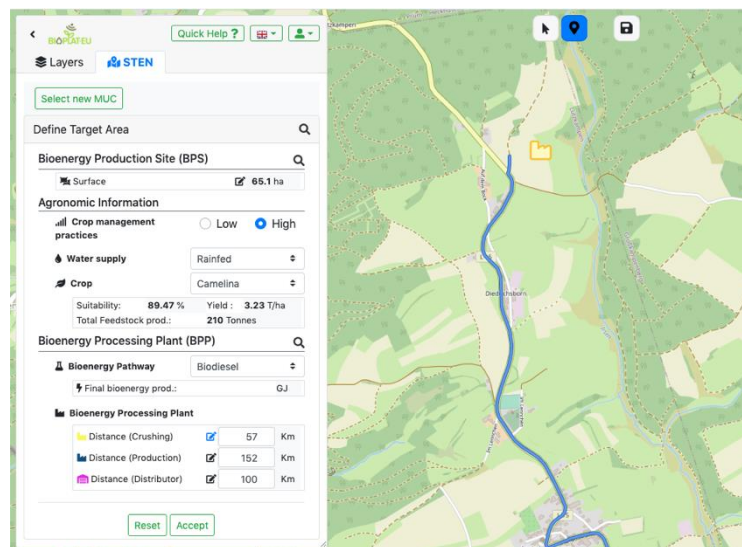


Figure 6 - Example of the editing tool to define a CRUSHING plant in the production of biodiesel

Map Tools

On the right side of the webGIs there are the tools for interaction with the map, such as: zoom, query tool for punctual information, and for selecting the MUC area for starting the process, etc. In this section, there is an information panel of the interaction tools, from which the user can view the legend of layers, the summary of the user input data in STEN, help guide, etc.

Query tool functionality

The operational webGIS Tool allows queries at multiple layers and at any map scale. The tool fixes a pushpin at the point of the queried map, showing results in the right part of the screen, as shown in Figure 7, in which the selected point intersects with an Underutilized Land and Contaminated Land.

It allows the selection of the desired MUC to initiate the input data flow to the STEN, by clicking on the SELECT button.

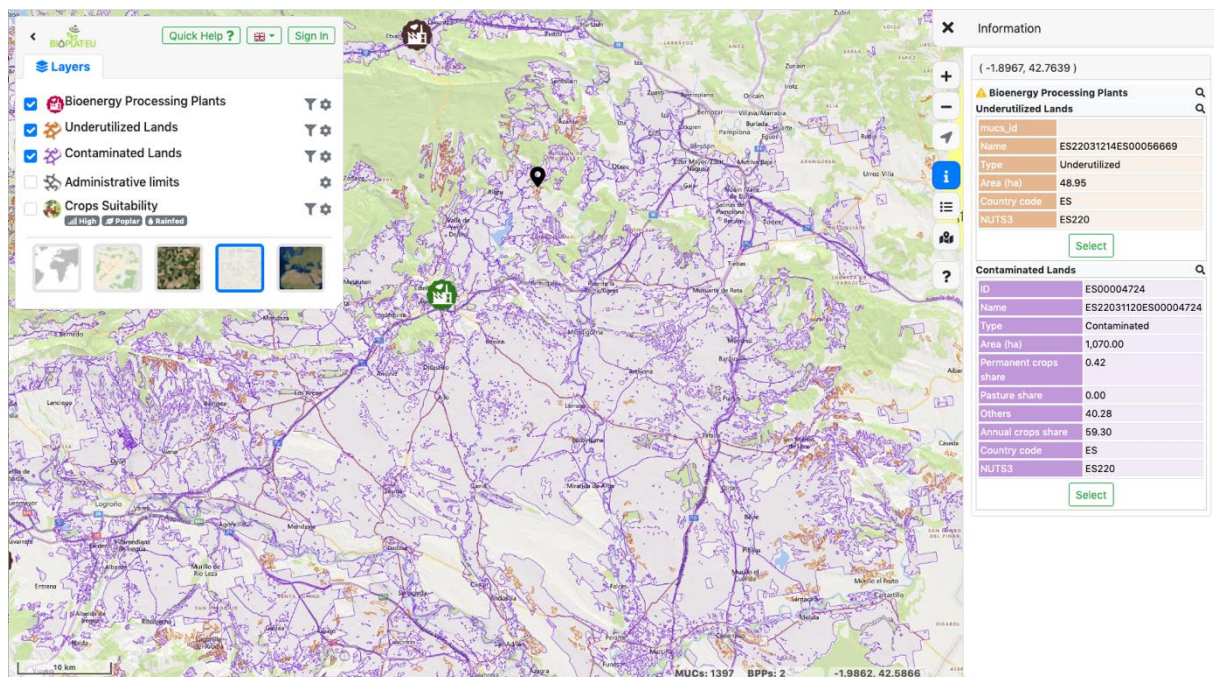


Figure 7 - Map view using the information tool for the layers: BPP, Underutilized and Contaminated lands

Main webGIS Tools

Management Layer:

The layer manager is located on the left side of the webGIS screen; the user can manage the layer settings from here. The available layers in the webGIS Tool are:

- Biomass Processing Plants: Represents raw material processing plants (BPPs), industrial companies transforming raw materials to a bioenergy pathway. It incorporates filtering functionality by type of bioenergy pathway to locate different BPPs
- Contaminated Lands: It represents contaminated land. More information on the procedure for the creation of this map is available under chapter 2.2 (Contaminated Land Mapping) of Deliverable 2.3 (Report on Tier-1 Map)
- Underutilized lands: It represents underutilized lands. All details on the methodology are available under chapter 2.3 (Underutilized Land Mapping) of Deliverable 2.3 (Report on Tier-1 Map)
- Administrative limits: It is a layer composed of countries, groups of regions, regions, municipalities. This set of layers facilitates geographic reference. This layer is displayed on the map according to the utilized zoom level. It is used to define the target area and it provides the statistical data to STEN from the target area base layer.
- Crop Suitability: The crop suitability layer is a set of hundreds of layers from the GAEZ model in a single layer. The layer manages yield and suitability of the soil according to a set of parameters. The layer shows the suitability of the crop worldwide for a certain type of soil under certain water supply and agronomic input level.

The layer manager allows cloning layers, applying different filters to each layer. This helps to compare the suitability in areas, having a powerful analysis tool.

- Base Layers: Base layers are the open street map layer, the bing layer, and the sentinel2 2020 RGB mosaic. The user can select among these the one to display, according to his interest.

All layers have a set of basic functionalities: enable or disable layer, transparency, ordering, information query, filter by layer attributes, layer cloning, layer metadata in INSPIRE format and downloadable, as shown in Figure 8.

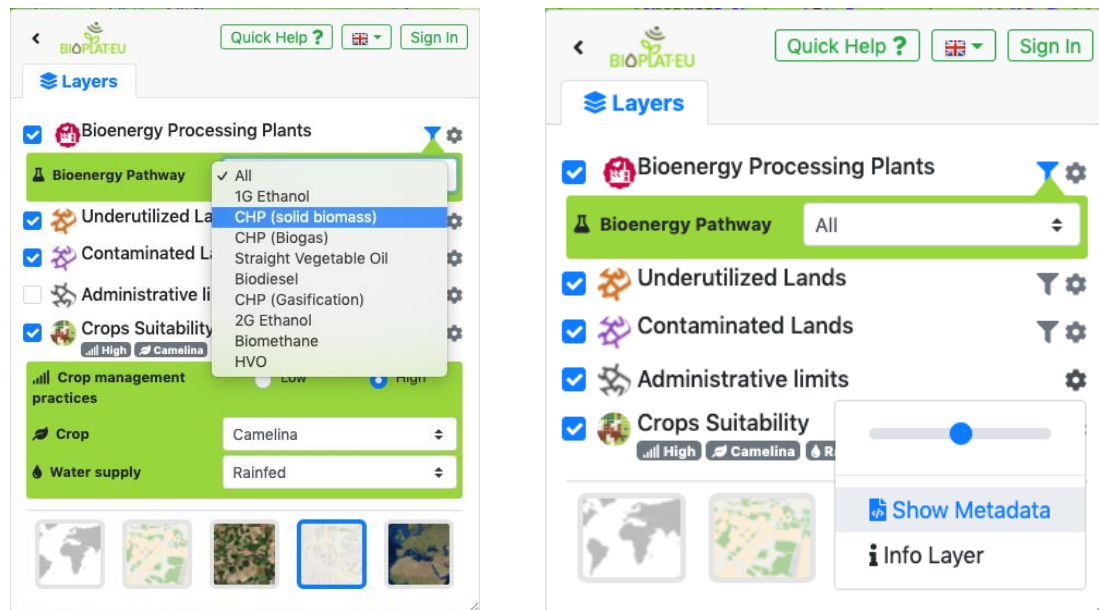


Figure 8 - Layer functionalities and access to information applying filters

STEN Tool

The STEN tool is in charge of evaluating, via the sustainability indicators, the viability of non-food biomass production on marginal, underutilised and contaminated lands for bioenergy purposes in the defined target area. The potential of webGIS + STEN lies in the combination of both tools, allowing visual display of information about the area of interest to evaluate the different options.

The STEN tab in the webGIS establishes data flow with the STEN Tool. The tool is designed to facilitate the definition of the target study area through a set of steps.

The first step is to activate the layer information tool that allows the user to consult the map elements. The information panel shows the information at one point (coordinates) for all visible layers. From this section the user can select the MUC of interest to start the STEN Tool.

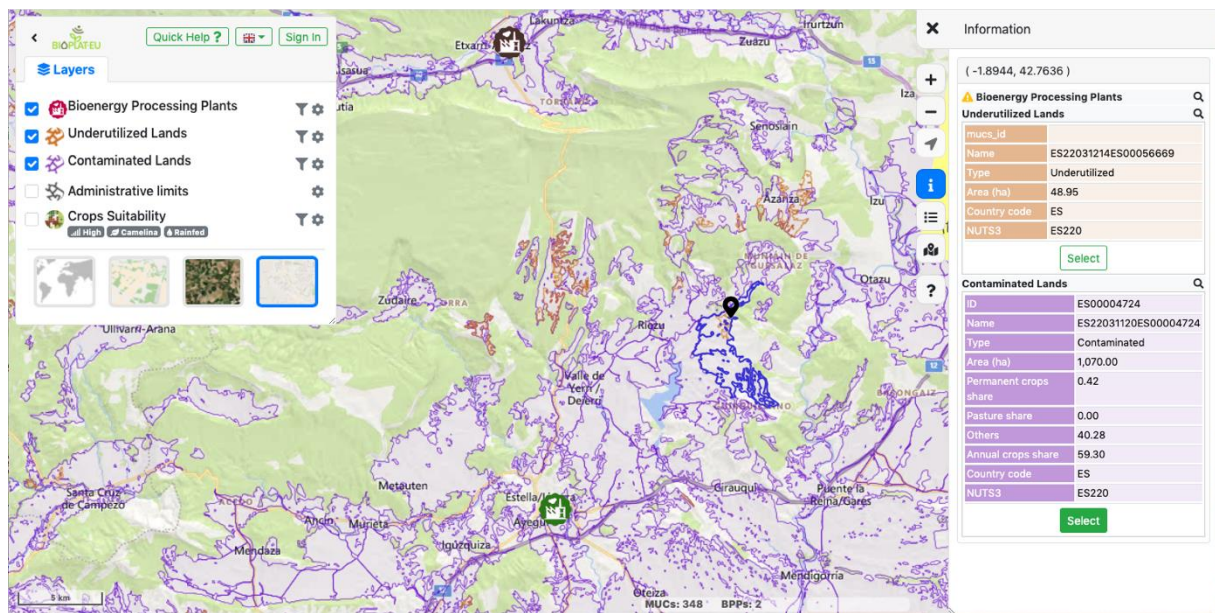


Figure 9 - MUC selection tool to start STEN Tool

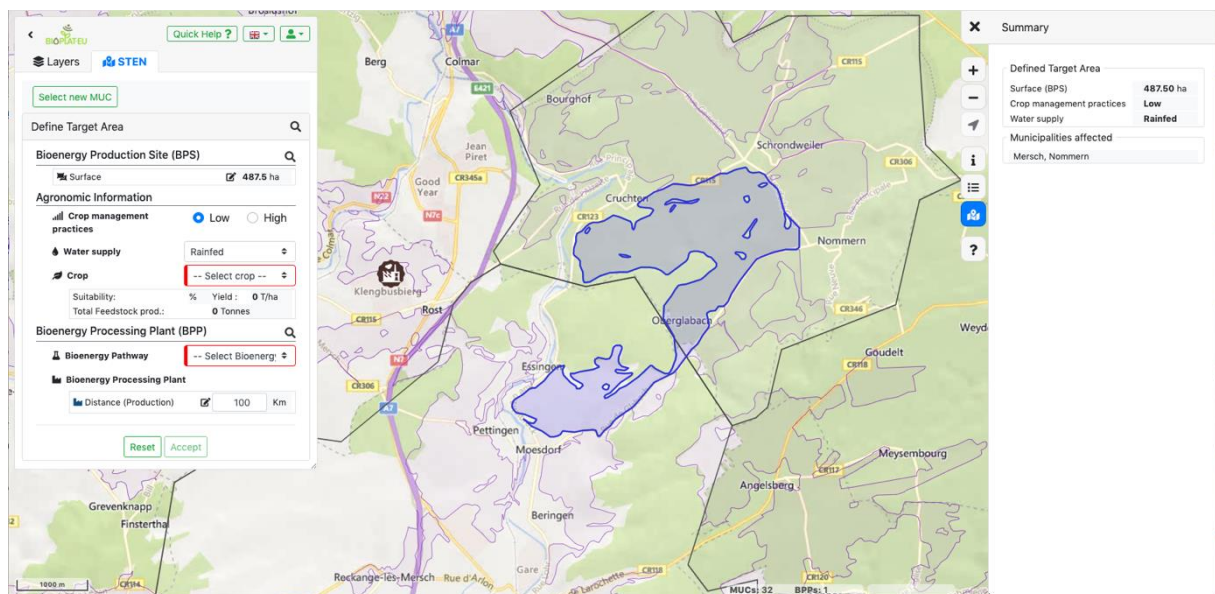


Figure 10 - STEN target area definition panel - STEN form to input data flow

The second step is to establish the BPS. By default, the BPS size is the entire MUC. The user can customize the area by enabling the surface editing tool to draw the area of his choice.

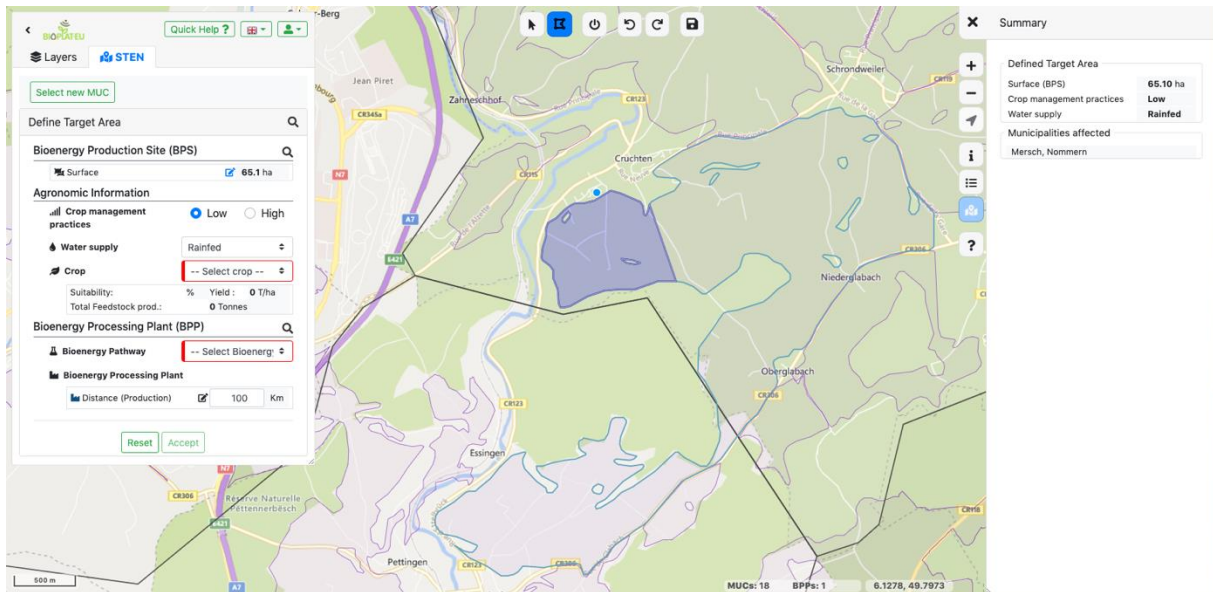


Figure 11 - Polygon editing tool to define the BPS freehand

Note: The STEN tool is linked to the layer view, allowing the crop selection criteria and / or bioenergy pathway to be viewed on the map from the STEN form.

The webGIS tool requires to select the crop, bioenergy pathway and processing plant data compatible with soil suitability from agronomic management level (Low or High) and water supply (Rainfed or Irrigated). The webGIS calculates “on the fly” the yield and the percentage of yield of a selected crop in the selected BPS according to the GAEZ model. The freedom of drawing a BPS by hand prevents to have pre-calculated data on yield and suitability of crops associated with MUCs. The calculation is carried out through a raster-vector algebraic operation (GAEZ vs BPS polygon). A zonal statistics process (Python script) applies to obtain crop suitability and yield for the BPS polygon, as shown in Figure 12. The response to these operations is a list of agronomic information on crops which suitability for the BPS polygon is greater than 30%.

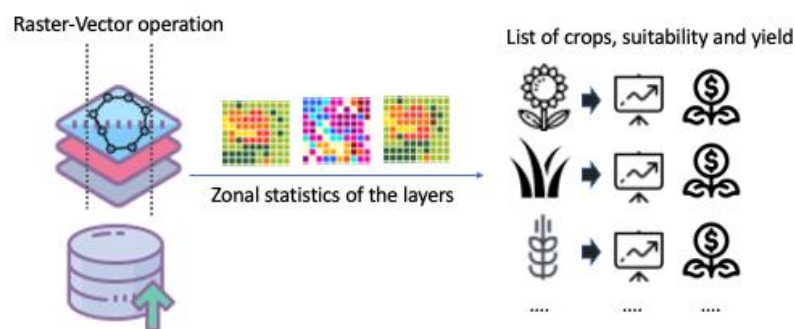


Figure 12 - Diagram of the analysis of crops in an area based on the suitability crop and yield

The suitability crops layer is a set of hundreds of GAEZ layers and other external sources, which are necessary to extract a statistical analysis of the affected pixels in a vector delimited area. This operation is key in the project, as it obtains the crop suitability and yield on the BPS. The

system makes it possible to extract information from a collection of images with multiple projections and resolutions and harmonize it through data extraction flows. The information returns in an array of value structures for each image. **Fehler! Verweisquelle konnte nicht gefunden werden.** shows the list of crops which suitability and yield layers are uploaded on the system.


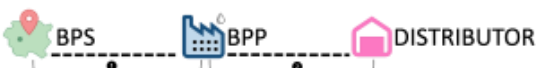

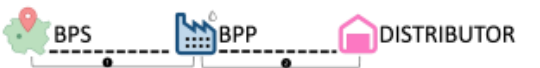



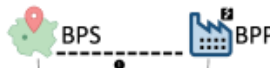



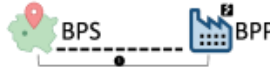

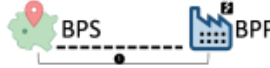




Table 3 - Crops available in webGIS Tool according to agronomic conditions.

Crops:	Input Level: LOW	Input Level: HIGH
Black locust	Rainfed	Rainfed
Camelina	Rainfed	Rainfed
Eucalyptus	Rainfed	Rainfed
Giant reed	Rainfed	IRRIGATED
Maize	Rainfed	IRRIGATED
Miscanthus	Rainfed	Rainfed
Poplar	Rainfed	Rainfed
Rapeseed	Rainfed	Rainfed
Sorghum	Rainfed	Rainfed
Soybean	Rainfed	IRRIGATED
Sugar beet	Rainfed	IRRIGATED
Sunflower	Rainfed	Rainfed
Switchgrass	Rainfed	Rainfed
Wheat	Rainfed	Rainfed
Straw	Rainfed	Rainfed
Willow	Rainfed	Rainfed

The choice of the type of bioenergy pathway, and so the corresponding BPP, requires compatibility criteria with the crop. When the user selects a BPP type, the webGIS automatically calculates the route from the center of the BPS to the closest BPP. The selection of the bioenergy pathway can be made after or before the crop, the decision of which will affect the selection of the crop and vice versa.

Routing service calculates distance from the raw material to the final distributor in different transport sections according to the bioenergy pathway, as shown in Table 4.

Table 4 - Calculation of Transport feedstock, SVO and/or distribution according to bioenergy pathway

	Bioenergy Pathways	Technology generation	Transport sections
	1G Ethanol	I° generation	
	2G Ethanol	II° generation	
	CHP (solid biomass)	I° generation	
	CHP (Biogas)	I° generation	
	CHP (Gasification)	I° generation	
	Biomethane	II° generation	
	Straight Vegetable Oil	I° generation	
	Biodiesel	I° generation	
	HVO	II° generation	

Description of transport according to the bioenergy pathway:

- E.g. CHP (biomass): the distance calculation is estimated in a single section (BSP to BPP). The BPP is in charge of carrying out the complete process of transformation of biomass to electricity and distribution (electricity poured into the electricity grid).
- E.g. 2G Ethanol: there are two sections in the transport, a first section from the BPS to the BPP to obtain the ethanol, and a second section from the BPP to the distributor.
- E.g. Biodiesel or HVO: the system calculates three sections. A first section from BPS to the oil crushing plant where crude oil is produced. A second section where the oil is transported to the refinery (BPP) and a third section to the distributor.

The system automatically establishes the closest route to the plant by the bioenergy pathway type, according to the roads available on the open street map layer. Users can edit these distances either numerically or through the map, by clicking on the map with the editing tool. For those points that cannot be established geographically, the webGIS establishes 100km by default (can be modified by the user) between each point of the route, as shown in Figure 13.

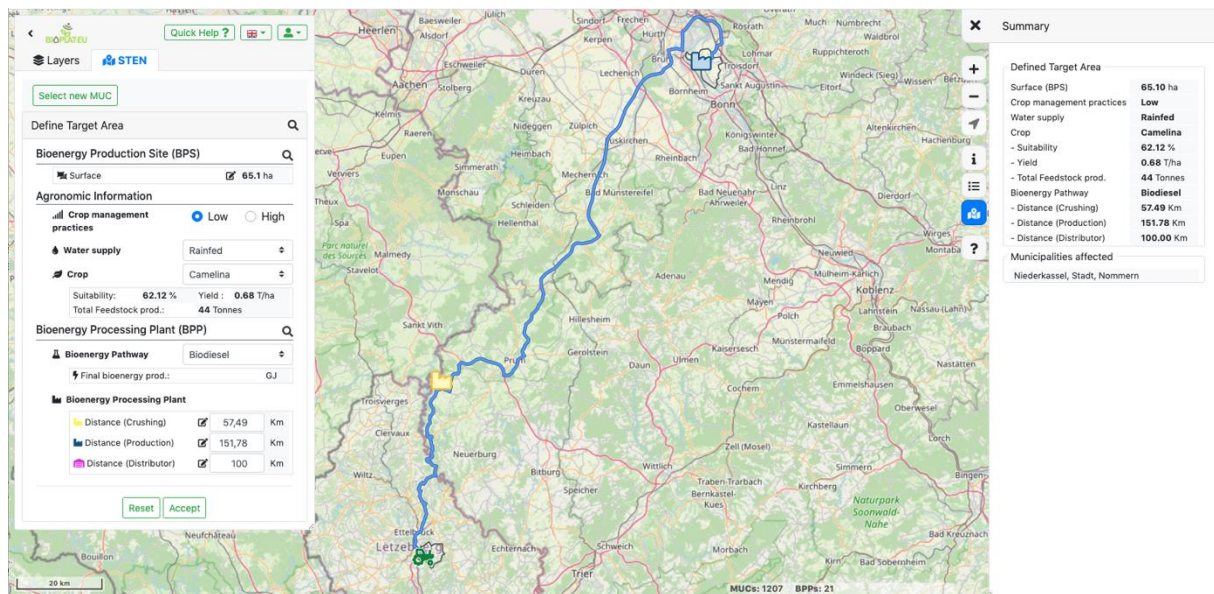


Figure 13 - View of the map of affected municipalities and transport route from feedstock.

Once the set of basic data box parameters have been defined for the target area, the value chain of the evaluation indicators of the three pillars of sustainable development (environmental, social and economic) defined in STEN Engine can be calculated.

The information of the value chain databox extracted from the data model and the basic layers of the webGIS is displayed in a full screen window, as shown in Figure 14. Furthermore, this window shows the affected municipalities, associated zone data and an image of the target area map. The variables of the value chain can be edited by advanced users (registered users), to customize the data offered.

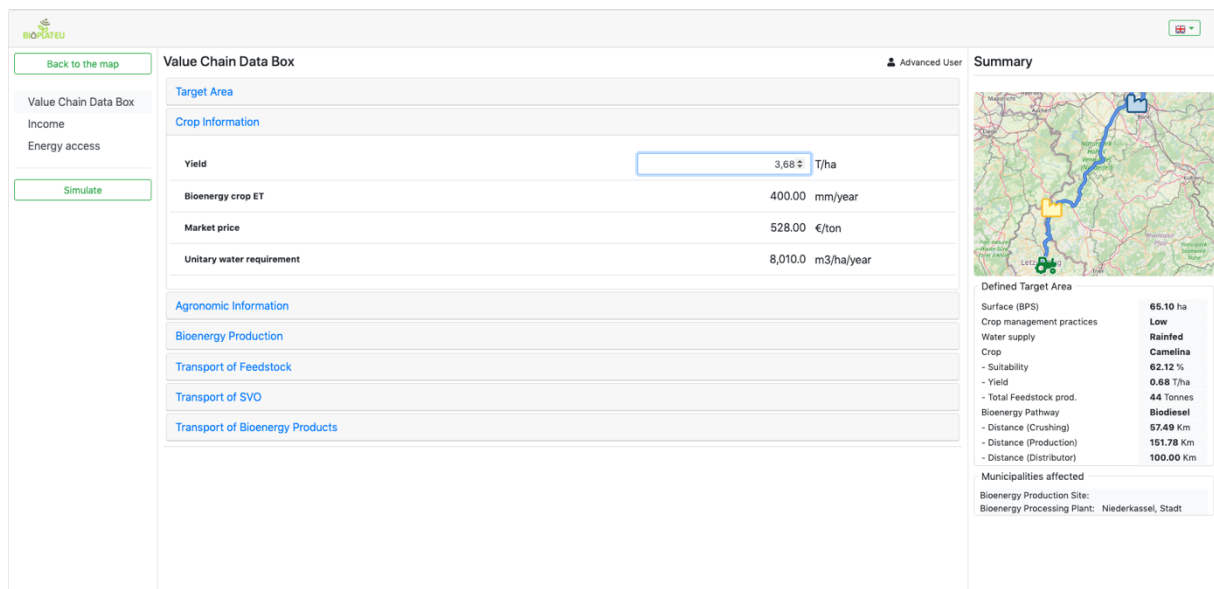


Figure 14 - Value chain data box for a target area

The next step is to send the parameters to the simulator. The webGIS Tool retrieves all the information from the value chain databox and sends it to the STEN Engine Web services to compute the indicators. The system displays a window with the results of the indicators

grouped in CORE & ADVANCE indicators in the style of the STEN Excel tool. In the "Outputs" section you can find more detailed information.

Authentication Area

The authentication area allows users to register or login into the webGIS Tool. This web area is accessible from the top left of the viewer, in the "sign in" button.

- Sign in: Login form to the webGIS Tool
- Sign up: User registration in the webGIS Tool
- Recovery Password: Forgotten credentials recovery service

Registered users have advanced options in the webGIS Tool, where they can edit the value chain data box and obtain advanced analysis indicators.

Web Manager

It is the management interface of the data model defined for BIOPLAT-EU. The web manager has been set up using "Parse Dashboard". It is a standalone dashboard for managing Parse Server apps. This option has been selected for handling the tool, since it allows managing the basic user data and the data model, as shown in Figure 15. This part is exclusively accessible by the system administrator.

PARSE DASHBOARD 2.1.0

ADMIN

Parse BIOPLAT-EU - my...

Core

Browser

Create a class

Role

3

Session

32

User

4

BioCrops

17

BioGlobalReferences

4

BioIndicator

11

BioPathways

9

DataSource

10

EnvironmentMap

2

Group

1

LayerStyleDomain

3

MediaFile

1

UserProfile

3

Webhooks

Jobs

Logs

Config

API Console

Push

Open Source Hub

GitHub

Docs

...

CLASS

BioCrops 17 objects

Add Row

Manage Columns

Refresh

Filter

Security

Edit

<input type="checkbox"/>	objectId	String	enable	waterByInputLevel	ACL	ACL	uri	String	updatedAt	Date	crop	String	valueChain	Obj
<input type="checkbox"/>	FTMV0gzvup		False	{"low": "a", "high": "b"}	Public Read + Wri...	Public Read + Wri...	bioplat:biocrops:...	24 Apr 2021 at 14...	willow				{"cropInfo": "a"}	
<input type="checkbox"/>	s18AYdrrM9		False	{"low": "a", "high": "b"}	Public Read + Wri...	Public Read + Wri...	bioplat:biocrops:...	24 Apr 2021 at 14...	straw				{"cropInfo": "a"}	
<input type="checkbox"/>	zBY97DXJGJ		True	{"low": "a", "high": "b"}	Public Read + Wri...	Public Read + Wri...	bioplat:biocrops:...	24 Apr 2021 at 14...	wheat				{"cropInfo": "a"}	
<input type="checkbox"/>	n0W7m6NFBQ		True	{"low": "a", "high": "b"}	Public Read + Wri...	Public Read + Wri...	bioplat:biocrops:...	24 Apr 2021 at 14...	switchgrass				{"cropInfo": "a"}	
<input type="checkbox"/>	4HLcN82x7F		True	{"low": "a", "high": "b"}	Public Read + Wri...	Public Read + Wri...	bioplat:biocrops:...	24 Apr 2021 at 14...	sunflower				{"cropInfo": "a"}	
<input type="checkbox"/>	dGVUXC1DQ		True	{"low": "a", "high": "b"}	Public Read + Wri...	Public Read + Wri...	bioplat:biocrops:...	24 Apr 2021 at 14...	sugarBeet				{"cropInfo": "a"}	
<input type="checkbox"/>	MX1LavW5NH		True	{"low": "a", "high": "b"}	Public Read + Wri...	Public Read + Wri...	bioplat:biocrops:...	24 Apr 2021 at 14...	soybean				{"cropInfo": "a"}	
<input type="checkbox"/>	nTMog50XVG		True	{"low": "a", "high": "b"}	Public Read + Wri...	Public Read + Wri...	bioplat:biocrops:...	24 Apr 2021 at 14...	sorghum				{"cropInfo": "a"}	
<input type="checkbox"/>	00t9HBFDG		False	{"low": "a", "high": "b"}	Public Read + Wri...	Public Read + Wri...	bioplat:biocrops:...	24 Apr 2021 at 14...	smilgrass				{"cropInfo": "a"}	
<input type="checkbox"/>	FBLAv8JYz5		True	{"low": "a", "high": "b"}	Public Read + Wri...	Public Read + Wri...	bioplat:biocrops:...	24 Apr 2021 at 14...	rapeseed				{"cropInfo": "a"}	
<input type="checkbox"/>	v5ZcbKBW2		False	{"low": "a", "high": "b"}	Public Read + Wri...	Public Read + Wri...	bioplat:biocrops:...	24 Apr 2021 at 14...	poplar				{"cropInfo": "a"}	
<input type="checkbox"/>	HoEwRUGsRj		True	{"low": "a", "high": "b"}	Public Read + Wri...	Public Read + Wri...	bioplat:biocrops:...	24 Apr 2021 at 14...	miscanthus				{"cropInfo": "a"}	
<input type="checkbox"/>	JVZao5ogcz		True	{"low": "a", "high": "b"}	Public Read + Wri...	Public Read + Wri...	bioplat:biocrops:...	24 Apr 2021 at 14...	maize				{"cropInfo": "a"}	
<input type="checkbox"/>	vAVfj8GU09		False	{"low": "a", "high": "b"}	Public Read + Wri...	Public Read + Wri...	bioplat:biocrops:...	24 Apr 2021 at 14...	giantReed				{"cropInfo": "a"}	
<input type="checkbox"/>	GeBelZ0kZo		False	{"low": "a", "high": "b"}	Public Read + Wri...	Public Read + Wri...	bioplat:biocrops:...	24 Apr 2021 at 14...	eucalyptus				{"cropInfo": "a"}	
<input type="checkbox"/>	EVxenQ8SKC		False	{"low": "a", "high": "b"}	Public Read + Wri...	Public Read + Wri...	bioplat:biocrops:...	24 Apr 2021 at 14...	camelina				{"cropInfo": "a"}	
<input type="checkbox"/>	pb4JnyCa0D		False	{"low": "a", "high": "b"}	Public Read + Wri...	Public Read + Wri...	bioplat:biocrops:...	24 Apr 2021 at 14...	blackLocust				{"cropInfo": "a"}	

Figure 15 - System admin dashboard view

2.2 STEN Engine:

The STEN Engine is the computing core of the webGIS tool for social, economic and environmental indicators.

Translating the STEN tool from the Excel file developed by FAO in a computing language that is able to be accessed via a web required creating a compiler of a language similar to that employed in spreadsheets like Excel. The procedure has enough flexibility to adapt to the changes on the spreadsheet, which has actually happened several times. Therefore, a new language named SheetScript was made up along with its corresponding interpreter/compiler. In deliverable 3.5 prototype BIOPLAT-EU webGIS Tool, appendix B its grammar, lexemes it uses, etc. is defined in detail.

This way, as the STEN Engine turns out to be based on a computing language processor, the model that defines the indicators becomes the source code to process, and likewise user inputs become a sort of constants available at a compiling time. This is so because user inputs can't change once the user starts a simulation, which now is in a sense, a compilation.

It should be noted that if the indicators model change in the future, it would be necessary to modify just the source code, i.e., a list of formulas written in SheetScript, but not so the engine itself, which can remain unaltered; this means its satisfactory validation also remain unaltered.

Currently, all indicators of STEN Tool version "STEN Tool_Final_may.xlsx" have been implemented. This version supports 8 "core" indicators and 2 advanced ones. The STEN Engine works as its own autonomous web service, but it is integrated into the BIOPLAT-EU backend. BIOPLAT-EU's Web services act as a wrapper to feed data to the calculation engine from data extracted from the system and user data.

2.3 Web Services:

Web services are the public part of the backend. It's the endpoint that connects with the logic and functionality of the system. The system web services are based on Parse Server, which is an open-source Backend-as-a-Service (BaaS) framework.

Parse Server is designed for the development of applications in general. To satisfy the functional requirements of BIOPLAT-EU, we have worked on the line defined in D3.5 based on the set of REST services distributed in three main blocks. In annex [C] the routes to the main available services are detailed.

- **API Services:** Developed on Parse Server to manage the main services of the webGIS Tool. Four important subgroups are managed from this API:
 - Authentication, Session, Users and Groups
 - Metadata of environments, layers and schemas of spatial models
 - DataModel: bioenergy pathways, crops

- STEN value chain data (Agronomical information, crop information, biomass production, transport, climatic information.....).
- **STEN Services:** the services in charge of interacting are:
 - STEN Engine simulator
 - The calculation of value chain data (Agronomic information, indicators, crops...)
 - Crop suitability and yield in area
 - Target area calculation service.
- **Map Services:** They are the services in charge of connecting with the spatial model of the system and the map server offering raster and vector layers.

Parse Server is oriented to the development of standard applications. As it does not have advanced spatial data processing, additional services have been designed for spatial and processing of STEN requirements.

Map Services are in charge of serving raster and vector maps of the main base layers.

Raster: WMTS services for suitability-crops, MUCs, precipitation, countries, regions, provinces and municipalities layers.

Vectorial: GeoJSON and Vector Tile (VT) output formats. Vector tiles (VT) are designed and focused mainly on visualization. It is not a Shapefile, GeoJSON, etc. style vector data format designed to work (do analysis, data exploitation, etc.).

The map service has been designed using different techniques for handling large amounts of vector data, in order to provide a European-scale response for the representation of millions of polygon points in the map viewer. For this, three types of services are available:

- Vector tiles on the fly from the geodatabase without pre-calculated tiles. The service allows filtering the layer data and returning it in VT format, in order to represent large amounts of data in a webGIS.
- Clustering: offering groupings of points based on three geographic levels; country, region and real points.
- GeoJSON format based on the bounding box strategy, simplifying geometries based on the number of vertex points of the polygon. This service has a maximum limit of 5000 points per polygon, simplifying in flight time those geometries that exceed that threshold using SimplifyPreserveTopology with a tolerance of 0.01. This ensures smooth operation in the map viewer, especially when rendering large and complex geometries.

The number of points is key in the map viewer, a simplification of features of the layer guarantee the functioning of the webGIS in complex polygons

2.4 Data Model:

The database model determines the logical structure of a database and, fundamentally, how to store, organize, and manipulate data.

Data is an essential part of GIS, without them, GIS applications and others element found in the environment are useless. The data model has not undergone major changes compared to the one proposed in the D3.5 prototype. The handling of a large volume of vector data of the areas and the hundreds of calculation variables for the set of indicators, already posed a challenge in the design and implementation of the webGIS Tool. A data model capable of optimally storing and retrieving that information is required. The problem of representing a large number of elements in a vector form on a Web viewer has been added. A large amount of data to be used by the user and for the management of the system is complex to manage.

Analyzing the data model of the operational BIOPLAT-EU webGIS Tool from a high-level point of view, encompasses three large data sets.

- A set of spatial data composed of basic layers such as MUCs, Base layer of the target area (TABL), suitable crops and BPP, Administrative limits, BaseMap, Routing Service Layer, yield crops, precipitation and water deficit.
- The STEN Tool data set and reference tables. It is a combination of the GIS layers with associated system data for the extraction of the value chain data box. The data in reference tables belong to a multitude of information variables with data related to crop bioenergetics, feedstock, agricultural inputs, water, emission, employment, biomass production plants...
- Set of data related to the management of the webGIS. This model is in charge of managing the information of Users, Sessions, Roles, Schemas of the GIS and STEN model, metadata of layers, Crops, Indicators, Bioenergy pathways, etc.

The data model bottleneck was overcome in D3.5 by proposing a two-tier data model. The two-level design will be detailed later, allowing great flexibility in the data model. This design aspect, together with the stability in the reference tables raised in STEN Tool during the webGIS prototype phase, have helped to finalize the model.

This has required adapting the GAEZ model, the definition of associated data indicators from STEN Tools, the mapping of TIER 1 and TIER 2 layers that make up the MUCs layer and the statistical data associated with the Target Area Base Layer (TABL). It has been a complex task.

The design of the model has made it possible to incorporate the latest STEN modifications to the model, as well as to add a new layer of water deficit for irrigated crops.

These difficulties have been overcome and a data model has been developed that combines this information with the goal of satisfying the information storage and retrieval of the three large data sets through an architecture capable of storing different data schemas.

2.4.1 Data model architecture

The architecture of the data model has been designed at two levels using the one already proposed in D3.5; A first level in charge of managing the data model of the general system of metadata of the System and data belonging to STEN; And a second level linked to the first level based on an architecture of independent data schemas where the spatial information of the system layers is stored.

It is a hybrid system that combines the registered information of layers or metadata of the layers with the vector and raster information dataset of the SQLite databases. This second level contains the schemas of the data types and layers. These allow these data structures to be stored in a distributed way on a central system that orchestrates it.

First level of the data model

A non-relational data model has been designed as it does not have a specific data model from the beginning of the project and due to the complexity of the data and models. The database is No-SQL to have versatility in the design of the data model, depending to a great extent on the definition of dependent data from STEN Tool in WP2 and WP3. This first level is based on MongoDB and the data is exploited through the Web services of Parse Server.

Second level of data model

This second level is represented by a set of relational databases with a spatial nature, based on SQLite + Spatialite (the system is designed to support other relational database management systems). These databases have small data models where the layers are stored. This system allows to have a scalable data model with a schema adapted to the needs of each layer.

It is a scalable structure distributed in multiple databases. It prevents a monobloc database system from growing excessively due to a large number of records and / or layer sizes. Large volumes of data complicate handling, backup, and performance. The proposed architecture allows the system layers to be stored in independent SQLite, where their management at the system level is like treating a file, facilitating system backups and their publication in a Data Management Platform such as Zenodo. The disadvantage of using lightweight databases is the complexity of the indexed spatial queries and the limited spatial functionalities that this type of database presents. These disadvantages have not limited the BIOPLAT-EU requirements for the webGIS tool prototype and are not expected to appear.

For the construction of this second level, different data schemas have been designed to store all the basic layers of the webGIS Tool.

Layers are divided into two formats: raster and vector. These two formats differ in the storage of spatial information. Vector types store information about types of entities as mathematical trajectories: Example: Polygons as a series of x, y coordinates that start and end in the same place. Raster format data is a cell-based representation of features on the Earth's surface. Each cell has a different value, and all cells with the same value represent a specific characteristic.

From these principles, more complex spatial data structures can be created, which allow combining both, obtaining structures such as the indexed tiles on vector and / or raster layers used in BIOPLAT-EU.



Figure 16 - Diagram of the data model Architecture

2.4.2 Types of Data Schemas:

All schemas contain the model-specific tables and system management metadata tables.

Schema patterns (templates) have been created from which custom schemas are generated according to needs. The templates cover all the current and future layers that the system must support with the current requirements.

- TileIndex (Allow add custom fields)
- TileIndex-Time (Allow add custom fields)

- VectorModel (Allow add custom fields)
- MBTiles (draft)
 - MBTileRaster
 - MBTileVector
- VRT [Raster]
- RoutingTable

From these templates, the necessary fields and tables are defined for each of the layers. In Annex D, the data schemas implemented in the system are attached. The prototype has the necessary logic to recognize the data schemas. Web Services generate the access queries for the storage and retrieval of data from the model.

2.4.3 Layers of the webGIS Tool

Table 5- Layers and schemas used in the webGIS Tool

NAME	FORMAT	SCHEMA	DESCRIPTION
MUC: TIER 1	vector	VectorModel	All the countries listed in Annex E have been loaded
MUC: TIER 2 (HotSpot)	vector	VectorModel	Underutilized lands at tier 2 for 6 countries
COUNTRIES	vector	VectorModel	GADM maps. Country limits
REGIONS	vector	VectorModel	GADM maps. Community limits
PROVINCES	vector	VectorModel	GADM maps. Province limits
TARGET AREA BASE LAYER (TABL)	Vector	VectorModel	Municipalities layer fully loaded as vector tiles
SUITABILITY CROPS	Raster	TileIndex	GAEZ layers: straw, wheat, switchgrass, sunflower, sugarBeet, soybean, sorghum, rapeseed, miscanthus, maize, camelina.
BIO. PROCESSING PLANTS (BPP)	Vector	VectorModel	Draft version of the scheme of layer, each BPP point has information about pathways supported.
ROUTING SERVICES	vector	-	Data from the Open Street Routing service. No storage required
PRECIPITATION	Raster	VRT	European-wide raster precipitation 1950-2019 Copernicus Climate Service
WATER DEFICIT	Raster	TileIndex	WDE layers from GAEZ
BASE MAP	Tile raster	-	OpenStreetMap Service. No storage required

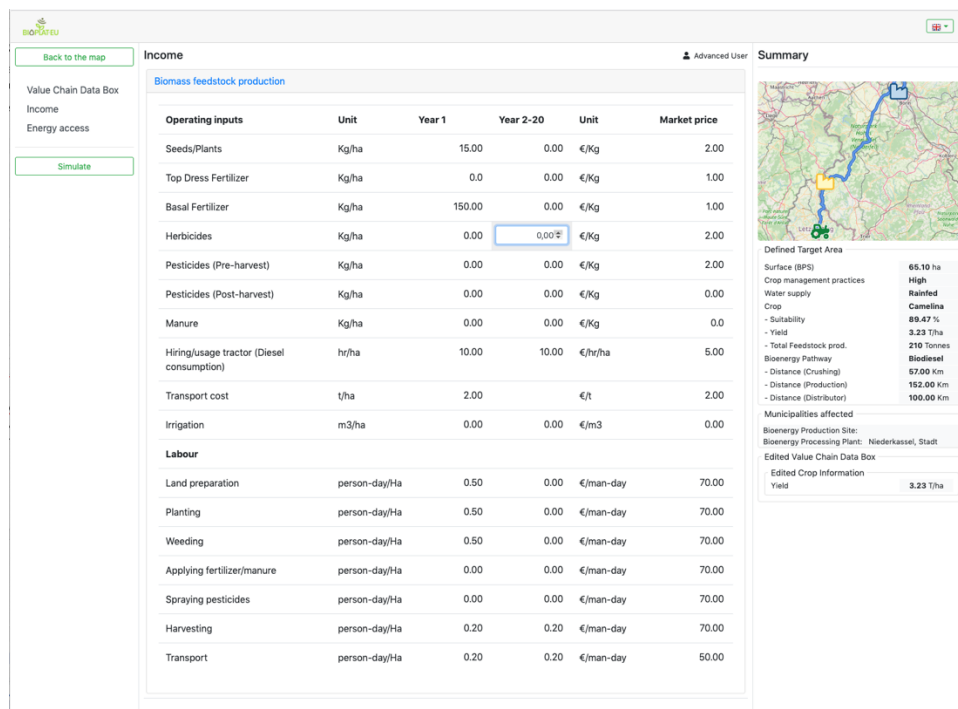
2.5 Output:

The system output is responsible for generating and representing the indicator outputs obtained by the STEN Engine. The system produces two outputs: 1) value chain data values of the defined target area, 2) final report of the indicators simulated by the STEN Engine. All these values can be downloaded in a pdf format.

The operational webGIS Tool allows consulting and editing the output of the socio-economic and environmental assessment of value chains for the possible enhancement of the MUC area, by customizing the pre-intermediate output values that serve as data input to the STEN Engine. Advanced users can edit and introduce their own data for improving the simulation. An advanced user is the one who is registered in BIOPLAT-EU webGIS.

The output window of the value chain and indicators has been distributed in three columns:

- Left panel: it is a menu in the navigation where user can find the navigation between the data input forms and the buttons to go back to the map and calculate indicators.
- Central panel: The input data box forms are located in this part. These data inputs are those used by the STEN Engine for the calculation of indicators.
- Right panel: Contains a small view of the map and a summary of the most important parameters of the value chain data box.



The screenshot displays the 'Income' section of the 'Biomass feedstock production' window. It features a table of operating inputs and labour, a map of the defined target area, and a summary panel.

Operating inputs	Unit	Year 1	Year 2-20	Unit	Market price
Seeds/Plants	Kg/ha	15.00	0.00	€/Kg	2.00
Top Dress Fertilizer	Kg/ha	0.0	0.00	€/Kg	1.00
Basal Fertilizer	Kg/ha	150.00	0.00	€/Kg	1.00
Herbicides	Kg/ha	0.00	0.00	€/Kg	2.00
Pesticides (Pre-harvest)	Kg/ha	0.00	0.00	€/Kg	2.00
Pesticides (Post-harvest)	Kg/ha	0.00	0.00	€/Kg	0.00
Manure	Kg/ha	0.00	0.00	€/Kg	0.0
Hiring/usage tractor (Diesel consumption)	hr/ha	10.00	10.00	€/hr/ha	5.00
Transport cost	t/ha	2.00		€/t	2.00
Irrigation	m3/ha	0.00	0.00	€/m3	0.00

Labour	
Land preparation	person-day/ha
Planting	person-day/ha
Weeding	person-day/ha
Applying fertilizer/manure	person-day/ha
Spraying pesticides	person-day/ha
Harvesting	person-day/ha
Transport	person-day/ha

Summary

Defined Target Area

- Surface (BPS): 66.10 ha
- Crop management practices: High
- Water supply: Rainfed
- Crop: Camelina
- Sustainability: 89.47 %
- Yield: 3.23 T/ha
- Total Feedstock prod.: 210 Tonnes
- Bioenergy Pathway: Biodiesel
- Distance (Crushing): 57.00 Km
- Distance (Production): 152.00 Km
- Distance (Distributor): 100.00 Km

Municipalities affected

Bioenergy Production Site: Bioenergy Processing Plant: Hiederassel, Stadt

Edited Value Chain Data Box

Edited Crop Information

Yield: 3.23 T/ha

Figure 17 - Screenshot of the value chain data box window

The generation of reports is possible in the operational webGIS Tool. The results of the indicators are shown in table mode grouped in STANDARD and ADVANCED indicators in the

style of Excel STEN Tool. The results shown on the Web can be downloaded by the user in pdf format.

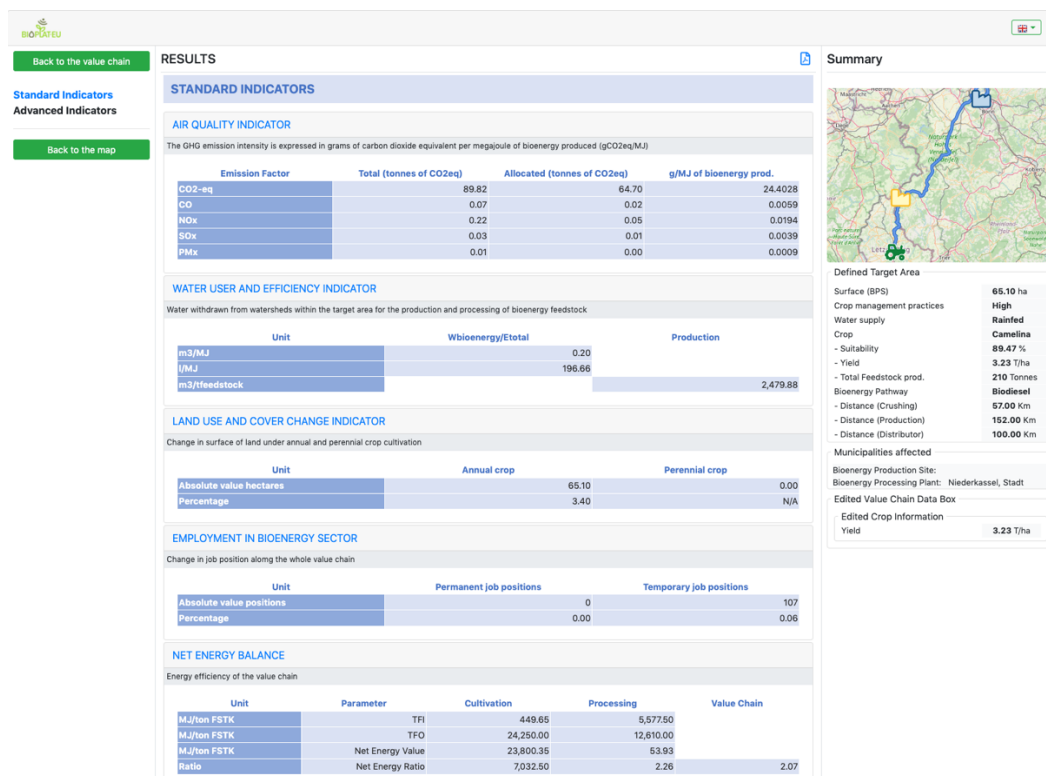


Figure 18 - Screenshot of results of standard & advanced indicators

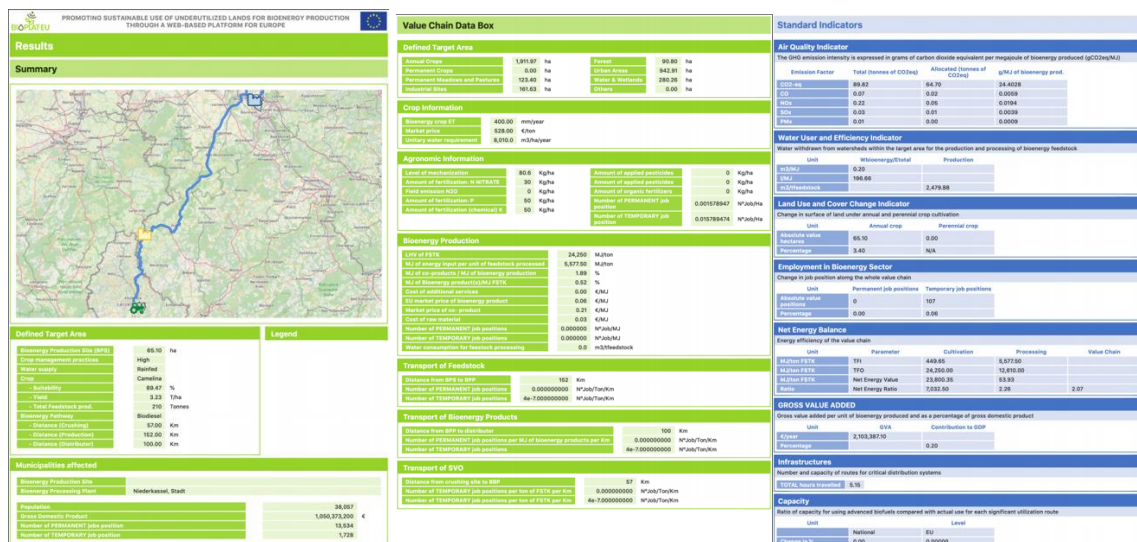


Figure 19 - Thumbnail view of the PDF Output of a report

3 Conclusions and recommendations

In its current state, the BIOPLAT-EU webGIS v1.0 system is capable of operating on the complete set of ten socio-economic and environmental indicators that make up the STEN tool. The numerical outputs associated with these indicators will allow decision-making for the exploitation and sustainability of bioenergy value chains on Marginal, Underutilized and Contaminated (MUC) areas, not suitable for food production, in Europe and neighboring countries.

The BIOPLAT-EU webGIS v1.0 system provides users with access to simulations that incorporate the socio-economic and environmental indicators of bioenergy value chains for decision-making in the use of MUC areas for bioenergy production. In addition, it responds to the objective of having a tool that is easy to use, accessible, and with sufficient computing power for the described user requirements, in accordance with the project objectives. For anonymous non-registered users, the webGIS Tool is capable of calculating the set of CORE indicators. Registered users can access to the STANDARD and ADVANCED indicators and introduce their own data.

The operation of the webGIS covers the functional and non-functional users' requirements. Multilanguage operation and adapting to the different decimal system notation are among these non-functional requirements. As this document describes, the webGIS tool manages large volumes of data. Representation techniques based on zoom levels have been simplified by using WMS + Vectorial requests at municipal zoom levels. According to the user requirement, MUC layer splits in Contaminated lands and Underutilized lands.

Selecting the required MUC through the query tool requires only clicking on the map. It activates the STEN module, define the target area and launch the simulation to obtain the value of indicators. All map services are functional and offer the information of the base layers defined in the project.

The data model has been defined and a vertices reduction process has been applied in the MUCs layer to speed up the loading and handling of features for the client. The crop-suitability, crop-yield, contaminated lands, underutilized lands, limits, target area base layer, BPP, and water deficit layers are loaded and functional in the webGIS Tool.

The STEN Tool interface have been simplified for improving user accessibility. The tool allows defining different transport distances according to the bioenergy pathway. Editing the geometric elements on the map is allowed, either to delimit the study area and / or to define the route and raw material treatment plant.

The STEN Engine Web services are operational for all indicators (8 CORE indicators and 2 Advanced indicators) provided in the version "STEN Tool_FAO_MAY.xlsx" by FAO. New calculations have been incorporated to incorporate the water deficit for crops with irrigated water supply in the calculation of certain indicators.

ANNEX A - Technical aspects

The main user requirements have not changed according to D3.4 and D3.5. This section contains a summary of the main functionalities developed to complete the operational webGIS Tool as well as a summary of the webGIS workflow with the STEN.

It should be noted, with respect to the STEN requirements, that the indicators have changed slightly with respect to those raised in D3.5, see Table 6

Table 6 - BIOPLAT-EU CORE and Advanced suitability indicators

BIOPLAT-EU expected suitability indicators in D3.5		BIOPLAT-EU suitability indicators	
CORE Indicators (Standard users)	ADVANCED Indicators (Advanced users / registered users)	CORE Indicators (Standard users)	ADVANCED Indicators (Advanced users / registered users)
Air Quality	Water Quality	Air Quality	Income
Water Use	Biodiversity	Water Use	Energy Access
Land Use Change	Land Tenure	Land Use Change	
Change in Income	Energy Access		
Jobs in Bioenergy Sector	Capacity of Use of Bioenergy	Jobs in Bioenergy Sector	
Productivity		Capacity of Use of Bioenergy	
Net Energy Balance		Net Energy Balance	
Gross Value Added		Gross Value Added	
Infrastructure		Infrastructure	

A.2 Main functionalities

Table 7 shows a summary of the main functionalities that the webGIS Tool must represent as it was defined in D3.4. For the construction of the operational webGIS Tool, all the requirements have been developed except F-12 and F-13, which have been partially developed.

Table 7 - Main functionalities developed in the BIOPLAT webGIS tool

Functional requirements		
<u>Accessibility</u>	F-01	A compatible client with desktop computer and mobile devices (responsive)
	F-02	Login & Authorization. Individualized connection based on unique users and password.
<u>Functionalities related with the Map</u>	F-03	Visualization of the Layers in a viewer. The basic layers are MUC lands, base maps such as OSM, layers of infrastructure, biomass processing plants...
	F-04	Visualization of those attributes and other detailed information belonging to a determined MUC land
	F-05	Edition of MUC lands attributes which could be liable to change over time
	F-06	Download of layers information
	F-07	Search of lands / plots by: <ul style="list-style-type: none"> • Coordinate system • Toponymy • Locator
<u>Functionalities related with the Sustainability Tool</u>	F-08	Implementation of the Sustainability Tool for European and Neighbouring countries (STEN) to provide an estimation of the potential bioenergy production adapted to specific crop/farm characteristics. The tool (STEN) should be defined by the user inputs for simulation, in addition to the specific data of each area of the member states (MS) to perform the calculation. STEN tool allows to calculate the estimation considering one crop and one Biomass Production Site (BPS) at a time.
	F-09	Easy-to-use results generation. This will allow users to generate the results and download a report from the system when allowed.
	F-10	Display and download either input layer either output layer from STEN tool.
<u>Functionalities related with the Administrator</u>	F-11	Manage system users. Define roles and user authorization in the system
	F-12	Manage the layers of the system*. The system should allow to manage the map display layers as well as the distributed spatially necessary indicators data layers for STEN.
	F-13	MUC land manager system *. The system must allow loading MUC in the system (<i>partial functionality</i>)
<u>Non-functional requirements</u>	F-14	A scalable infrastructure and a georeferenced database
<u>WS</u>	F-15	Basic online layer-algebra operations: Vector & Vector, Raster & vector. Layer-algebra operations goal is to spatially extract and overlay information from the layers and so it can

		be used as an input for STEN. That way, the system gets values of the indicator for each of the layers of the system. Using this dataset as inputs for the STEN tool
	F-16	Routing BPS to bioenergy industry. The system must obtain routing from the BPS to the nearest biomass processing plant, based on external services such as Open Street Maps (OSM), Google...

* F-12: Parse Dashboard has been integrated for data model management. F-13: The System has scripts that allow to dump the shapefiles to the VectorModel data model - MUCs (it does not have a manager to load interactive MUCs).

A.3 User input data flow

This annex describes the user interaction flow on the map, with the aim of executing the STEN tool. This task has been possible thanks to the previous design of a mockup in the first months of development and to the requirements set out in the conceptual design D3.4. The objective is to calculate the set of STANDARD and ADVANCED indicators, simplifying to the maximum the data entry by the user for STEN and simplifying the flow of user interaction by avoiding filling in a large number of variables and associated spatial information of the study area for the calculation of indicators.

The data flow can be analysed from two aspects: 1) User interaction with the map, 2) the simulation process with STEN.

- 1) Map interaction: The system is designed on a full screen map viewer to view all the information necessary for the study. In the central part is the map, on the sides there are two main panels. A left panel containing the main layer management tools and the STEN tool. A right panel of map tools to perform searches, zoom, legend, query information, etc. and display information on the intervening elements.

The layer manager is composed of:

- Background base layers for reference on the map.
- MUC areas based on spatial imaging techniques.
- Crop-based soil suitability maps based on the GAEZ model
- Administrative limits at European level
- Biomass Processing Plants.

The interaction with these layers allows to visualize this information on the map. This allows the user to detect MUC zones, crop suitability at a glance, and available processing plant infrastructure. Information is grouped by zoom level, to simplify viewing of MUC and BPP at the same time.

Another aspect of interest is the visualization of the crop suitability layer based on the GAEZ model. This allows analyzing on the map where a crop works better, since the model has determined a dozen parameters such as soil, climatic conditions, etc. for the suitability and yield of the crop.

- 2) The STEN calculation process is represented in three steps: 1) User inputs, 2) Value chain data box and 3) Core Indicators calculations and outputs.

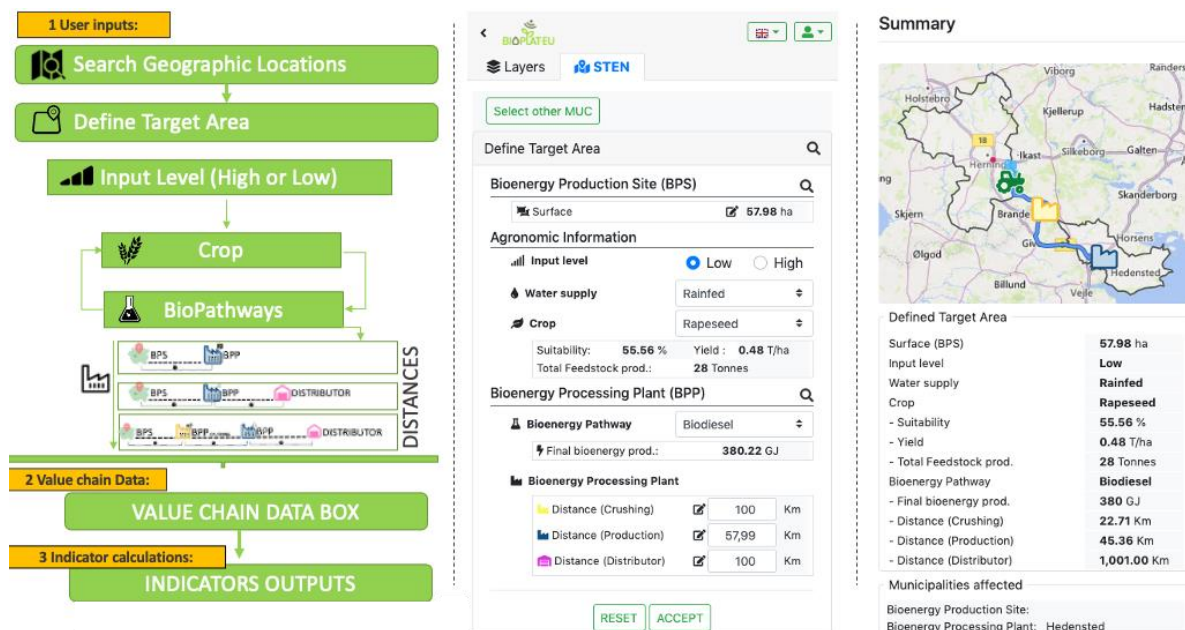


Figure 20 - Data flow diagram for STEN calculation

The first phase, "User inputs" is a set of steps that provides the system with the minimum information necessary for the calculations of indicators: 1) The search for a work area within MUC to establish the BPS. This location can be done through a search engine by toponym, by filter by different parameters (type of MUC, area, crop ...) or by navigating on the map. The MUCs and BPPs information is displayed on the map as a grouping of elements according to zoom level. 2) Define the work area or BPS on the map. The user draws a polygon or selects all MUC area. The system intersects the area drawn with the MUCs and delimits the BPS within a MUC. This functionality simplifies the interaction of the polygon drawn by the user, as it is automatically adjusted to the limits of the MUC. At this point, we are working with the partners to solve the casuistry of underutilised and contaminated MUCs overlap areas. 3) In this step the user establishes the STEN parameters; input level (at least one default value), crop, pathways and BPP. The different input options are linked to ensure correct input data. The form shows the consistency in the data collection process to define the target area. This allows a flexible and powerful system, as the choice will depend on the user. A user could be interested in a certain crop, or in a certain bioenergy pathway or even in the processing of biomass in a certain BPP. Examples: Selecting a crop loads the bioenergy pathways compatible with that crop and BPPs compatible with pathways. If instead the user chooses a Pathway firstly, the system

retrieves the crops compatible with the pathways for that work area, and BPPs compatible for that pathway. The system analyzes the suitability crops in the BPS.

The second phase (Value Chain Data) of the workflow is from the user inputs of the previous phase. The system obtains the data and parameters stored in layers and reference tables. These values will be the inputs to STEN Engine for the calculation of the indicators. An advanced user could adjust these parameters, in order to customize the simulation values. The standard user, on the other hand, does not have access to manipulating the Value Chain Data.

The third phase is the calculation of indicators and the obtaining of results. In this section, the STEN Engine executes the different variables of which the indicators are composed, from the input data of the value chain data box. The result is a set of indicator variables.

ANNEX B – Web Services

This annex contains the request to the different blocks of system services: API Services, STEN Services and Map Services.

The API Services are developed using Parse Serve, refer to the official documentation (<https://docs.parseplatform.org>).

The Map Services and STEN services are collected in the following tables by means of example requests for the BIOPLAT-EU webGIS Tool prototype.

MAP Services - Clustering	
Description	Request to the MUC layer in Cluster type "C" format with area less than 150 for a grouping at the country level
URL	<a href="https://webgis.bioplat.eu/mapservices/geojson/cluster/mucs?area=<150&type=C&zoom=3&bbox=-57.03,29.48,73.03,64.41">https://webgis.bioplat.eu/mapservices/geojson/cluster/mucs?area=<150&type=C&zoom=3&bbox=-57.03,29.48,73.03,64.41
Description	Request to the MUC layer in Cluster type "C" format with area greater than 150 for a grouping at the country level
URL	150&type=C&zoom=3&bbox=-57.03,29.48,73.03,64.41">https://webgis.bioplat.eu/mapservices/geojson/cluster/mucs?area=>150&type=C&zoom=3&bbox=-57.03,29.48,73.03,64.41
Description	Request to the BPP layer in Cluster format for German plants that process CHP or Biogas
URL	https://webgis.bioplat.eu/mapservices/geojson/cluster/processing-plants?biopathways=CHP,Biogas&country=DE&zoom=3&bbox=-57.03,29.48,73.03,64.41

Map Services – Vector Layers	
Description	Request to the MUC layer in MVT type C format with area less than 150
URL	<a href="https://webgis.bioplat.eu/mapservices/mvt/mucs/8/137/88.pbf?area=<150&type=C">https://webgis.bioplat.eu/mapservices/mvt/mucs/8/137/88.pbf?area=<150&type=C
Description	Request to the MUC layer in GeoJSON type C format with area less than 150
URL	<a href="https://webgis.bioplat.eu/mapservices/geojson/getmap/mucs?area=<150&type=C&bbox=6.18,49.91,7.79,50.34">https://webgis.bioplat.eu/mapservices/geojson/getmap/mucs?area=<150&type=C&bbox=6.18,49.91,7.79,50.34
Description	Request to the BPP layer in GeoJSON format for German plants that process CHP or Biogas
URL	https://webgis.bioplat.eu/mapservices/geojson/getmap/processing-plants?biopathways=CHP,Biogas&country=DE&bbox=-57.03,29.48,73.03,64.41
Description	BPP layer with plants called "Biogas Neuttrebbin GmbH & Co. KG":
URL	https://webgis.bioplat.eu/mapservices/geojson/getmap/processing-plants?name=Biogas%20Neuttrebbin%20GmbH%20%26%20Co.%20KG&bbox=-57.03,29.48,73.03,64.41

Map Services – Feature Query

Description	Request for specific information of an element by ID of the mucs layer
URL	https://webgis.bioplat.eu/mapservices/geojson/getfeature/mucs?id=f53b7CBBed
Description	Request for a specific query for information to an element of the MUC layer for the X and Y coords.
URL	https://webgis.bioplat.eu/mapservices/geojson/getfeature/mucs?x=1351034.241217394&y=5267861.576468132&srs=EPSG:3857

Map Services – WMS Layers

Description	<p>Suitability-crops layer WMS service. Layers available:</p> <ul style="list-style-type: none"> • suitability-crops • yield-crops • mucs • countries • regions • provinces • municipalities <p>Parameters for the suitability-crops and yield-crops layer:</p> <p>crop:</p> <ul style="list-style-type: none"> • camelina • eucalyptus • miscanthus • maize • rapeseed • straw • sunflower • soybean • sorghum • smilgrass • sugarBeet • switchgrass • poplar • giantReed • wheat • willow <p>inputlevel:</p> <ul style="list-style-type: none"> • low => Low
-------------	---

	<ul style="list-style-type: none"> • high => High <p>water:</p> <ul style="list-style-type: none"> • a => Rainfed all phases • s => Sprinkler irrigation
URL	https://webgis.bioplat.eu/mapserv?map=/share/bioplateu/mapfiles/layer.map&SERVICE=WMS&VERSION=1.3.0&REQUEST=GetMap&FORMAT=image%2Fpng&TRANSPARENT=true&LAYERS=yield-crops&CRS=EPSG%3A3857&STYLES&WIDTH=2481&HEIGHT=899&BBOX=-3780269.670871677%2C3915410.3368798676%2C2288218.878745036%2C6113127.774135256&crop=maize

Title	
STEN Services	
Description	List of crops available in a specific area. POST request example: <pre>{ "crop": "maize", "bpsWKT": "POLYGON ((-2.0798492431640625 39.118341154165186, -2.0994186401367188 39.09489712966929, -2.0609664916992188 39.101291727840604, -2.071266174316406 39.12153746241925, -2.0798492431640625 39.118341154165186))", "water": "a", "inputlevel": "high" }</pre>
URL	https://webgis.bioplat.eu/sten/getcrops
Description	List of Biomass Processing Plants closest to a point for a given bioenergy pathway
URL	https://webgis.bioplat.eu/sten/nearest-bpp?x=9.931640625&y=49.6249456465&srs=EPSG:4326&biopathway=Biogas&distance=100&limit=10
Description	Calculation of the Target area given the geometry of the BPS and the BPP. POST request example: <pre>{ "bppWKT": "POINT (-3.6941528320312496 38.024295124443995)", "bpsWKT": "POLYGON ((-2.65869140625 39.5633531658293, -2.558441162109375 39.47118523471246, -2.4224853515625 39.551706503542654, -2.51861572265625 39.590873865955906, -2.5323486328125 39.594048628201314, -2.65869140625 39.5633531658293))" }</pre>
URL	https://webgis.bioplat.eu/sten/target-area
Description	Request that returns the value chain from the user input data. POST request example: <pre>{ "water": "s", "crop": "rapeseed", }</pre>

	<pre> "bppWKT": "POINT(13.231561 51.454525)", "bpsWKT": "POLYGON ((-2.0798492431640625 39.118341154165186, -2.0994186401367188 39.09489712966929, -2.0609664916992188 39.101291727840604, -2.071266174316406 39.12153746241925, -2.0798492431640625 39.118341154165186))", "inputlevel": "high", "biopathway": "biodiesel" } </pre>
URL	https://webgis.bioplat.eu/sten/value-chain
Description	<p>Request for calculating STEN indicators from the user's value chain data. POST request example:</p> <pre> {"engine":"sten","input":{"CROPINPUTLEVEL":"high","CROP":"sorghum","BIOENERGYPATHWAY":"biogas", "BPS2BPPDISTANCE":1281.57,"BPP2DISTRIBUTORDISTANCE":50,"BPSSURFACE":29.9,"YIELD":3.26,"ENER GYPERFSTK":5},"output":["airQualityMechCO2eq","airQualityEmissionFromAgricultureCO2eq","airQuality FstkTransCO2eq","airQualityProcCO2eq","airQualityBioTransCO2eq","airQualityTotalEmissionCO2eq","air QualityEmissionsByEnergyOfMainCO2eq","airQualityEmissionsByValueOfMainCO2eq","airQualityEmissio nsByEnergyOfCo1CO2eq","airQualityEmissionsByValueOfCo1CO2eq","airQualityEmissionsByEnergyOfCo2 CO2eq","airQualityEmissionsByValueOfCo2CO2eq","incomeGrossMargin_1","incomeGrossMargin_2_20", "incomeNetMargin_1","incomeNetMargin_2_20","LUCchangeAnnualCrops","LUCchangeAnnualCropsHa" ,"LUCchangePerennialCrops","LUCchangePerennialCropsHa","NEBcultivationValue","NEBcultivationRatio" ,"NEBprocessingValue","NEBprocessingRatio","NEBefficiency"]} </pre>
URL	https://webgis.bioplat.eu/sten-engine/advanced

ANNEX C - DataModel Sub-schemas

These schemas are the specific ones of the data model for the webGIS Tool. From the base schemas the customized schemas have been created for each of the base layers of the project.

TileIndex – SUITABILITY CROPS

It is based on a TileIndex type structure whose specific fields are: suitability, input_level, water, crop and _formula. It stores the map images generated by GAEZ and other external sources on the suitability of the crops supported in the system.

Column	Type	Description
_id	STRING UNIQUE KEY	Unique identifier
_created_at	DATETIME	Creation date
_updated_at	DATETIME	Registration date
_acl	JSON	JSON with registry access permissions
ogc_fid	INTEGER PRIMARY KEY	Unique feature identifier
location	VARCHAR	File path
src_srs_	VARCHAR	EPSG
GEOMETRY	Geometry Type {Point, Line, Polygon, GEOMETRY}	Image bbox
suitability	VARCHAR(2)	Suitability per Yield: Sc: Crop suitability index in classes Su: Crop suitability index continuous Yc: Average attainable yield of current cultivated land
input_level	VARCHAR(1)	Input Level del campo: High (H) o Low (L)
water	VARCHAR(1)	Water supply: a: Rainfed all phases s: Sprinkler irrigation
crop	VARCHAR(5)	Crop: mis: Miscanthus srg: Sorghum cme: Camelina wlo: Willow mze: Maize sub: Sugar Beet grd: Gian reed ely: Eucalyptus rsd: Rapeseed

		swg: Switchgrass ppl: Poplar sfl: Sunflower whe: Wheat sml: Smilgrass soy: Soybean stw: Straw
abstract	TEXT	Image abstract
_formula	TEXT	Transformation formula of Pixel value to yield.

TileIndex – WATER DEFICIT CROPS

It is based on a TileIndex type structure whose specific fields are: type, input_level, water, crop and _formula. It stores the map images generated by GAEZ and other external sources on the water deficit of the crops supported in the system.

Column	Type	Description
_id	STRING UNIQUE KEY	Unique identifier
_created_at	DATETIME	Creation date
_updated_at	DATETIME	Registration date
_acl	JSON	JSON with registry access permissions
ogc_fid	INTEGER PRIMARY KEY	Unique feature identifier
location	VARCHAR	File path
src_srs_	VARCHAR	EPSG
GEOMETRY	Geometry Type {Point, Line, Polygon, GEOMETRY}	Image bbox
input_level	VARCHAR(1)	Input Level del campo: High (H) o Low (L)
water	VARCHAR(1)	Water supply: a: Rainfed all phases s: Sprinkler irrigation
crop	VARCHAR(5)	Crop: mze: Maize sub: Sugar Beet grd: Gian reed soy: Soybean
abstract	TEXT	Image abstract
_formula	TEXT	Transformation formula of Pixel value to yield.

VectorModel – COUNTRIES

Layer of countries worldwide

Column	Type	Description
_id	STRING UNIQUE KEY	Unique identifier
_created_at	DATETIME	Creation date
_updated_at	DATETIME	Registration date
_acl	JSON	JSON with registry access permissions
ogc_fid	INTEGER PRIMARY KEY	Unique feature identifier
GEOMETRY	MultiPolygon	Element geometry
CNTR_ID	TEXT	Identifier
CNTR_NAME	TEXT	Original Name (Name National)
CNTR_NAME_ENG	TEXT	Name in English (Name Latin)
ISO3_CODE	TEXT	ISO 3 Code
AREA	TEXT	Surface

Table of data associated with countries

Column	Type	Description
_id	STRING UNIQUE KEY	Unique identifier
_created_at	DATETIME	Creation date
_updated_at	DATETIME	Registration date
_acl	JSON	JSON with registry access permissions
CNTR_ID	TEXT	Country identifier
POP	INTEGER	population data 2016
GDP	REAL	Gross Domestic Product 2016 [€]
WORK_RATE	REAL	Rate of working-age (20-64 years) people [%]
EMP_RATE	REAL	Employment rate [%]
TEMPWORK	REAL	Rate of temporary employment [%]
UNSKILLED	REAL	Rate of unskilled people, age group 20-64 [%]
SKILLED	REAL	Rate of skilled people, age group 20-64 [%]
ANCR	REAL	Annual Crops [ha]
PECR	REAL	Permanent Crops [ha]
PEMEPA	REAL	Permanent Meadows and Pastures [ha]
INSI	REAL	Industrial Sites [ha]
FO	REAL	Forest [ha]
URAR	REAL	Urban Areas [ha]

WE	REAL	Water & Wetlands [ha]
OT	REAL	Others [ha]

VectorModel – REGIONS

Regions Layer

Column	TIPO	Description
_id	STRING UNIQUE KEY	Unique identifier
_created_at	DATETIME	Creation date
_updated_at	DATETIME	Registration date
_acl	JSON	JSON with registry access permissions
ogc_fid	INTEGER PRIMARY KEY	Unique feature identifier
GEOMETRY	MultiPolygon	Element geometry.
REGN_ID	TEXT	Region identifier
CNTR_CODE	TEXT	ISO country code
CNTR_NAME	TEXT	Name
CNTR_NAME_ENG	TEXT	Name in English (Name Latin)
REGN_CODE	TEXT	ISO 3 Code
AREA	TEXT	Surface

Table of associated data for regions

Column	Type	Description
_id	STRING UNIQUE KEY	Unique identifier
_created_at	DATETIME	Creation date
_updated_at	DATETIME	Registration date
_acl	JSON	JSON with registry access permissions
REGN_ID	TEXT	Region identifier
POP	INTEGER	Population 2016
GDP	REAL	Gross Domestic Product 2016 [€]
WORK_RATE	REAL	Rate of working-age (20-64 years) people [%]
EMP_RATE	REAL	Employment rate [%]
TEMPWORK	REAL	Rate of temporary employment [%]
UNSKILLED	REAL	Rate of unskilled people, age group 20-64 [%]
SKILLED	REAL	Rate of skilled people, age group 20-64 [%]
ANCR	REAL	Annual Crops [ha]
PECR	REAL	Permanent Crops [ha]

PEMEPA	REAL	Permanent Meadows and Pastures [ha]
INSI	REAL	Industrial Sites [ha]
FO	REAL	Forest [ha]
URAR	REAL	Urban Areas [ha]
WE	REAL	Water & Wetlands [ha]
OT	REAL	Others [ha]

VectorModel – PROVINCES

Province Layer.

Column	Type	Description
_id	STRING UNIQUE KEY	Unique identifier
_created_at	DATETIME	Creation date
_updated_at	DATETIME	Registration date
_acl	JSON	JSON with registry access permissions
ogc_fid	INTEGER PRIMARY KEY	Unique feature identifier
GEOMETRY	MultiPolygon	Element geometry.
PROV_ID	TEXT	Province identifier
CNTR_CODE	TEXT	ISO country code
CNTR_NAME	TEXT	Country name
PROV_NAME	TEXT	Province name
REGN_NAME	TEXT	ISO 3 Code of the region
AREA	TEXT	Surface

Table of associated data of the autonomous community

Column	Type	Description
_id	STRING UNIQUE KEY	Unique identifier
_created_at	DATETIME	Creation date
_updated_at	DATETIME	Registration date
_acl	JSON	JSON with registry access permissions
PROV_ID	TEXT	Province identifier
POP	INTEGER	Population 2016
GDP	REAL	Gross Domestic Product 2016 [€]
WORK_RATE	REAL	Rate of working-age (20-64 years) people [%]
EMP_RATE	REAL	Employment rate [%]
TEMPWORK	REAL	Rate of temporary employment [%]

UNSKILLED	REAL	Rate of unskilled people, age group 20-64 [%]
SKILLED	REAL	Rate of skilled people, age group 20-64 [%]
ANCR	REAL	Annual Crops [ha]
PECR	REAL	Permanent Crops [ha]
PEMEPA	REAL	Permanent Meadows and Pastures [ha]
INSI	REAL	Industrial Sites [ha]
FO	REAL	Forest [ha]
URAR	REAL	Urban Areas [ha]
WE	REAL	Water & Wetlands [ha]
OT	REAL	Others [ha]

VectorModel – TARGET AREA BASE LAYER

Vector layer that represents the municipalities at the European level and their statistical population data.

Column	Type	Description
_id	STRING UNIQUE KEY	Unique identifier
_created_at	DATETIME	Creation date
_updated_at	DATETIME	Registration date
_acl	JSON	JSON with registry access permissions
ogc_fid	INTEGER PRIMARY KEY	Unique feature identifier
GEOMETRY	MultiPolygon	Element geometry.
CNTR_CODE	TEXT	Country Code
NUTS3_CODE	TEXT	Nomenclature of Territorial Units for Statistics
LAU_CODE	TEXT	Local Administrative Units
MUN_NAME	TEXT	Municipality name
MUN_NAME_ENG	TEXT	Municipality name in English
MUNNATCODE	TEXT	Unique Identifier: NUTS3_CODE + LAU_CODE
INSPIREID	TEXT	Unique INSPIRE ID: Namespace:localid:versionid

Table associated with data to municipalities

Column	Type	Description
_id	STRING UNIQUE KEY	Unique identifier
_created_at	DATETIME	Creation date
_updated_at	DATETIME	Registration date
_acl	JSON	JSON with registry access permissions

MUNNATCODE	TEXT	Unique Identifier: NUTS3_CODE + LAU_CODE
POP	INTEGER	Population 2016
GDP	DOUBLE	Gross Domestic Product 2016 [€]
WORK_RATE	DOUBLE	Rate of working-age (20-64 years) people [%]
EMP_RATE	DOUBLE	Employment rate [%]
TEMPWORK	DOUBLE	Rate of temporary employment [%]
UNSKILLED	DOUBLE	Rate of unskilled people, age group 20-64 [%]
SKILLED	DOUBLE	Rate of skilled people, age group 20-64 [%]
AnCr	DOUBLE	Annual Crops [ha]
PeCr	DOUBLE	Permanent Crops [ha]
PeMePa	DOUBLE	Permanent Meadows and Pastures [ha]
InSi	DOUBLE	Industrial Sites [ha]
Fo	DOUBLE	Forest [ha]
UrAr	DOUBLE	Urban Areas [ha]
We	DOUBLE	Water & Wetlands [ha]
Ot	DOUBLE	Others [ha]

Note: Data Based on CORINE Landcover 2018 (Allocation see table below) and Data on NUTS3 Level and Data on NUTSO Level

VectorModel – MUCS (TIER 1 & 2)

Geometry layer of MUC areas

Column	Type	Description
_id	STRING UNIQUE KEY	Unique identifier
_created_at	DATETIME	Creation date
_updated_at	DATETIME	Registration date
_acl	JSON	JSON with registry access permissions
ogc_fid	INTEGER PRIMARY KEY	Unique feature identifier
GEOMETRY	MultiPolygon	Element geometry.
MUC_ID	TEXT	MUC identifier
NAME_CODE	TEXT	NUTS3_CODE + LAU_CODE + MUC_ID
CNTR_CODE	TEXT	ISO 3166-1 – Alpha-2-code
NUTS3_CODE	TEXT	Nomenclature of Territorial Units for Statistics
LAU_CODE	TEXT	Local Administrative Units (ASSIGN MUC CENTROID)
TYPE	TEXT	Type: MU; C;
AREA	TEXT	Area

Associated data table for contaminated lands

Column	Type	Description
_id	STRING UNIQUE KEY	Unique identifier
_created_at	DATETIME	Creation date
_updated_at	DATETIME	Registration date
_acl	JSON	JSON with registry access permissions
MUC_ID	TEXT	MUC identifier
AnnCrSh	TEXT	Annual crops share
PermCrSH	TEXT	Permanent crops share
PastSH	TEXT	Pasture share
OthersSh	TEXT	Others

COUNTRY		TIER	TYPE	LAYER
Albania	✓	TIER 1	UnderutilizedLandsNoCaseStudyAreas	UUALbaniaV1
Austria	✓	TIER 1	UnderutilizedLandsNoCaseStudyAreas	UUAustriaV2
Belgium	✓	TIER 1	UnderutilizedLandsNoCaseStudyAreas	UUBelgiumV2
Bulgaria	✓	TIER 1	UnderutilizedLandsNoCaseStudyAreas	UUBulgariaV2
Croatia	✓	TIER 1	UnderutilizedLandsNoCaseStudyAreas	UUCroatiaV1
Czechia	✓	TIER 1	UnderutilizedLandsNoCaseStudyAreas	UUCzechiaV2
Denmark	✓	TIER 1	UnderutilizedLandsNoCaseStudyAreas	UUDenmarkV2
Estonia	✓	TIER 1	UnderutilizedLandsNoCaseStudyAreas	UUEstoniaV1
Finland	✓	TIER 1	UnderutilizedLandsNoCaseStudyAreas	UUFinlandV1
France	✓	TIER 1	UnderutilizedLandsNoCaseStudyAreas	UUFranceV3
Greece	✓	TIER 1	UnderutilizedLandsNoCaseStudyAreas	UUGreeceV2
Ireland	✓	TIER 1	UnderutilizedLandsNoCaseStudyAreas	UUIrelandV2
Latvia	✓	TIER 1	UnderutilizedLandsNoCaseStudyAreas	UULatviaV1
Lithuania	✓	TIER 1	UnderutilizedLandsNoCaseStudyAreas	UULithuaniaV2
Luxembourg	✓	TIER 1	UnderutilizedLandsNoCaseStudyAreas	UULuxembourgV3
Netherlands	✓	TIER 1	UnderutilizedLandsNoCaseStudyAreas	UUNetherlandsV2
NorthMacedonia	✓	TIER 1	UnderutilizedLandsNoCaseStudyAreas	UUNorthMacedoniaV1
Norway	✓	TIER 1	UnderutilizedLandsNoCaseStudyAreas	UUNorwayV1

Poland	✓	TIER 1	UnderutilizedLandsNoCaseStudyAreas	UUPolandV1
Portugal	✓	TIER 1	UnderutilizedLandsNoCaseStudyAreas	UUPortugalV1
Serbia	✓	TIER 1	UnderutilizedLandsNoCaseStudyAreas	UUSerbiaV1
Slovakia	✓	TIER 1	UnderutilizedLandsNoCaseStudyAreas	UUSlovakiaV1
Slovenia	✓	TIER 1	UnderutilizedLandsNoCaseStudyAreas	UUSloveniaV2
Sweden	✓	TIER 1	UnderutilizedLandsNoCaseStudyAreas	UUSwedenV1
Switzerland	✓	TIER 1	UnderutilizedLandsNoCaseStudyAreas	UUSwitzerlandV1
UnitedKingdom	✓	TIER 1	UnderutilizedLandsNoCaseStudyAreas	UUUnitedKingdomV1

COUNTRY		TIER	TYPE	LAYER	DATA
Austria	✓	TIER1	ContaminatedLands	CLAustriaV3	CLAustriaLUSharesV3
Belgium	✓	TIER1	ContaminatedLands	CLBelgiumV3	CLBelgiumLUSharesV3
Bulgaria	✓	TIER1	ContaminatedLands	CLBulgariaV3	CLBulgariaLUSharesV3
Czechia	✓	TIER1	ContaminatedLands	CLCzechiaV2	CLCzechiaLUSharesV2
Denmark	✓	TIER1	ContaminatedLands	CLDenmarkV2	CLDenmarkLUSharesV2
France	✓	TIER1	ContaminatedLands	CLFranceV3	CLFranceLUSharesV3
Germany	✓	TIER1	ContaminatedLands	CLGermanyV3	CLGermanyLUSharesV3
Greece	✓	TIER1	ContaminatedLands	CLGreeceV2	CLGreeceLUSharesV2
Hungary	✓	TIER1	ContaminatedLands	CLHungaryV2	CLHungaryLUSharesV2
Ireland	✓	TIER1	ContaminatedLands	CLIrelandV4	CLIrelandLUSharesV4
Italy	✓	TIER1	ContaminatedLands	CLItalyV3	CLItalyLUSharesV3
Liechtenstein	✓	TIER1	ContaminatedLands	CLLiechtensteinV1	CLLiechtensteinLUSharesV1
Luxembourg	✓	TIER1	ContaminatedLands	CLLuxembourgV3	CLLuxembourgLUSharesV3
Netherlands	✓	TIER1	ContaminatedLands	CLNetherlandsV2	CLNetherlandsLUSharesV2
Portugal	✓	TIER1	ContaminatedLands	CLPortugalV2	CLPortugalLUSharesV2
Slovakia	✓	TIER1	ContaminatedLands	CLSlovakiaV2	CLSlovakiaLUSharesV2
Slovenia	✓	TIER1	ContaminatedLands	CLSloveniaV2	CLSloveniaLUSharesV2
Spain	✓	TIER1	ContaminatedLands	CLSpainV3	CLSpainLUSharesV3
Sweden	✓	TIER1	ContaminatedLands	CLSwedenV1	CLSwedenLUSharesV1
UnitedKingdom	✓	TIER1	ContaminatedLands	CLUnitedKingdomV3	CLUnitedKingdomLUSharesV3

COUNTRY		TIER	TYPE	LAYER	DATA
Germany	✓	TIER1&2	UnderutilizedLandsInclTIER2	DEV8	UUGermanyMergeV8
Italy	✓	TIER1&2	UnderutilizedLandsInclTIER2	ITV3	UUItalyMergeV3
Spain	✓	TIER1&2	UnderutilizedLandsInclTIER2	ESV4	UUSpainMergeV4
Ukraine	✓	TIER1&2	UnderutilizedLandsInclTIER2	UAV4	UUUkraineMergeV4
Hungary	✓	TIER1&2	UnderutilizedLandsInclTIER2	HUV2	UUHungaryMergeV2
Romania	✓	TIER1&2	UnderutilizedLandsInclTIER2	ROV2	UURomaniaMergeV2

VectorModel – Biomass processing plants (BPP)

Column	Type	Description
_id	STRING UNIQUE KEY	Unique identifier
_created_at	DATETIME	Creation date
_updated_at	DATETIME	Registration date
_acl	JSON	JSON with registry access permissions
ogc_fid	INTEGER PRIMARY KEY	Unique feature identifier
GEOMETRY	POINT	Element geometry.
BPP_ID	TEXT	BPP identifier
BPP_NAME	TEXT	Plant name
BPP_ADDRESS	TEXT	postal address
BPP_POSTCODE	TEXT	PostCode
BPP_WEBSITE	TEXT	Plant website
BPP_CONTACT	TEXT	contact information
BPP_COMMENT	TEXT	
CNTR_NAME	TEXT	Country Name
CNTR_CODE	TEXT	ISO country code
CNTR_CODE3	TEXT	Country code
MUN_NAME	TEXT	Municipality name
MUN_CODE	TEXT	Municipality code
NUTS3_CODE	TEXT	Nomenclature of Territorial Units for Statistics

Associated data table for processing plants

Column	Type	Description
_id	STRING UNIQUE KEY	Unique identifier
_created_at	DATETIME	Creation date
_updated_at	DATETIME	Registration date

_acl	JSON	JSON with registry access permissions
BPP_ID	TEXT	BPP identifier
CAPACITY	INTEGER	Plant capacity
BIOPATHWAY	TEXT	Type of bioenergy pathway

COUNTRY		LAYER	DATA
ALL	✓	BPPV3	BPPAIIV3UTF8

ANNEX D – Map Viewer – visualization strategies

The visualization strategies allow to represent data on the map viewer in different formats according to the scale and / or interaction with the map. In order to represent large volumes of vector data in the viewer, different strategies and data structures have been developed between client and server.

A first strategy consists of grouping elements at the server level (countries and regions) and clustering by distance on the client. Performing a clustering representation of MUCs and / or BPPs.

The second strategy consists of a large-scale representation of the Web Map Tile Services (WMTS) format of the MUCs and BPPs points, to finally represent the data in vector format on a municipal scale. This strategy allows to visualize the real zones from the beginning.

Both strategies have been developed in the prototype to improve user interaction with the webGIS. Sometimes a point cloud can prevent us from clearly reading a map, especially when we work at small scales where a large area can show a large number of elements that are represented very close without letting us see the underlying elements.

One of the non-functional goals is to simplify user interaction to find an area of interest and user input data. We have worked on different strategies to represent the information adapted according to the display zoom on the map for the MUCs and BPP layers, to help the user to easily visualize large amounts of information at the European level and neighboring countries.

CLUSTERING STRATEGY:

The clustering strategy provides the webGIS Tool with a better analysis of the information. It offers a more simplified view of the areas of interest and available markers.

By default, the map servers, in vector format serve the original coordinates, the client being in charge of clustering by distance. A map viewer can cluster and easily manage hundreds of points, but that amount is insufficient for a MUCs type layer at a European level as it represents thousands of points. In addition, the user in BIOPLAT-EU requires filtering this information, which prevents having pre-calculated data in the system ready to be displayed in a cluster. For this reason, 3 levels of client-server requests have been designed based on zoom; at the level of country, region and a last level based on distance between points for a bounding box view. These clustering count the number of elements and the sum of hectares involved by each mark on the map.

SCALE-LAYER STRATEGY IN WMTS MAPS:

A Web Map Tile Services (WMTS) is a standard protocol for serving pre-rendered or run-time computed georeferenced map tiles over the Internet. It allows to produce dynamically spatially referenced data maps in PNG, GIF or JPEG image format. The server is in charge of rendering the real information from raster and / or vector layers and serving them as images. Its

advantage is the ease of viewing this data in a map viewer. Its main disadvantage is that it does not allow interaction with the map elements as it is an image format.

In the map viewer, scale layer strategies have been defined in combining WMTS and vector. This allows the use of the image-based WMTS format on a large scale, that is, at the country and / or regional level. Using a vector format at lower municipal scales would improve the user interaction with the map elements. The vector format allows an interaction to occur by hovering the mouse over an element, for example highlighting the element, selecting it or displaying information.

The map viewer internally handles requests to the server according to the zoom level to ensure that the layer data is optimal for display. The main layers of the system are WMTS with the possibility of filters, to combine this strategy in the layers of MUCs and BPPs.

ANNEX E - Repositories & Installation

Server software requirements:

- Linux Ubuntu 20.04 LTS
- MapServer version 7.6.0
- nginx/1.17.10 (Ubuntu)
- spatialite 3.31.1
- GDAL 3.1.0
- Python3.8
- MongoDB 4.2.7
- Node 12.18

Sources:

Table 8 - Summary table of source code repositories used for the operational webGIS Tool

Name	Module	Repository	Description
PARSE-SERVER-BIOPLAT	Backend	https://github.com/tsigbio/parse-server-bioplant	BIOPLAT webGIS WebServices
PARSE-CLI-BIOPLAT	cli	https://github.com/tsigbio/parse-cli-bioplant	Data model loader to PARSE-SERVER-BIOPLAT
STENALONE	Backend	https://github.com/tsigbio/stenalone	STEN Engine Web Services in charge of calculating the STEN Tool indicators
<i>webGISTool</i>	Frontend	https://github.com/tsigbio/webGISTool	Web application with the map viewer developed in Angular 11 that connects to the PARSE-SERVER-BIOPLAT & STENALONE services.